Implementing Integrated
Solid Waste Management Systems in India

Moving Towards the Regional Approach

There are many challenges regarding the safe disposal of municipal solid waste in India. Recent attempts have been concerned with finding ways to provide safe and sanitary disposal for solid waste so that our environment is no longer damaged by polluting, open dumps.

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Report

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Contents

Introduction

This document is intended for decisionmakers who are concerned with reducing the pollution and health hazards that are caused by the uncontrolled disposal of thousands of tons of waste each day in open dumps. It will also be helpful for decisionmakers who are concerned with urban governance and urban management. While it does contain some technical information, the messages can be easily understood by those with an interest in municipal issues but no formal training in scientific or technical disciplines. The challenges of safe disposal of municipal solid waste (MSW) were deliberated on at two workshops held in January 2007, under the auspices of the Ministry of Urban Development with the participation of a wide range of experts and practitioners, and the support of Water and Sanitation Program-South Asia (of the World Bank). This document echoes the opinions expressed in these workshops. Information provided by the participants touched upon many critical issues. The speakers presented views and experiences from state, national, and international levels. In particular, N. C. Vasuki drew on experiences from Delaware in the United States as well as his extensive knowledge of the issue in the Indian context. Adrian Coad also provided inputs from global experiences on implementing sanitary landfills. Brief information about the workshops, as well as the participants and resource persons, is found in Appendix A.

The focus has been primarily on finding ways to provide safe and sanitary disposal for solid waste so that our environment is no longer damaged by polluting, open dumps. After considering the present situation, available alternatives, obstacles, and challenges, as well as the institutional, financial, and technical aspects, this report proposes some recommendations for an approach that can meet the basic and essential objective of minimizing risks to public health and to the environment. This approach provides a way for solid residues from all towns and cities to be disposed of in an engineered disposal facility at a cost that is affordable.

This publication answers questions such as:

- To what extent are current solid waste management practices in India threatening our health and environment?
- What are the reasons for the current state of affairs?
- What are the strengths and weaknesses of current strategies for disposing solid waste?
- What are the economically and environmentally sustainable options for disposing waste from both large and small communities?

Solid waste management suffers from vagueness in the definitions of many commonly used words, so footnotes and Appendix B explain how certain key words are used in this report.

In India today, there is considerable concern about why the compliance deadlines of the Municipal Solid Waste Rules of 2000 have not been met, more so since major allocations of financial assistance are being made available to fund improvements in waste management.

An unprecedented initiative for providing training in solid waste management is also gathering momentum. It is a time for change, for progress. It is a time for bold yet thoughtful action.

It is sincerely hoped that this report will play a part in the achievement of a safer and healthier environment throughout the nation.

Objectives and Priorities

For decisionmakers working on solid waste management, it is important to go back to first principles, that is, to clarify the objectives that need to be met. Since there is a range of objectives that solid waste management can address, we need to decide how these should be sequenced in terms of priority. The choice of prioritization of objectives influences decisionmaking and thereby has a direct bearing on the outcomes achieved. The following list suggests some stated objectives that often govern decisionmaking in solid waste management,[1] and mentions briefly the consequences of adopting each of them as a primary objective. The reader is invited to consider them carefully.

As the report will go on to show, most of the generally accepted objectives listed below are essentially an outcome of sound integrated municipal waste management. For instance, pursuing the fundamental objective of protecting public health and the environment through sanitary waste disposal does not preclude the other objectives, which should ideally be treated as sub-objectives of the sector.

Safeguarding Public Health

It is not appropriate in this short publication to detail all the harmful impacts on health that can be caused by improper disposal[2] of solid waste. Any review of the public health implications of solid waste management would include the following categories of hazards:

- Inhalation of contaminated dust, toxins, and smoke from burning waste.
- Breeding of vectors that spread disease.
- Pollution of surface and groundwater.
- Injuries from sharp objects.
- Infection from contaminated wastes, especially if they are reused.
- Poisoning and injury by hazardous chemicals.

Any satisfactory method of waste disposal must prevent or dramatically reduce the probability of all these threats. However, safeguarding public health through safe disposal also entails a safe and comprehensive waste collection and transportation system which could be designed in a manner to incorporate some of the other objectives listed below as sub-objectives.

Environmental Protection

Impacts on the environment can be divided into two groups—those related to preventing pollution and those related to conservation. In the context of solid waste management, many of the reasons for striving to prevent pollution are related directly to health impacts, but there are also global considerations—primarily the reduction in the production of greenhouse gases that cause climate change. In addition, there is also the concern to reduce the consumption of raw materials and energy, and also the areas of land used for waste disposal. The focus then is on reuse, treatment, and recycling of waste, often neglecting, or in the absence of, systems for safe disposal. Proper environmental protection therefore includes a safe disposal system and does not preclude the importance of an efficient waste collection and transportation system.

Beautiful Cities

It is desirable to clean cities beyond the standard required for health protection according to considerations of economics and politics. However, this perspective limits the focus to street sweeping and waste collection, rather than treatment or disposal.

Employment Generation

This is another consideration that sometimes influences decisions in solid waste management, but again this generally affects waste collection, not treatment or disposal. Informal sector recycling provides a livelihood for many people, and this fact should be included in decisions regarding waste treatment and disposal.

Meeting Legal Requirements

Many local administrations show little concern for waste disposal for a variety of reasons. In such cases attempts may be made to use legislation as the motivating factor to achieve improvements. Legislation is also used in some industrialized nations to encourage resource recovery.[3] While

[1] Solid waste management is defined as all activities that aim to minimize undesirable impacts of solid wastes and to derive some benefit from these wastes.

[2] Disposal is the last stage of solid waste management. The only satisfactory method of disposal involves placing the remaining residues into an engineered receiving area and minimizing their contact with, and impact on, the external environment. This process is known as sanitary or engineered landfilling.

[3] Resource recovery embraces all means of gaining some economic benefit from waste. This may involve reusing items in the waste in their original form, processing them to make new materials or products, or burning the waste or a product from the waste to gain energy, which may be converted into electrical power.

In solid waste management it is important to first go back to principles, that is, to identify the objectives that need to be met. The choice of objectives has a direct bearing on the outcomes achieved.

complying with legislation may be the objective of a local administrative body, it is important to take one step back and ask (a) what objectives the legislation addresses; and (b) if following legislation requirements leads to the desired outcomes.

Being Modern and Sophisticated

This objective may sometimes be stated explicitly, but more often it appears to be implicitly influencing decisions. The desire to be seen as technologically very advanced may be evidenced by the interest in waste treatment technologies that are still in the experimental stage, or have not been exploited at more than the pilot scale in even the most industrialized of countries. (An alternative reason for advocating sophisticated and unproven technologies may be that simpler technologies have been tried without success, so that, in desperation, decisionmakers grasp at any other option. They fail to realize that if local managements have not been able to operate a well-tried technology successfully, they are very unlikely to enjoy success with a more complex and less understood process.) Persuasive salesmen and seemingly attractive contract conditions may influence some administrations to opt for highly sophisticated technologies. In some circles, the word 'integrated' has great significance.[4] Various modern connotations are associated with this word. Some people use it to insist on intensive resource recovery. However, the concept of an integrated solid waste management system, in which the requirements and impacts of each link in the chain from generation to disposal[5] should be considered in the design of all the other stages, is of great significance, and is not new. *An important consequence of the integrated approach is that the disposal stage should always be considered a vital part of every waste management system.*

Satisfying Voters

In one sense, it is the essence of democracy to provide the voters with what they want. However, the democratic process generally results in short-term horizons, and politicians are generally reluctant to impose fees or taxes that will lead to sustainable systems; they see little benefit in acquiring land that will provide a good means of waste disposal for decades rather than years.

Unless it is carefully done, acquiring land for waste disposal generates opposition rather than votes, and so politicians may be unwilling to take action that will ensure good solutions for the disposal of waste. The best waste disposal solutions may involve accepting waste from other local administrations, and this can lead to additional voter displeasure. Votes can often be won by a good waste collection service, but very rarely by a sound waste disposal system. Good solid waste management requires leadership, vision, a consideration of the longer term, and of ensuing benefits that voters might not understand.

Earning Money from Waste

Over the last two decades there has been considerable interest in the idea of generating profit from waste. And while it is true that it is possible to sell compost and electric power, the costs of producing these commodities from waste are usually significantly more than the prevailing market prices.

Usable energy can be obtained from waste, but these processes require subsidies even in countries where the waste has high energy content. In many industrialized countries, legislation and taxes imposed on disposal are needed to motivate local administrations to bear the additional costs of treatment processes that seek to gain some value from waste.

Experience across the world suggests that the bulk of the revenues generated in the sector arise from fees paid by waste generators, not the financial value of the waste itself.

In some situations, small-scale composting generates sufficient income to support a family, especially where there is a dependable income from sales to plantations, commercial complexes or households owning exotic plants.

Any satisfactory waste management system must be paid for. Nevertheless, in the minds of politicians and decisionmakers, the attractiveness of the concept often outweighs the experience and ground realities, and large sums continue to be invested in the expectation of turning waste into wealth.

[4] For more information on this approach, see the report of the CWG workshop, *Planning for sustainable and integrated solid waste management*, which can be found on the Skat website at www.skat.ch/publications/

[5] The chain of solid waste management operations can, in broad terms, be taken to include the following stages: generation, storage, collection, treatment (or processing), and disposal.

Where are We Now?

It is necessary to know where we are before we can plan the route to the place where we wish to be.

Box 1 provides a general overview of the situation in India.[6] This overview suggests that while efforts are being made to improve collection and transportation, the situation with regard to treatment and disposal of solid waste in India is still very unsatisfactory with much remaining to be done.

The Municipal Solid Waste (MSW) Rules and Their Impact

Following from a private petition brought to the Supreme Court, a group of solid waste management specialists drafted the Municipal Solid Waste (Management and Handling) Rules 2000 that define the standards that were to be achieved by the end of 2003 (see Box 2).

"Compliance [with MSW Rules] has been poor to moderate in respect of storage, collection, sweeping, and transportation of waste. Compliance has been extremely poor in the area of treatment and disposal of waste."
(P. U. Asnani)

Figure 1 presents the findings from a survey in 2004, on the degree to which Class 1 cities had complied with the requirements of the Rules. It is of particular note that the compliance for processing[7] of wastes and landfilling are very low indeed. The figure for sanitary landfilling causes special concern because of the associated health and environment impacts. It is to be expected that processing incorporates more challenges and difficulties because of the machinery and process control requirements, and because of the need to find markets or outlets for the product, yet we find that the amount of waste that is landfilled is even lower than the amount that is processed.

Box 1. The Present Scenario in India

- Streets are generally treated as the receptacles of waste. Consequently, unsanitary conditions affect overall health and environment.
- There is partial segregation of recyclable waste. Waste paper, plastic, metal, glass, rubber, rags, and so on are thrown on the streets along with domestic, trade, and institutional wastes.
- Transportation is not well coordinated with primary collection, resulting in multiple and manual handling of waste. This is injurious to the health of workers.
- Transportation systems are characterized by poorly maintained equipment that is inefficiently operated.
- Waste is disposed of on the roadside or open spaces within or just outside the city boundaries. The method of crude dumping[8] is adopted for waste disposal. Waste is not spread, compacted or covered.

Source: Based on a presentation by P. U. Asnani.

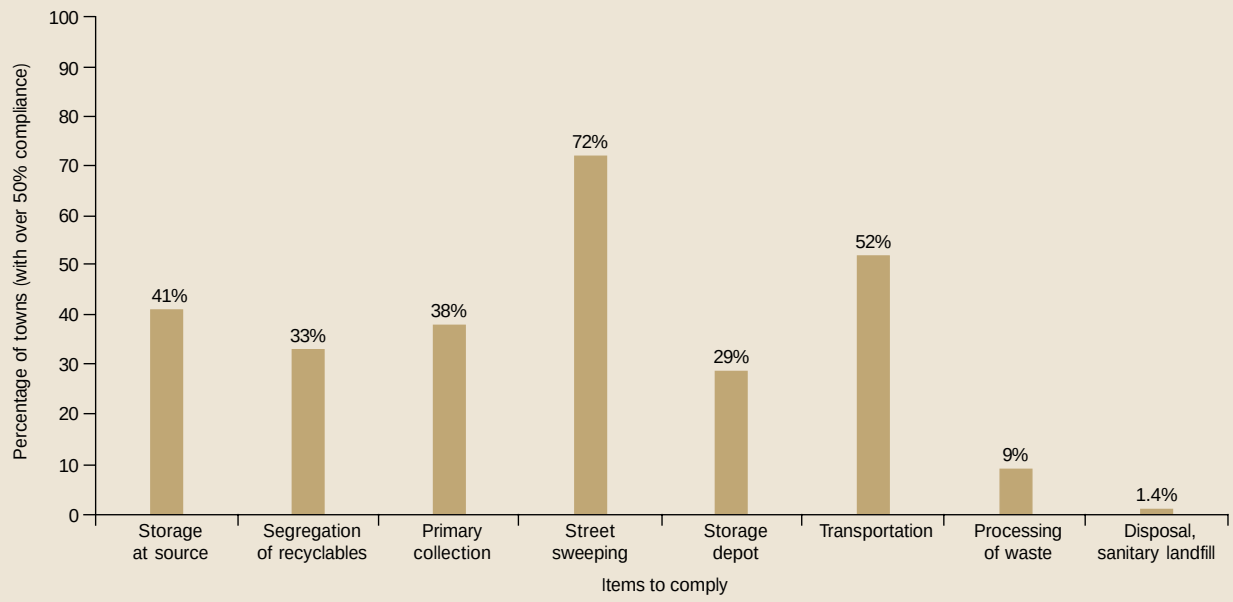
Box 2. Mandatory Directions under Municipal Solid Waste (Management and Handling) Rules 2000

- Storage of waste at source.
- Segregation of waste at source.
- Primary collection from the doorstep and abolition of open waste storage sites.
- Daily street sweeping.
- Transportation of waste in covered vehicles.
- Processing of waste by composting or for power generation.
- Disposal of nonbiodegradables only, at the sanitary landfill sites.

[6] Information about presenters and resource persons is provided in Appendix A.
[7] Processing and treatment are considered to have the same meaning in this report.
[8] Dumping: Crude or open dumping refers to the unloading of waste without taking care to minimize pollution, utilize the land area well, or restore the site when disposal operations cease. In such situations waste is often burnt, causing serious air pollution. The word 'landfilling' should not be used to describe such operations.

While efforts are being made to improve collection and transportation, the situation with regard to treatment and disposal of solid waste in India is still very unsatisfactory with much remaining to be done.

Figure 1. Indication of Compliance with Municipal Solid Waste Rules 2000 for Class 1 Cities



Source: Data compiled by P. U. Asnani, 2004.

The MSW Rules allow for only inert waste to be disposed of to landfills. A particular consequence of this requirement is that cities that do not have an operational processing facility for all their mixed waste feel prohibited from landfilling their waste (since it contains biodegradable waste) and so the waste of the city continues to be dumped in an unsatisfactory way, even if a landfill is available. It is clearly preferable to process biodegradable waste in a satisfactory way rather than to landfill it, but it is also clearly preferable to landfill biodegradable waste rather than to dump it.

Further, since landfills may be designed to accept only the proportion of waste that cannot be processed or recycled, it is argued that they are too small to receive all of the waste generated on a routine basis.

Recent attempts to analyze the issue include examining the reasons for the negligible compliance with the requirements for processing and landfilling, and to suggest remedies for this situation.

What has Been Happening to Our Processing Plants?

Over the last 15 years many treatment projects have been set up in the country—the majority of these are based on aerobic composting processes. The experience till now has, however, been discouraging. Most of the plants have shut down; the ones that are operational are malfunctioning or operating well below capacity. Not much investigation has been done on the reasons for this poor track record of treatment plants. However, in a recent study undertaken at the behest of Water and Sanitation Program-South Asia (WSP-SA), based on detailed assessments of some such projects, an effort was made to diagnose the reasons for failure as also recommendations for future projects. More information on this study is provided below.

Apart from aerobic composting, other treatment options include vermicomposting—a modification of the composting process—that uses earthworms to process waste into a valuable compost product. Incineration is another process that has a long history in the treatment of municipal solid wastes. Very large incinerators in industrialized countries are able to

generate electricity using the heat derived from burning. Experience in India with this technology has been generally unfavorable. High moisture content and inert fractions, as well as the diversion for recycling of dry materials, such as paper and plastic, combine to make incineration an undesirable option for treatment of municipal wastes.

Refuse-derived fuel (RDF) is another technology that has been used for energy recovery; the waste is processed so that it can be used as a fuel for generating electricity or steam. For over a decade, cities in India have been considering biomethanation (anaerobic digestion) as a means of producing methane gas that can fuel electricity generators.

All of these options have been tried in India. Unfortunately, very little effort has been made to catalog these experiences for use in future decisionmaking. The WSP-SA study was undertaken in an effort to reduce this knowledge gap.

The study of experiences with waste treatment plants was undertaken by Asit Nema at the behest of WSP-SA (see Box 3). As part of this study, a review of waste treatment projects implemented in India over the last 10-15 years was undertaken and lessons drawn from the same. A summary of the findings of this study is provided in Box 3.

"Japanese research has shown that the largest generators of dioxins (a family of toxic chemicals) in the world are burning dumps (not landfills) in India and China." *(N. C. Vasuki)*

This biomethanation plant, costing over Rs 70 crore (approx US$17 million)[9], is no longer operating. Wastes are being dumped on land adjacent to it because there is no sanitary landfill.

"Even with the best efforts to improve collection and transportation, public health is *not* safeguarded until urban local bodies provide for safe and sanitary disposal." *(Vandana Bhatnagar)*

The findings of this study clearly indicate that, till now, failure rather than success appears to be the norm in waste treatment projects. Some of the problems encountered (for example, siting, finance, and contract management) can be overcome with enhanced capacity, improved procedures, and expectations. However, problems associated with development and adoption of appropriate technologies and lack of experienced operators will take time to overcome. The MSW Rules need to be interpreted in a way that recognizes these ground realities and allows time for appropriate processes and mechanisms to be developed.

There is the risk that large sums of money will be wasted if the mistakes of the past are repeated. There is also the risk that financial support for waste treatment will not be available in the future if current investments prove fruitless. Already one agency that has been lending for biomethanation schemes has indicated that it is no longer keen on considering further loans for such plants, and one private agency that was involved in solid waste composting for many years has withdrawn from this activity. Repeating unsuccessful experiences can be very costly. We need to learn from past experiences, and be willing to admit that mistakes have been made. We also need to face the fact that income

[9] US$1 = INR 40.69 (as of September 7, 2007). Conversion rates are from www.xe.com; all conversions in the text are approximations.

Box 3. Operating Experience of Processing Facilities

In 2000, a total of 88 medium- and large-scale plants were being planned or were in existence.[10] More than 50 were composting plants with a total processing capacity of around 15,000 tons per day. There were four to five large-scale vermicomposting plants. Twelve biomethanation plants had been planned but only two had been implemented. There was one large mass burn incinerator for energy recovery, but this was not being used. Of the five refuse-derived fuel (RDF) plants that had been constructed, only two were in operation. The status of these plants six years later was found to be that 30 percent were in operation, 20 percent of them had been closed down, and 50 percent of those that were planned had not, in fact, been constructed. As part of the study, detailed analyses (including field visits) were done for nine treatment and disposal facilities that included composting, biomethanation, and RDF plants located across the country.[11] Field visits were undertaken as part of the study during the period October 2005 to February 2006. Some were still operating, though mostly not at full capacity, but others had been closed before the end of their intended lifetime and some had actually been dismantled and removed. The lessons learned from these nine cases were summarized as follows:

- Protection of the environment and public health was not being addressed since untreated waste and residues were still being dumped in an unsatisfactory way.
- Rapid wear and tear of equipment led to high maintenance costs.
- Seasonal and climatic factors (such as the seasonal demand for compost and the low demand for waste heat in hot climates) reduced the financial viability of some processes.
- The inability or unwillingness of urban local bodies to contribute to the costs of the processing, coupled with an overestimation of the revenue streams (from the sale of compost and energy), led to financial problems.
- The lack of operator control on the quality and quantity of the feedstock (the incoming waste) caused operational shortfalls.
- Inadequate allowance was made for the sensitivity of biological and microbiological processes. This is particularly significant for vermicomposting and in the anaerobic processes used in biomethanation, in which changes in temperature and feedstock can disrupt bacterial action.
- Large-scale plants were generally less reliable than small-scale operations, but the overall impact of small-scale operations on quantities requiring disposal was minimal.
- Odor emissions led to plant closures.
- Deficiencies in transparency and in public consultation during project development led to subsequent public opposition.
- Inadequate contract management (in terms of operational and financial control) was blamed for some difficulties.
- The importance of site-specific factors (such as location and markets) was not given sufficient attention.

Among the cases studied, one concerned a sanitary landfill facility that had been constructed but had not been used, and was deteriorating. The incoming waste was not being placed in the landfill because there was no effective treatment system for the waste, and the Municipal Solid Waste Rules were interpreted to mean that the mixed waste (that is, including biodegradable waste) should not be disposed of in this facility. Instead, the waste was being dumped in a very unsatisfactory way on unprepared ground adjacent to the facility. The result was continuing environmental pollution coupled with the wastage of a significant investment.

Additional information on the Hyderabad RDF plant (from a CPCB presentation): Located in Gandamguda village on 10 acres of land, the plant has been working since December 1999. The plant's processing capacity is 500 tpd (tons per day) of municipal solid waste in three shifts. Currently operating in only one shift, it was producing only 30 tpd of RDF.

Source: Based on a presentation by Asit Nema.

[10] Devi, Kirti, and S. Satyanarayana. May 2001. Financial Resources and Private Sector Participation in Solid Waste Management in India. TCGI and Padco, Indo-US Financial Institutions Reform and Expansion (FIRE) Project. USAID.
[11] Thane, Trivandrum, Hyderabad, Bangalore, Surat, Lucknow, Mumbai, Vijaywada, and Suryapet.

from the sale of compost or energy is unlikely to be sufficient to cover even the operating costs of the processes—we must expect to have to pay for treatment processes.

"Resource recovery has not ensured the achievement of the primary objectives of protecting the environment and public health. Landfills are essential for backstopping." *(Asit Nema)*

The results of this study make for hard reading. However, we need to know the truth about difficulties that have been faced so that decisions and strategies can be based on realities rather than misplaced assumptions. There is an urgent need for more studies of this kind and for their widespread distribution among decisionmakers and engineers within India.

Given the funds being allocated under the Twelfth Finance Commission and Jawaharlal Nehru National Urban Renewal Mission, it becomes even more critical to internalize lessons from past experience and invest in projects that are sustainable in the long term.

Obstacles to Safe and Sanitary Disposal

Even when there are effective and reliable systems that are processing all the treatable or recyclable fraction of the waste (and this is unlikely to be achieved in India in the short term), there will still be a need for sanitary landfills to dispose of rejects, residues (from treatment processes), and nonbiodegradable material. Therefore, whatever the treatment system, a sanitary landfill is an integral component of a scientific waste management

The sanitary landfilling facility (top) is not in use because there is no treatment plant to process the waste and the use of the site has been prevented on the grounds that the waste contains biodegradable material. As a result the waste is being dumped in an unsanitary way, as shown above, and the landfill facility appears to be deteriorating through neglect.

There is a processing plant, but this is not safe and sanitary waste management.

system in order that the primary objectives of safeguarding public health and the environment be achieved. Sanitary landfills also offer opportunities for resource recovery, for instance, methane gas can be collected from landfills and used to generate electricity.

In some cases decomposed waste can be excavated and screened, and then sold as soil conditioner, as has been done in Mumbai.

In spite of the essential role of sanitary landfills in modern, integrated solid waste management, India has very few operational landfills that meet the necessary criteria for environmental protection. The following points suggest three basic reasons for this gap.

- *Technical capacity.* India clearly has some engineers who are very knowledgeable regarding the design of landfill sites, but there are too few to meet the immediate needs of even the Class 1 cities.

  There also appears to be a shortage in the numbers of indigenous contractors with the specialist skills needed to construct landfill sites. Perhaps the greatest lack is in the operational skills and experience needed to operate a sanitary landfill. It is likely that most officials who are responsible for waste management in Class 1 cities have never even seen an engineered sanitary landfill being operated. These gaps must be filled.

"Guidelines for closure of old waste dumps and for expansion of existing sites are needed." *(Manoj Datta)*

- *Cost.* The general perception is that landfills require a substantial

investment with no scope for revenue generation (unlike treatment plants that offer some potential for generating incomes).

In addition, a tipping fee is also required to be paid for landfilling on an ongoing basis. The costs tend to be particularly intimidating for smaller municipalities given their limited finances and the absence of scale economies in landfills of these sizes.

- *Where to do it.* Finding a site for a sanitary landfill is rarely an easy matter. There are various criteria that need to be met, not least the acceptance of the neighboring communities.

  The practice of open dumping and its associated hazards has only served to strengthen the 'not in my back yard' (NIMBY) sentiment vis-à-vis landfills that commonly tend to be mistaken for open dumps.

  Large areas are required (preferably much larger than many that have been acquired so far) for reasons given in Box 4.

  The benefits of identifying sites that can serve a cluster of towns and cities will be discussed later in this publication.

"Governance and land are the two most critical issues while developing landfills." *(Raghu Rama Swamy)*

Box 4. The Size of a Landfill Site

Some sites that have been acquired appear to be much too small, the area requirement being based on the assumption that only a small fraction of the waste will need to be landfilled (after all the waste has been processed and only inert material that has no recycling potential is left), and that a lifetime of 10 years or less is sufficient. Sites for landfills should be much larger for the following reasons:

- Landfill sites will be needed for the foreseeable future, so it is wise to acquire a site that will last for at least 20-25 years, especially since the cost of acquiring the land is low compared to the total costs of the site. If a new disposal technology replaces landfilling during this period, the site can be handed over to other purposes.
- The facility can be constructed incrementally. Since construction is usually the major cost (see Table 1) new cells can be constructed as they are needed. It is cost-effective to concentrate landfilling operations on one large site rather than using many small sites, as will be discussed later.
- Not all of the site area can be used for landfilling. Space is needed for a buffer zone around the site (to hide operations and prevent nuisance to, and opposition from, neighbors), for roads, parking, and administration, for storing cover material, and for leachate storage or treatment.
- It cannot be assumed that only nonbiodegradable waste will be needed to be landfilled throughout the lifetime of the site, even though this is desirable and required by law. Treatment plants are shut down temporarily for many reasons, or there may be other disruptions in operation. Delays in the implementation of treatment plants should not cause delays in implementing safe and sanitary disposal. Landfills are robust and able to accept large changes in the quantities and characteristics of the incoming waste. This flexibility and robustness should not be constrained by inadequate facility sizes or other flawed assumptions.
- As will be discussed later, there are advantages to a regional approach to landfilling, in which waste from a number of neighboring towns and cities is disposed of in one landfill. Allowance should be made for the receiving of waste from additional communities.
- Rapid economic growth leads to increases in waste quantities and changes in waste composition. These changes cannot be accurately predicted, so allowance for them must be made beforehand.

Table 1. Cost Components of Sanitary Landfilling (South Regional Landfill, Delaware, USA)

From 1984-2006, nearly 3.5 million tons of waste were landfilled at this site. The remaining life of the site is more than 20 years.

Item or activity	Percentage of total cost
Acquisition of land	1.7
Design and supervision of construction	7.8
Construction of the four cells that have been developed till now	77.0
Landfill gas collection and management system	4.1
Capping to close off completed sections of the site	9.8
Total	100.0

Source: From a presentation by N. C. Vasuki.

- *Misapplication of MSW Rules.* The Rules that have been established to govern solid waste management in India are intended to improve public health and the environment, so they should not be used to prevent environmental improvements, as has happened in places where landfills are unused because treatment facilities are not available to process all of the waste.

  Continuation of open dumping on this basis is against the spirit and objectives of the MSW Rules. Other sanctions should be used to oblige urban local bodies to set up treatment systems for their waste.

Sanitary Landfilling

Key Principles

"Each landfill has a site-specific design. Detailed engineering is important." *(Manoj Datta)*

The scope of this document does not permit a detailed discussion of the design features and techniques of sanitary landfilling. Nevertheless, the basic objectives of sanitary landfilling can be summarized as:

- Averting water pollution.
- Preventing the air pollution that results from burning.
- Minimizing any nuisance to surrounding communities (from explosive gases, odor, dust, windblown litter, appearance, noise, birds, and insects).
- Reducing hazards and nuisance to people working on the site.
- Using the land in an economical way and operating vehicles and machines in an efficient way.

In addition to these basic objectives, and especially for larger landfills, are added the objectives of minimizing the escape of methane (which is a greenhouse gas that causes global warming), and of using the gas to provide heat, generate electricity or even serve as fuel for vehicles. Some of these objectives are discussed in more detail in Box 5.

Emphasis on Operations

"Costs associated with disposal facilities are significantly *backended*—costs are incurred throughout the active life of the site and after the flow of incoming waste ceases." *(Raghu Rama Swamy)*

This landfill cell has been lined with an impermeable plastic liner so that underground water will not be polluted when solid wastes are placed in the cell.

Box 5. Brief Notes on Key Features of Sanitary Landfilling

Water pollution. A major reason for investing in sanitary landfilling is to prevent the pollution of water resources. Pollution from landfills cannot be reversed by standard potable water treatment technologies, and effects may persist in underground aquifers for a century or more. Landfills, therefore, are either sited in areas where the natural geology provides protection against water pollution, or are constructed in such a way that polluted water that has been in contact with the waste is prevented from contaminating the outside environment. Ideally both means of protection are used together. In all cases, the polluted water should be collected and treated so that it can be released into the environment without causing harm.

Air pollution. Many people associate burning dumps with waste disposal. Smoke from burning dumps is a serious health hazard. However, a sanitary landfill should be operated in such a way that there are never any fires on the site. Fires in waste can burn for months, fuelled by methane gas generated by decomposition as well as by the burning of the waste itself.

Method of laying the waste. Waste should be laid down in dense and uniform layers and covered to reduce nuisance and minimize difficulties experienced by vehicles operating on the site.

Economical use of the site. By placing the waste in dense, uniform layers, and working to a design for the final profile, it is possible to build a hill of waste of considerable height (30 meters or more). In this way a large volume of waste can be placed in a given area.

Sanitary landfilling is more about an activity, not merely a facility. The environment and public health are not protected by a sanitary landfill, but by sanitary landfilling.

Part of a sanitary landfill in the United States of America.

When the waste reaches a predetermined height, it is covered and planted with vegetation. The vegetation stabilizes the soil and gives the completed landfill a pleasant appearance.

Box 6. Some Effects of Bad Operation of a Sanitary Landfill

Polluted water derived from the waste itself or from incoming rainwater that has been in contact with the waste is called leachate. This leachate is much more polluting than domestic wastewater. It should be collected and recirculated, evaporated or treated. If untreated leachate is allowed to escape from a sanitary landfill it has the capacity to seriously contaminate the surrounding environment. Fires at a badly managed disposal site that was designed as a sanitary landfill can be more intensive, since the greater depth of waste may provide a greater reservoir of methane to fuel the fire, and make any attempt to extinguish the fire more difficult. If the waste is not placed according to the correct operating principles, the nuisance to neighboring communities of a badly managed landfill facility can be the same as for an open dump. The same can be said for difficulties in driving on the waste.

Designing and constructing a sanitary landfill is not enough. The facility must be operated as a sanitary landfill.

Sanitary landfilling is more about an activity, not merely a facility. The environment and public health are not protected by a sanitary landfill, but by sanitary landfilling. The objective is to dispose of waste in a safe and sanitary way, not just to have a site where this activity might be performed. Unfortunately it is very common for almost all the attention to be focused on the design of a site, with very little thought being given to how the site will be used. There are many cases in which investments in sanitary landfill facilities have been wasted by ignoring the requirements of the operations phase. Box 6 suggests some ways in which a well constructed sanitary landfill facility can quickly become as, or even more, polluting as an open dump if operations are not managed in a satisfactory way.

The Regional Approach

What is a 'Regional Approach'?

As per the conventional approach to waste treatment and disposal, each town or city was expected to make its own arrangements for these functions, independent of other urban areas. In contrast, the regional approach entails several autonomous urban administrations joining together to use one facility. One sanitary landfill may serve two, three or even 20 cities and towns. Box 7 looks at some institutional aspects of the regional approach.

Why is a Regional Approach Appropriate?

"NIMBY—not in my back yard—signifies local opposition to any waste management facility. In Kerala it is proposed to reduce the NIMBY syndrome from 1,057 local bodies to just six associated with the regional facilities." *(Dr Kurian Baby and P. U. Asnani)*

There are two strong arguments in favor of regional or inter-municipal associations for disposal of solid waste—one is an issue of cost and the other concerns expertise. Table 2 illustrates the cost savings resulting from a regional approach.

"Several variables affect cost of landfilling but size is one of the most important." *(Vandana Bhatnagar)*

Economies of scale. Since they are receiving waste from a number of communities, regional landfills are larger than the facilities that would be set up by individual urban local bodies (ULBs). There are clear economies of scale[12] for sanitary landfills (as discussed in Box 8 and illustrated in Table 3), allowing ULBs to save money on waste disposal by partnering together.

"Though larger in size, regional facilities use land more efficiently." *(Vandana Bhatnagar)*

Improved expertise. Expertise is needed in setting up sanitary landfills, in operating them, and in monitoring.

Since the number of experts in these fields is limited, better standards can be achieved if the number of facilities is limited.

[12] An economy of scale is demonstrated when the unit cost (such as the cost of disposal of 1 ton of waste) is less for a larger operation than for an equivalent but smaller operation.

Box 7. Institutional Aspects of a Regional Approach

A regional facility entails some kind of an *institutional arrangement that enables the coming together of the partnering municipalities*.

Attributes of the regional approach:

- It is constituted specifically to provide a particular service (namely, solid waste processing and disposal).
- It is governed by a board of directors, a council or some similar executive oversight body, unique to the organization.
- It is usually not dependent on taxes for funding, but raises funds through service charges (or tipping fees) paid by its customers—the partnering local bodies.
- It may or may not involve the participation of a private sector service provider.
- It often requires special legislation and ordinances for its establishment.

Source: From a presentation by Vandana Bhatnagar.

Table 2. Advantages of Regional Landfills: Estimates for Kerala

Factor	Individual landfills	Regional landfills	Conclusions
Total land area required (hectare)	2,316	957	Less than 42% is required
Land cost (cost per hectare)	0.40	0.18	Savings: Rs 754 crore (approx US$186 million)
Operations cost (cost per ton)	555	388	Annual savings: Rs 13 crore (approx US$3 million)

Source: From presentations by Dr Kurian Baby and P. U. Asnani.

The regional approach entails several autonomous urban administrations joining together to use one facility. One sanitary landfill may serve two, three or even 20 cities and towns.

Box 8. Reasons for Economies of Scale in Sanitary Landfilling

The cost of landfilling 1 ton of solid waste in a large landfill can be expected to be less than the cost of achieving the same results in a small landfill for the following reasons:

- *Larger sites are cheaper to construct per square meter* than several smaller sites with the same total area because the necessary infrastructure that must be provided on all sites (weighbridge, site roads, among other things) can be used more intensively on a larger site. Moreover, since the ratio of perimeter to area is lower for a large site, the proportional spending on perimeter fencing and buffer zones is less for a large site.
- For a given side slope (determined by considerations of slope stability, aesthetics, and ease of construction) a greater height can be reached if the dimensions of the base area are greater. This *allows more waste to be placed on each square meter* in the parts of larger landfill sites where the depth is greater.
- *Equipment (such as bulldozers and other specialized machinery) can be used more intensively* on a large site, and the greater workload allows specialized machines to be employed on larger sites.

  The use of specialized machines allows greater efficiency. For example, a small site might be operated by a small tracked vehicle with a combination bucket that allows it to bulldoze waste and spread cover soil, but it does not compact the waste very significantly and may move slowly.

  A large site might have a landfill compactor that compacts the waste to a higher density, a bulldozer for earthmoving, and a wheeled loader that can load and distribute cover material very efficiently.

Table 3. Illustrations of Economies of Scale Using Data from India

a) Estimates of cost of treatment and landfilling

				Cost of waste processing and disposal (Rs)	
City (Revenue division)	Town classification	Population in 2001	Waste tons/day	Per ton	Per capita/year
Aurangabad	Corporation	1,000,000	300	191.73	24.76
Latur (Aurangabad)	Class 1	299,828	120	289.71	49.90
Wardha (Nagpur)	Class 1	111,070	40	320.80	62.15
Yavatmal (Amravati)	Class 1	120,763	25	562.72	50.14
Hingoli (Hingoli)	B Class	69,552	15	617.19	57.29
Talode (Nandurabar)	C Class	25,034	5	1,154.71	99.26

Source: Action Plan for Implementation of MSW Rules 2000 in Maharashtra. December 2004. AIILSG.

b) Actual landfill construction costs

The first four results below show that the cost per m^2 drops markedly with size, but the last two points show no trend. There are many factors that affect construction costs.

City	Area (m^2)	Total cost (US$ million)*	Cost/m^2 (US$)
Ichalkaranji	8,070	0.15	17.96
Pune LF1	12,400	0.22	17.35
Solapur	19,600	0.32	15.80
Pimpri Chinchwad	22,800	0.29	12.28
Chandigarh	33,508	0.58	16.93
Pune LF2	45,000	0.78	16.95

Source: From a presentation by A. N. Purandare.

c) Examples of investment costs

Location	Incoming waste (tpd)	Total investment (US$ million)	Investment/input (US$/tpd)	Proportion spent on infrastructure and equipment
Coimbatore	550	4.72	8,600	15%
Solapur	350	1.99	5,600	32%
Ujjain	150	1.16	7,600	44%
Madgaon	40	0.69	17,200	70%

These data are based on small samples, but illustrate trends that have a theoretical basis. As a rule of thumb, Bhatnagar suggested that sanitary landfills require a contributing population of 800,000 to one million people for economical operation. Less than half of India's urban population lives in communities of this size. More than 98 percent of the urban communities are smaller. Hence there is a clear need for urban local bodies to join together.

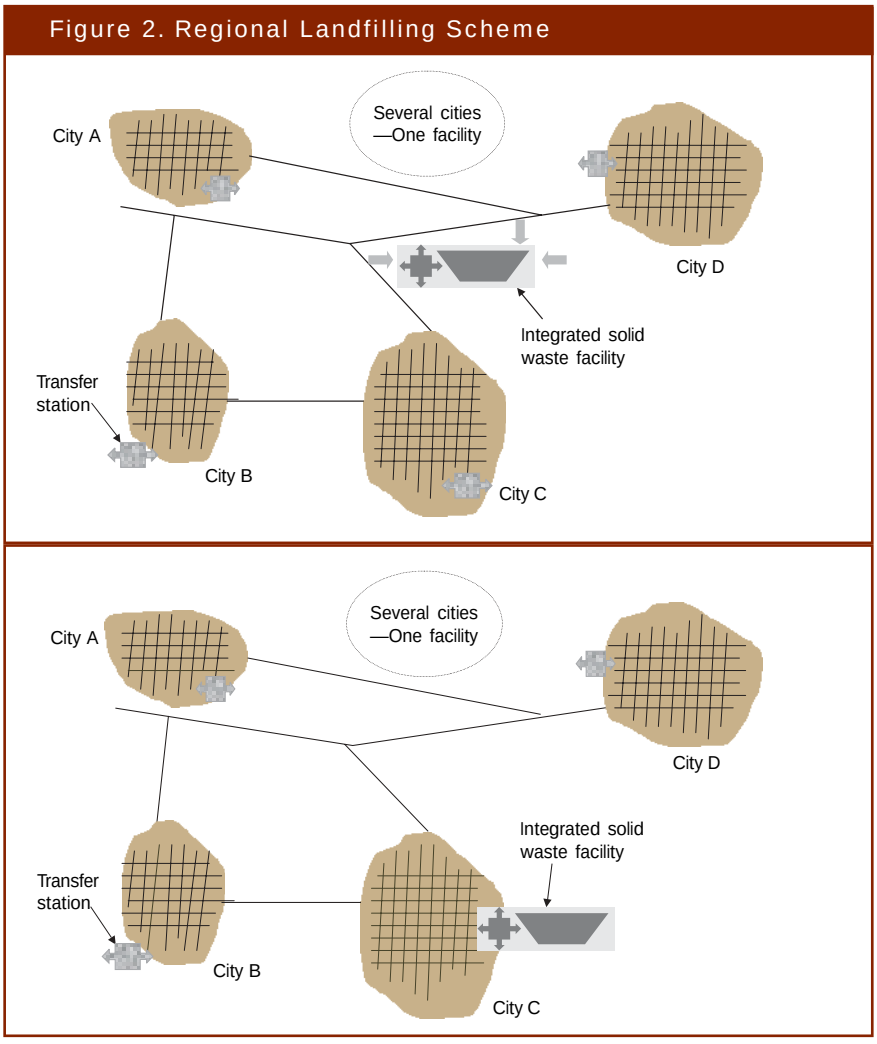
Source: From a presentation by A. N. Purandare.

* US$1 = INR 40.69 (as of September 7, 2007). Conversion rates are from www.xe.com; all conversions in the text are approximations.

Box 9 illustrates the reductions in disposal site numbers that have been achieved in the United States by adopting regional facilities. Smaller number of sites also allow for better quality of monitoring and enforcement.

There is no upper limit on the desirable lifetime of a sanitary landfill. The site can be constructed incrementally. For example, in a site that may be large enough for 40 years' operation, a cell that is sufficient for only five years can be constructed. Experience gained from operating that cell can be used to improve the design and operating efficiency of the next cell, and so on. A large site benefits from economies of scale and allows the establishment of a

Figure 2. Regional Landfilling Scheme



Solid wastes from all these towns and villages are disposed of at the regional sanitary landfill.

Box 9. Experience of Reducing Sites in the United States

In 1978, the United States Environmental Protection Agency's national open dump survey showed more than 8,500 dumps in the United States, each usually serving only one town or city. This was when the Environmental Protection Agency ordered the closure of open dumps. By 2002, the number of disposal sites had dropped to 1,767. Now 200 of the nation's sanitary landfills receive 75 percent of the nation's solid waste, and the biggest 250 sanitary landfills are large enough to take all the waste of the United States.

Source: From a presentation by N. C. Vasuki.

wide buffer zone (provided that there are strict measures to prevent encroachment) so that complaints from neighbors are reduced. It is important to demonstrate that sanitary landfills give much less reason for protest than open dumps. They have lower nuisance value (appearance, odor, dust); have lesser health and environmental impact; are typically accompanied by organized recycling and treatment facilities within the same site; and allow reuse of the land once a landfill cell has been capped. When calculating the minimum life of the site, it should be assumed that all waste, inert and biodegradable, will be landfilled, because experience shows that it is not possible to guarantee that waste treatment technologies will be reliable, especially in the short term. Such an assumption does not necessarily imply wasteful allocation of land, since even if high levels of recycling or treatment are attained in due course, it will automatically extend the life of the landfill. Alternatively, additional recycling and treatment facilities may be subsequently installed within the landfill premises. Nevertheless, on a precautionary basis, enough land should be acquired upfront so that at least 20-30 years' operation is assured for waste generated (with little or no adjustment for recycling and treatment).

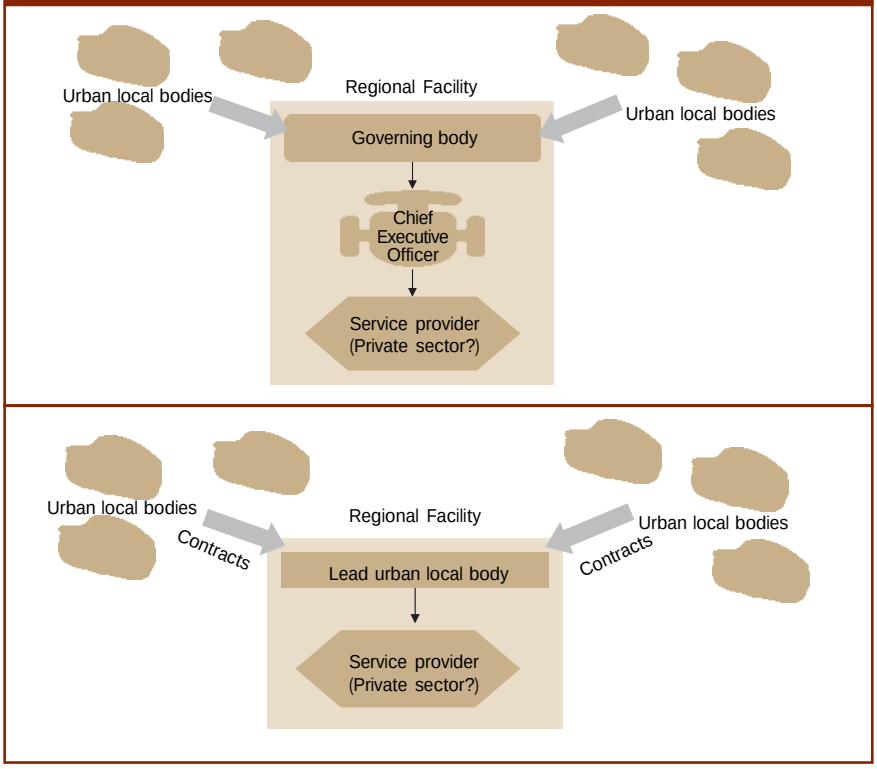
Challenges Associated with Regional Landfilling

"The primary concern of urban local bodies is likely to be that sharing would lead to landfill life being exhausted quickly." *(Raghu Rama Swamy)*

Various challenges may arise in setting up a regional disposal scheme.

- *Loss of political control.* Solid waste management may be one of the main items on an urban local body budget, and the leaders of the ULB may not wish to pass control of this item to others. In most cases only a part of the solid waste service will be managed by the regional association so the ULB will retain control of perhaps the major part of solid waste management expenditure, that is, collection, transportation, and maybe even treatment. After the formation of a regional grouping, many of the decisions affecting solid waste management will no longer be made by the heads of the individual ULBs, but instead by the regional bodies. This loss of authority may be a source of irritation to political leaders who enjoy the exercise of power. Additionally, ULBs in which regional landfills are located may be reluctant to surrender their authority for the parcel of land given over to waste disposal. The degree of control that they retain for this site must be clearly defined in the agreement or constitution that governs the regional association.
- *Loss of management control.* If the formation of the regional association requires ULBs to hand over land, vehicles, equipment, and staff, this loss of management control may cause problems. For example, a ULB may no longer be able to instruct a truck driver to work in a certain place or do additional work, if that driver has been transferred to the regional body. Disciplinary action in connection with transferred staff should now be taken through the regional association. There is also an issue of financial management. The autonomous ULBs within an association are all expected to pay their shares of the costs, and proper mechanisms are needed to deal with ULBs that do not pay, or delay paying, their fees. Management procedures become more complicated, but ways can be found to overcome these challenges. It is advisable to face them in the initial stages when the rules of association or the constitution are being developed.
- *Initial negotiations.* It will be necessary to invest considerable time and effort on discussing and negotiating the institutional arrangements for a new regional association. It is important to achieve full agreement on modalities, responsibilities, and risks before operations begin. A particular issue is whether all participating ULBs have the same status or whether one is designated as the leading ULB.
- *Reluctance of host community* to receive waste from another community. Often, a community that is prepared to dispose of its own waste at a particular site objects strongly to the waste of other communities being disposed there. The agreement of the host community may be obtained by the payment of additional money by the other communities involved, by the provision of improved facilities or services, or by the promise of employment. Landfill sites should be designed in a way that is sensitive to the concerns of the neighbors—designers should put themselves in the shoes of those living near the site. Local residents should be involved in the monitoring of the operation of the site.
- *Additional expense.* When switching from dumping at a nearby open dump to disposal at a regional landfill, extra expenditure can be anticipated. Small and slow vehicles that are not suited to transporting waste over longer distances must be replaced or supplemented by larger vehicles, often with the introduction of transfer stations. These additional costs are usually offset by the economies harnessed in regional landfilling. In many cases it is the change from dumping to landfilling that entails the additional expense, rather than the change from a municipal landfill to a regional one. Perhaps the motivation to improve waste disposal must come from enforcement of the law, that is, ban on open dumping. When that motivation is present, regional landfilling will generally be seen as an attractive option.
- *Uncertainty about the future.* The lifetime of a sanitary landfill should be more than 20 years whenever possible. So the question would be: How permanent are the institutional arrangements that hold the participating communities together in a regional association? As political and administrative leaders and policies change, will one of the participating ULBs be left with the responsibility for the site, or perhaps for paying a contractor after the other ULBs withdraw? Because

Figure 3. Generic Institutional Models for Regional Facilities



Box 10. International Examples of Regional or Intermunicipal Arrangements

Delaware, United States: A publicly-owned but independent utility was established to manage secondary transport and disposal services for Delaware state. The services are provided by the private sector. Several landfill sites are used to cover the whole state. ***England:*** Counties (usually incorporating at least one city, several towns, and numerous rural districts) are responsible for arranging and monitoring waste disposal, and invite bids from private companies for waste disposal services. Several communities may use one landfill and several landfill sites may be used by each of the larger counties. Waste from one county may be landfilled in a neighboring county. ***Chile:*** In the area of the capital (Santiago), 16 municipalities joined to form an informal association for the purposes of waste disposal, and engaged a private company to construct and operate one sanitary landfill. All the municipalities signed the concession agreement. ***Gaza:*** Eleven towns and villages formed an independent utility, which itself provides secondary transport and disposal services, using one landfill site.

of these concerns there should be legal, financial, and institutional safeguards that maintain the status quo or allow it to change in a way that does not threaten any of the partners nor discourage any from joining.

What are the Arrangements?

There is a wide range of possible arrangements for the regional approach. Key aspects of a regional or inter-municipal arrangement include:

- The origin of the initiative that brings the ULBs together (such as: Did the idea originate with the ULBs themselves or was it imposed from a higher tier of government?).
- What is the nature of the agreement between the participating bodies: informal, formal, contractual, legal?
- How is the leadership of the association arranged? Does one ULB play a leading role or are they all equal institutionally?
- Is the private sector involved? If so, what are the contractual modalities and how is performance monitored?
- What services is the association responsible for? (It could be one or more of the following: secondary transport, treatment, and disposal.)
- What are the cohesive forces that hold the association together? What sanctions or incentives are available to prevent any member from resigning from the association?
- What measures are taken to ensure that all participants honor their financial obligations?

Several institutional arrangements are possible for structuring a regional facility. Figure 3 shows some of the generic models. Box 10 illustrates the range of arrangements that are in use across the world.

Realizing Regional Disposal

"Solid waste transfer stations are essential for efficient operation of regional landfills." *(N. C. Vasuki)*

Any proposal for a regional disposal scheme should make sense in terms of geography and economics. The first challenge is to find a suitable site, including the securing of the agreement of neighboring communities and obtaining the necessary environmental permits. The geography of the region must be considered, especially the distances, travel times, and road conditions between the disposal site and the contributing communities. Economics will then dictate which communities can be served by the site. Rules of thumb[13] are useful in deciding how far waste should be transported. However, it is also useful to carry out specific calculations to estimate the costs of transporting the waste from potential partner communities to a particular site. Because of the wide range of possible models or arrangements, it is not possible to define a simple procedure for setting up a regional disposal scheme. All of the factors listed in the previous section (see 'What are the Arrangements?', on page 22) must be considered carefully. The most appropriate arrangement must be chosen from all the available options. If the private sector is to be involved, the modalities and contract conditions must be selected carefully. Considerable negotiation will usually be necessary, particularly to gain agreement on the financial details, including how inequalities in transport distances and waste quantity will be allowed for. Agreement may be necessary on conditions that will apply if one member wishes to leave the association, or if a new member wishes to join. Box 11 refers to steps that have already been taken to establish regional disposal systems in India.

Box 11. Regional or Intermunicipal Arrangements under Development—Indian Examples

Andhra Pradesh: The state government has developed a strategy and issued comprehensive guidelines for setting up regional facilities. It is proposed to group 134 urban local bodies into 19 clusters. Five proposals for regional facilities, covering 37 municipalities, were recently cleared by the state government. Facilities are to be established and operated by the private sector under concession agreements. ***Gujarat:*** Regional landfill sites have been identified using geographic information system (GIS) techniques—45 sites have been proposed for 130 municipalities, such that the maximum transport distance is 25 km; 20 of these 45 sites had already been acquired. Proposals envisage private sector involvement, and the Gujarat State Waste Management Company will be the sole contracting agent. ***Kerala:*** A recent study recommended that the state be divided into six zones, each with its own landfill site for receiving waste from all the towns in that particular zone. ***West Bengal:*** In the KMDA[14] area, six municipalities propose to use one common landfill site. Regional landfills are also being planned in other parts of the state, for example, in Asansol-Durgapur.

Sustaining a Regional Disposal System

"Urban local bodies' sustained commitment is an absolute necessity for meeting public health objectives." *(Raghu Rama Swamy)*

There are two particular challenges to maintaining a regional or intermunicipal association. One is the motivation to pay for sanitary landfilling, especially when it is cheaper to revert to open dumping. Municipal officials and local politicians are often unable to understand the need for sanitary landfilling, being more concerned about short-term issues and services that directly affect the main urban areas. Even when there is general environmental awareness, it is necessary to rely on legislation that is enforced in an effective way, to ensure that satisfactory standards of waste disposal are adhered to. It is important to note that legislation is not enough; there must be enforcement measures that work. The second is the temptation to revert to an independent, municipal-based service. This may be particularly attractive when the disposal service is combined with secondary transport, and when one ULB acquires its own means of secondary transport, perhaps as a grant or soft loan from a government or development agency. That particular

[13] Some experts suggest that transporting waste up to 50 km is affordable in India.

[14] Kolkata Metropolitan Development Authority.

ULB may then wish to withdraw from the agreement, thinking that it can provide a satisfactory and cheaper service using its own resources. Development agencies and governmental authorities should be made aware of the need to support regional schemes and work with regional bodies rather than individual ULBs when supplying certain types of equipment or financial assistance. Mechanisms for overcoming these challenges should be built into the agreement between the collaborating ULBs. Effective enforcement of environmental standards and control of the granting of permits for waste disposal can discourage ULBs from reverting to local open dumps.

"The quality of service delivery depends on both responsibility and capability." *(Vandana Bhatnagar)*

Involving the Private Sector

Inputs from the private sector can take many forms and provide many different types of service. For instance, design consultants and construction contractors are usually involved in the preparation of a landfill site. Consultants may also be engaged to assist with the development of institutional, financial, and legal arrangements, as well as to design and lead a program of public consultation. The private sector may also be engaged to manage, operate, or own a site or facility. There are many ways in which a company may be involved in the operation of a sanitary landfill, and the reader is referred to other publications (such as Cointreau-Levine, Coad, and Gopalan 2000[15]) for more detailed information on this topic. The main advantages of involving the private sector are listed in Box 12.

Box 12. Advantages of Involving the Private Sector in Waste Disposal

- The private sector often has better access than local government to capital for financing construction and investment in equipment.
- Specialized firms have more experience in waste disposal, and can provide short- and long-term inputs as required. (However, a company that is expanding rapidly may propose staff who have little or no relevant experience.)
- Performance and environmental standards can be enforced by means of the contract in addition to the application of environmental legislation (provided that the contract is well-written and effectively enforced).
- Costs and financial obligations are clearly defined.

Apart from the generic prerequisites for the success of private sector participation, it is important to note a few important points in the context of treatment and disposal of waste:

- If more than one company is responsible for the design, construction, and operation stages, it may be very difficult to allocate responsibility for any shortcomings that become apparent during the operation phase.
- Emissions (of leachate and gas) and settlement continue after landfilling ceases and the site has been closed, so the responsibility for monitoring the site and correcting any problems during this post-closure stage should be defined.
- Landfills are a viable business proposition only if the operator is paid appropriate compensation for the activity. This typically takes the form of tipping fee. Care needs to be taken to ensure that this fee is fixed at a level that offers a satisfactory return for the private operator, while also being within the financial reach of the local body. Assumptions of revenue generation from carbon finance or treatment facilities (if integrated with the landfill) may be accounted for while calculating the tipping fee. Nevertheless, provisions should also be made for any recourse available to the private operator in the event of revenue streams not being realized (possibly due to factors beyond its control).
- Landfills need to be designed for a period of at least 20-25 years using realistic assumptions of the share of waste that will be treated or recycled. Over-optimistic assumptions on levels of segregation and hence treatment or recycling that can be achieved may result in the landfill getting filled up within a much shorter timeframe. Alongside this, incentive mechanisms[16] should also be put in place to maximize the life of the landfill.

[15] Cointreau-Levine, Sandra, Adrian Coad, and Prasad Gopalan. 2000. Guidance Pack: Private sector participation in municipal solid waste management. Skat, Switzerland. It can be downloaded from http://rru.worldbank.org/Toolkits/SolidWasteManagement/

[16] For example, the regulatory authority could mandate a phased reduction in percentage of waste landfilled, or an accelerated charge could be imposed on local bodies for each ton of waste landfilled, or a rent payment may be made to the private operator for unused land in the landfill area.

How Does It All Fit Together?

Chronological Planning

"We need a sense of urgency. We have lost time. We will keep this issue alive." *(Mr Rajamani, MoUD)*

The chronological issue to consider is: At what stage is it appropriate to introduce sanitary landfills in solid waste management systems?

There is clearly an imperative need for sanitary landfills now. Open dumping should be stopped as a matter of urgency because it offers no protection to water resources.

The process of getting the land, designing the facility, obtaining the necessary permits, and constructing the site may take anything from six months to more than two years, so there is a pressing need to start now. To support this process, there now exist adequate sources of finance as also a willingness in the higher tiers of government to provide the necessary technical support to local bodies. So there is no reason for delay.

"All open dumps in Delaware were closed and that allowed development of engineered landfills. The landfills have 20+ years remaining capacity for solid waste disposal (currently 1 million metric tons per year)." *(N. C. Vasuki)*

Institutional Structures

Effective enforcement is needed so that urban local bodies (ULBs) no longer see open dumping as an alternative. ULBs should be informed about safe and sanitary waste disposal, and the benefits of the regional approach. Advice and support are needed so that ULBs can be grouped together into regional units that can provide economical and environmentally acceptable sanitary landfilling. The participation of the private sector should be negotiated carefully, with due consideration of the range of options available and meticulous preparation of contract documents. In India, according to the 74th Constitutional Amendment, municipal solid waste (MSW) management is the responsibility of each ULB. If a regional system is set up by the state government, the responsibility of ULBs for this service may tend to get diluted. Care should to be taken to prevent this from happening; local bodies need to retain responsibility for solid waste management, even if some of the operations are being managed by a regional association.

"Active involvement of state agencies is needed to encourage and facilitate the regionalization process... but the locus of responsibility for all aspects of MSW management needs to remain with ULBs. Therefore, it is necessary to ensure proper consultation and the participation of ULBs at all stages of decisionmaking." *(Vandana Bhatnagar)*

Financial Systems

ULBs should realize that safe disposal must be paid for—typically in the form of tipping fees. If undertaken at an economically efficient scale, the costs of sanitary landfilling are not very different from the costs of waste collection; in many cases, they may be even lesser. And they may often be paid out of savings from improved efficiency of the collection service. However, mechanisms for charging for disposal services should neither be so high as to encourage clandestine open dumping, nor should they be so low as to discourage treatment and recycling.

Operational Procedures

Much greater attention should be given to both theoretical and practical training for landfill operations managers and plant operators. Site managers should be given the resources that they need to operate their landfills to an acceptable standard. Enforcement of operating standards is needed so that due attention is paid to the proper operation of landfill sites.

Recommendations

Clarify Requirements and Objectives of MSW Rules

There is an urgent need to clarify the demands of the MSW Rules to end associated anomalous situations. For instance, the current practice of open dumping even when there is an available sanitary landfill facility or state sector strategies that are in contradiction to the MSW Rules. Priority should be given to setting up sanitary landfills along with treatment facilities.

"Develop contingency plans [such as] Plan A, Plan B, and Plan C." *(N. C. Vasuki)*

Develop Capacity

The capacities of both private and public sectors need to be improved so that both sides are able to ensure safe and sanitary disposal of wastes. This requires both theoretical and hands-on training. It also demands changes in career structures and employment policies so that personal development is encouraged. (Staff will not take time to develop their competence in waste management if they know that they are likely to be transferred to a different field after a short time.) Coordination is needed between urban local bodies and states so that facilities that are operating well can be used intensively for providing site experience to those who have undergone classroom training. The MSW Rules and the funding that is available will result in a rush to implement new facilities. It is likely that the lack of experienced human resources will pose a major constraint on the successful implementation of effective solid waste treatment and disposal systems. Unfortunately, political and legal pressures may force the authorities to press ahead with implementation at a high speed, resulting in a shortage of qualified people to plan, design, construct, and operate these facilities. It is likely that this will lead to disappointing performance and an unacceptable wastage of public and private finance. Capacity building, which is much more than classroom training, must be given careful consideration *now*.

While there is a clear need for more experts in the fields of site selection and landfill design, there are less obvious but greater needs for much improved capacity in operating landfills, inspecting operations, and enforcing standards, as well as in working with the private sector.

Enhance Knowledge Management

Improvements in solid waste management can be assisted greatly by knowledge management—the collection and sharing of both descriptive and numerical information. Regarding the latter, many people think first of figures that refer to the composition and per capita generation of waste. Such information is seldom reliable, and often it is not relevant to the final decision (Box 13).

Of great importance are data that describe operating experience. In the context of this publication, the cost of disposal of 1 ton of waste is a very useful item of information. Even more important can be accurate information about the performance of treatment plants, particularly the associated costs and income, the inputs and outputs, and the period during which the plant was operational. Objective accounts of successes and difficulties are certainly needed. Without this information and its widespread publication, wrong decisions will be repeated and the result will be unnecessary wastage of public money. Box 4 has already discussed this issue.

An important means for sharing of information—apart from case studies, exchange, study trips, training—is networking. Solid waste management in India is an evolving profession that needs to develop networking between professionals. Networking allows the sharing of experience-based information that is not, or cannot be, published. Networking enables us to contact fellow professionals and ask for advice based on their experience, so that we can learn from their experience and avoid repeating mistakes. Professional associations help to set up such networks.

India now has its own professional association for solid waste management—the Indian Association for Solid Waste Management (IASWM). This organization will help members contact others who may have useful experience-based information to share on an informal basis. It is a non-profit, national-level professional association with its secretariat in New Delhi.[17]

Inform, Involve, and Motivate Citizens

Most senior officials who are involved in solid waste disposal are confident

[17] The organization can be contacted at: Indian Association for Solid Waste Management (IASWM), Room Number 27, Dr Ambedkar Stadium, Delhi Gate, Delhi 110 002, India. Telephone: +91 11 23320271; Fax: +91 11 23318571; E-mail: iaswm@yahoo.co.in

The capacities of both private and public sectors need to be improved so that both sides are able to ensure safe and sanitary disposal of wastes.

Box 13. Some Warnings about Waste Data

Much effort has been wasted in collecting data on waste composition (the percentage of biodegradable material, plastic, paper, and so on). This wastage of effort can be attributed to:

- Such data are usually collected with little thought of the purpose that the information will be put to. For example, if it is desired to examine the potential for recycling plastic, it is not enough to determine the gross percentage of plastic, but it may be necessary to separate the various polymers, separate molded plastic from plastic film, and choose carefully the point in the waste management chain at which the analysis should be carried out. If it is desired to examine the feasibility of incineration, accurate studies are needed of moisture content and of composition after informal waste picking, at different times of the year.
- Composition studies are often used to indicate the potential for composting. However, the potential for composting is more often determined by the amount of biodegradable waste that is collected separately from other wastes (and therefore not contaminated by glass, plastic, and so on) and by the potential market for the product.
- Waste composition results are strongly influenced by seasonal factors (weather and availability of fresh fruit and vegetables) and so should be carried out over a period that covers all seasons. Waste generation data are often unreliable and inadequate, since they may not take account of seasonal differences and waste picking, and do not consider all streams of waste—domestic, institutional, commercial, market, street, industrial, and so forth. The most useful data for management of sanitary landfills are the weights of incoming waste and of cover material, so a weighbridge is essential. It is also useful to determine the in-situ density of the waste by surveying the site at intervals of six months or a year. There is a tendency to accept any available data without questioning its accuracy or reliability. Inaccurate data can lead to major mistakes, delays, and the waste of large sums of money.

about dealing with technical and financial aspects, but are uncertain about social aspects—those relating to the public.

The members of the public should be informed about developments in solid waste management activities that concern them. They should be listened to and consulted. If these steps are not taken, the result may be concerted opposition by groups of citizens after investments have been made, resulting in the abandoning of expensive facilities. Public awareness of environmental considerations should be developed so that citizens support measures that protect and enhance the environment, and report illegal activities that cause pollution. Such awareness would also improve the citizens' willingness to pay for solid waste management services. Waste management organizations must learn to project a positive image of the work that they are doing, in order to gain public support and citizen loyalty.

Ensure Financial Sustainability

It is an obvious fact that there must be sufficient income to pay for the equipment and technologies that we select, and yet there seems to be too little consideration given to the operating costs of some treatment systems that are chosen to process solid waste. At a time when government grants or international funding are widely available, it is easy to lose sight of the need for recurrent funding to keep plants and facilities operating. Treatment plants, despite their seeming potential for generating revenues, do require considerable commitment to ongoing cost of operations (including availability of requisite technical manpower). While this is the case with sanitary landfilling as well, a unique advantage that it offers is that it can be developed in stages. From a financial standpoint, this implies that after the initial investment to acquire and prepare the site, the cells in which the waste is deposited can be developed in a phased manner. The capital expenditure can therefore be spread out over a long period of time, and does not require a heavy financial liability to be incurred upfront by the local body.

Conclusions

Priorities for waste management should be based upon clearly defined objectives of public health and environmental protection. In situations in which a proportion of the solid waste is left uncollected in urban areas or solid wastes are being left in open dumps, the urgent priority is to safeguard health and the environment. The first steps in such situations must therefore be to improve collection services and ensure safe and sanitary disposal of the waste. Means to minimize the waste stream flowing to the disposal may then be developed through recycling and treatment systems.

It is important to regard citizens—the waste generators—as partners and customers, and not just as beneficiaries. Information, Education and Communication (IEC) was referred to in many of the presentations. Experience has shown that the last letter should stand for Consultation, or that the communication, at the very least, should be a two-way process. The US experience of siting landfills showed the benefits of involving neighboring populations in the site selection process. The opinions of the wide range of stakeholders should be sought rather than assumed. IEC is often outside the comfort zone and experience of many engineers and planners. It is assumed that publication of information on one occasion will be sufficient to ensure a change of behavior. In reality, extended and multifaceted campaigns are usually necessary to change stakeholders' behavior in the desired way. Educated public opinion can be a useful ally of pollution control agencies and others who are seeking improved protection of public health and the environment.

The issue of motivation should receive careful consideration. Laws and penalties are not the only tools available for encouraging improvements. Financial instruments, competitions, and public opinion can all be effective in motivating change.

Achievement and progress should be assessed on the basis of services, not on the basis of assets or infrastructure. The number of waste collection trucks is not important; the reliability of the service that they provide is. The existence of a processing plant means nothing; what matter more are environmental impacts, throughputs, unit costs, and the usefulness of the product. The design and construction standards of a landfill lose significance if the site is not managed correctly.

Unfortunately, treatment and landfills have been viewed as competing alternatives rather than as complementary processes. Moreover, treatment has been given precedence over landfills, as is evident from the Indian experience. The reasons for this distortion are likely to be a combination of the following:

- There is insufficient awareness of the difference between open dumping and sanitary landfilling, so that responsible officials think that sanitary landfilling is not environmentally acceptable or that it does not require special inputs.
- Treatment has champions but landfills do not. Many treatment technologies are promoted by persuasive salesmen with attractive visual presentations, but there is no comparable promotional pressure by the advocates of sanitary landfills.
- Treatment appears to meet the less important objectives of appearing modern or sophisticated and it is often presented as a means of gaining profit from waste. These inferior objectives often supersede the key objectives of protecting public health and the environment.

All treatment technologies must be accompanied by safe and sanitary disposal systems for the disposal of residues and to take all of the waste when the treatment plants are not operating. The only safe and sanitary disposal system that exists at the present time is sanitary landfilling.

Sanitary landfills should be designed to accept biodegradable waste, since there are always biodegradable residues from any treatment process (apart from incineration) and even well-operated treatment plants may be closed from time to time. Sites for landfills should be large enough for long periods of operation—30 years, not five years—so that worries about capacity do not prevent the use of landfills when they are needed. In today's world, sanitary landfilling is not an option, it is a necessity.

Unless they are managed by a well-trained team, facilities that are designed as sanitary landfills can quickly degenerate into polluting dumps. Again and again we see disposal facilities where very little effort has been invested in training managers and

There is an urgent need for enforcement of standards, so that communities dispose of their waste in sanitary landfills rather than open dumps and sanitary landfills are operated to satisfactory standards.

equipment operators. The operational requirements of sanitary landfills are not highly complex or sophisticated, but it is essential that site managers have a strong and practical understanding of the principles and techniques involved.

There is an urgent need for enforcement of standards, so that communities dispose of their waste in sanitary landfills rather than open dumps and sanitary landfills are operated to satisfactory standards. This may require a major campaign to recruit and train inspectors, as well as effective support from the courts. It also appears that there is a need for clearly defining the roles and mandate of the pollution control boards; in some cases their involvement in implementation has diluted their monitoring and enforcement functions. The grouping together of urban areas and settlements so that they use one common sanitary landfill can result in cost savings and improved operational standards.

This regional approach should be implemented wherever geography and politics permit.

Box 14. Sanitary Landfills in Summary

- A sanitary landfill is an essential part of every solid waste management system.
- Sanitary landfills should be designed for at least 20-25 years of operation.
- After construction, close attention must be paid to the operation of sanitary landfills, with adequate provision being made for both human and financial resources.
- Regional landfills offer important advantages in most situations.

Appendix A

Many of the quotes and other data provided in this report were presented at two workshops organized in January 2007, sponsored by the Ministry of Urban Development, and supported by Water and Sanitation Program-South Asia (of the World Bank).

The main components of the workshops, as well as information about the presenters and resource persons, are summarized below.

Puri Workshop, January 10 to 12, 2007

- Introduction by Deepak Sanan
- Questionnaire forms were filled in at the beginning and end of the workshop to determine the opinions of the participants and to see whether those opinions had changed as a result of the presentations and discussions
- 'Why Manage Solid Waste?' by N. C. Vasuki
- 'Status of Solid Waste Management in India' by P. U. Asnani
- 'Past Experience with MSW Treatment and Disposal Projects and Lessons Learnt' by Asit Nema
- 'Landfill: Necessity in MSW Handling' by A. N. Purandare
- 'Strategy for Collection and Transportation under Nirmalnagar Project' by C. M. Ramakumar
- 'Experiences with Community-Based Models in SWM: Lessons in Collection and Transportation' by Sanjay K. Gupta
- 'Business Model for Collection and Transportation at Scale: CDC Experiences' by Dr Vivek S. Agrawal
- 'Indian Association for Solid Waste Management (IASWM)' by Ravi Dass, President, and A. K. Vidyarthi
- 'Regional SW Facility: Concept and Rationale' by Vandana Bhatnagar
- 'Regional Approaches: International Examples and General Comments' by Adrian Coad
- 'State-Level Experiences with Regionalization in Andhra Pradesh' by Dr G. Malsur
- 'Integrated Solid Waste Management in Kerala: Move Towards Regional Approach' by Dr Kurian Baby
- 'Gujarat: Regional Approach—A Beginning' by Lekhan Thakkar
- 'Framework for Implementation' presented by Raghu Rama Swamy
- Breakout session: The roles of the different organizations and various levels, considering communication strategies; capacity building; rules and guidelines; financing; implementation; monitoring and enforcement. One of the groups was formed by participants from the hill states
- Panel discussion

Delegates at the Puri workshop, which was organized from January 10 to 12, 2007.

Chennai Workshop, January 17 to 19, 2007

- Introduction by Deepak Sanan
- Questionnaire forms were filled in at the beginning and end of the workshop to determine the opinions of the participants and to see whether those opinions had changed as a result of the presentations and discussions
- 'Status of Solid Waste Management in India' by P. U. Asnani
- 'Why Manage Solid Waste?' by N. C. Vasuki

Delegates at the Chennai workshop, which was organized from January 17 to 19, 2007.

- Inaugural address by guest of honor, Mr Rajamani, Joint Secretary, Ministry of Urban Development
- 'Landfills: Existing Guidelines and Some Experiences' by Professor Manoj Datta
- 'Two Lessons from International Experience' by Adrian Coad
- 'Recent Treatment and Disposal Projects in India: Case Studies' by Asit Nema
- 'Regional SW Facility: Concept and Rationale' by Vandana Bhatnagar
- 'Regional Approaches: International Examples and General Comments' by Adrian Coad
- 'Indian Association for Solid Waste Management (IASWM)' by Mr Khandelwal, Vice President, and Mr Ananthaswamy, responsible for IASWM affairs in the South
- 'State-Level Experiences with Regionalization in Andhra Pradesh' by Lokesh Jayaswal, Joint Secretary
- 'Gujarat: Towards a Regional Approach in SWM' by K. Srinivas
- 'Kolkata Metropolitan Development Authority', a presentation by P. R. Baviskar
- 'Model Facility for Demonstration of Management of Municipal Solid Waste, and MSWM in West Bengal' by S. K. Adhikari
- 'Integrated Solid Waste Management in Kerala: Move Towards Regional Approach' presented by P. U. Asnani
- 'Private Sector Participation in Regional Landfilling' by Adrian Coad
- 'Framework for Implementation' presented by Raghu Rama Swamy
- Breakout Session and Feedback: Exploring the perceptions and reactions of stakeholders
- 'Presentation of a Competition Scheme in Maharashtra' by Sunil Soni, Director of Municipal Administration

Presenters and Resource Persons

S. K. Adhikari
Senior Environmental Engineer, Waste Management Cell, West Bengal Pollution Control Board, Kolkata
E-mail: shyamala@wbpcb.gov.in

Dr Vivek S. Agrawal
Trustee Secretary, Centre for Development Communication, Jaipur
E-mail: vivekjpr@gmail.com

P. U. Asnani
Senior Partner, Urban Management Consultants, Ahmedabad
E-mail: puasnani@satyam.net.in

Dr Kurian Baby
Senior Advisor, Socio Economic Unit Foundation, Kerala
E-mail: kurianb@yahoo.com

P. R. Baviskar
Chief Executive Officer, Kolkata Metropolitan Development Authority, Urban Development Department, Government of West Bengal, Kolkata

Vandana Bhatnagar
Urban Sector Specialist, Water and Sanitation Program, World Bank, New Delhi
E-mail: vbhatnagar@worldbank.org

Adrian Coad
Consultant, Egypt
E-mail: adriancoad@link.net

S. Dasgupta
Consultant, IFC and the World Bank, New Delhi
E-mail: Shubhagato@hotmail.com

Professor Manoj Datta
Department of Civil Engineering, Indian Institute of Technology, New Delhi
E-mail: mdatta@civil.iitd.ernet.in

Sanjay K. Gupta
Program Manager, Urban Services, USAID (GMED Program), Jaipur
E-mail: sanjayg@gmedindia.org

Lokesh Jayaswal
Joint Secretary, Municipal Administration & Urban Development Department, Government of Andhra Pradesh, Hyderabad

Dr G. Malsur
Project Director, Andhra Pradesh Urban Reforms and Municipal Services Project, Urban Department, Government of Andhra Pradesh
E-mail: pdmsu_apurmsp@yahoo.co.in

Asit Nema
Foundation for Greentech Environmental Systems, New Delhi
E-mail: greentech@touchtelindia.net

A. N. Purandare
Director, Eco Designs India Private Limited, Pune
E-mail: ecodesigns@vsnl.net

C. M. Ramakumar
Former Deputy Advisor, Karnataka Urban Infrastructure Development and Finance Corporation
E-mail: cm_ramakumar@yahoo.com

Deepak Sanan
Former India Country Team Leader, Water and Sanitation Program-South Asia, World Bank, and Principal Secretary, Department of Urban Development, Himachal Pradesh
E-mail: deepak_sanan@hotmail.com

K. Srinivas, IAS
Managing Director, Gujarat Urban Development Co Ltd, Gujarat
E-mail: ksrinivas_ias@yahoo.co.in

D. T. V. Raghu Rama Swamy
Head, Urban and Industrial Infrastructure, Infrastructure Development Corporation (Karnataka) Ltd, Bangalore
E-mail: raghu@idfc.com

Lekhan Thakkar
Vice President, Gujarat Urban Development Co Ltd, Gujarat
E-mail: lekhanthakkar@gmail.com

N. C. Vasuki
PE, DEE, Chief Executive Officer (retired), Delaware Solid Waste Association, and Past President of the International Solid Waste Association
E-mail: chokkanna@comcast.net

A. K. Vidyarthi
Environmental Engineer, Central Pollution Control Board, Delhi
E-mail: ajitvidyarthi@yahoo.co.in

Appendix B

Definitions and Data Notes

Biomethanation
This is a process used to produce methane gas, which can be used as a fuel, by means of bacteria that feed on the waste when there is little or no oxygen present. A more general term is anaerobic digestion. The conditions of the process (amount of water, temperature, and characteristics of the waste) must all be carefully controlled.

Chain
The chain of solid waste management operations can, in broad terms, be taken to include the following stages: generation, storage, collection, treatment (or processing), and disposal.

CPCB
Central Pollution Control Board

Crore
10 million

Disposal
Disposal is the last stage of solid waste management. The only satisfactory method of disposal involves placing the remaining residues into an engineered receiving area and minimizing their contact with, and impact on, the external environment. This process is known as sanitary or engineered landfilling.

Dumping
Crude or open dumping refers to the unloading of waste without taking care to minimizing pollution, utilizing the land area well, or restoring the site when disposal operations cease. In such situations waste is often burnt, causing serious air pollution. The word 'landfilling' should not be used to describe such operations.

Economy of scale
An economy of scale is demonstrated when the unit cost (such as the cost of disposal of 1 ton of waste) is less for a larger operation than for an equivalent but smaller operation, for reasons that are linked to the size of the operation.

Hectare
10,000 square meters or 2.471 acres

Lakh
100,000

Landfill
Referring to a sanitary landfill, which is an engineered secure waste disposal facility incorporating environmental safeguards such as liner, leachate control systems, gas collection systems, and so on.

MSW(M)
Municipal solid waste (management). Municipal solid waste is generally taken to include domestic, institutional, commercial, and street wastes. Agricultural wastes and hazardous solid wastes from industries and hospitals are excluded from this category, and construction and demolition waste is also usually excluded.

Processing
Processing and treatment are considered to have the same meaning in this publication.

RDF
Refuse-derived fuel, which is made from solid waste and is used as a substitute for coal in boilers. It may be in the form of short, extruded cylinders or as loose material, known as 'fluff'.

Resource recovery
Resource recovery embraces all means of gaining some economic benefit from waste. This may involve reusing items in the waste in their original form, processing them to make new materials or products, or burning the waste or a product from the waste to gain energy, which may be converted into electrical power.

Rs
Indian Rupees or INR (US$1 = INR 40.46, as of September 7, 2007).

Solid waste
Any item or material that is no longer of interest to the person who was responsible for it and that is not discharged through a pipe or directly into the air. (Laws and contracts may provide different definitions.) The ownership of solid waste at any stage or time can be an important issue in the context of recycling and legal liability.

Solid waste management
All activities that aim to minimize undesirable impacts of solid wastes and to derive some benefit from these wastes.

Tons
see 'tpd'

tpd
Tons per day. For the purposes of this report, the difference between the avoirdupois ton (2,240 lb) and the metric ton or tonne (1,000 kg, equivalent to 2,205 lb) is of no significance. The short ton (2,000 lb) is rarely heard of outside the United States. The megagram (Mg) is the same as the tonne.

Treatment
Waste treatment is taken to mean any process that changes the nature of waste in order to gain some benefit from it (such as energy recovery or using it as an input in a manufacturing process) or reduces the costs, risks or pollution associated with subsequent handling. Most treatment processes produce residues that require disposal. In other words, treatment is rarely the last stage in the solid waste management chain.

Water and Sanitation Program-
South Asia
World Bank
55 Lodi Estate
New Delhi 110 003
India

Phone: (91-11) 24690488, 24690489
Fax: (91-11) 24628250
E-mail: wspsa@worldbank.org
Web site: www.wsp.org

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TASK MANAGER:
Vandana Bhatnagar

PREPARED BY:
Adrian Coad

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