Municipal solid waste management in India: From waste disposal to recovery of resources?

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Abstract

Unlike that of western countries, the solid waste of Asian cities is often comprised of 70–80% organic matter, dirt and dust. Composting is considered to be the best option to deal with the waste generated. Composting helps reduce the waste transported to and disposed of in landfills. During the course of the research, the author learned that several developing countries established large-scale composting plants that eventually failed for various reasons. The main flaw that led to the unsuccessful establishment of the plants was the lack of application of simple scientific methods to select the material to be composted.

Landfills have also been widely unsuccessful in countries like India because the landfill sites have a very limited time frame of usage. The population of the developing countries is another factor that detrimentally impacts the function of landfill sites. As the population keeps increasing, the garbage quantity also increases, which, in turn, exhausts the landfill sites. Landfills are also becoming increasingly expensive because of the rising costs of construction and operation.

Incineration, which can greatly reduce the amount of incoming municipal solid waste, is the second most common method for disposal in developed countries. However, incinerator ash may contain hazardous materials including heavy metals and organic compounds such as dioxins, etc. Recycling plays a large role in solid waste management, especially in cities in developing countries.

None of the three methods mentioned here are free from problems. The aim of this study is thus to compare the three methods, keeping in mind the costs that would be incurred by the respective governments, and identify the most economical and best option possible to combat the waste disposal problem.

1. Introduction

Rapid population growth, urbanization and industrial growth have led to severe waste management problems in the cities of developing countries like India. The large quantity of waste generated necessitates a system of collection, transportation and disposal. It requires knowledge of what the wastes are comprised of, and how they need to be collected and disposed. Recycling of waste, energy generation and employment opportunities from waste management also have immense potential. However, it has been widely observed that the Municipal Corporations in India do not have adequate resources or the technical expertise necessary to deal with the problem. Successful waste management requires the participation of citizens, local governments, and private entrepreneurs.

The increase in the population and rapid income growth in India has changed the lifestyle of urban residents, thus changing the composition of the garbage generated. The presence of paper, plastic and metal is on the rise, resulting in more disposal difficulty. The municipalities have not been able to collect and dispose of the enormous quantity of waste being generated. Scavengers and rag pickers have helped the corporations with the collection of the garbage generated, since they collect it from households to garbage dumps and carry out the important function of waste segregation.

Waste management and disposal is a pressing issue facing India today, since about 90% of waste is currently disposed of by open dumping. Some commonly used methods by which the waste could be managed are: incineration, landfilling and composting. However, these methods are inefficient and harm the environment. This paper argues that the solution to waste management is not merely technical, but also organizational. There is a great need to move away from the disposal-centric approach and toward the recovery-centric approach of waste management. This paradigm shift requires some level of public participation by regulating and monitoring waste generation and disposal.

2. Incineration

Incineration refers to the combustion of waste materials that result in ash residue and air emissions. Waste incinerators do not eliminate waste – in fact they generate it. Since physical matter cannot be destroyed, an incinerator actually transforms the origi-
2.1. Is it a good option?

Global resistance to incineration is on the rise, with countries around the world banning incineration technologies, particularly the USA, Europe, and Japan. The incinerator companies in these countries are facing declining popularity and sales and are looking for new markets. The incineration facilities built in Manila, Lagos, Istanbul, and Mexico have not been used. When they were used, as in Indonesia, the cost was prohibitive (Martin Medina, 2005). The waste composition is largely organic in developing countries with a high moisture content, making incineration a poor option.

2.2. Health impact

The air emissions from waste incinerators have been identified as a cause of cancer. The incineration of solid waste leads to air emissions that contain heavy metals, dioxins, and other volatile organic compounds. Many of these substances, dioxins in particular, can be carried long distances from their emission sources, persist in the environment without breaking down into less harmful compounds, and accumulate in soil, water, and food sources (N.R.C., 2000). Ash is a product of incineration. The toxins in the ash will eventually leach into soil and water from landfill ash deposits.

2.3. Economic viability

Incinerators require a large capital investment with little economic return. The plants need a constant supply of waste for maintaining optimal combustion, which results in the creation of long-term contracts with local authorities that guarantee a certain ton of waste per year to the incinerator (Connett and Connett, 1994). This effectively destroys incentives for local decision-makers to minimize waste. Incinerators need material with high calorific value, such as paper, cardboard, and plastics, etc. to maintain combustion levels (Davis, 1994). In fact, the only materials in mixed waste that exceed the average calorific value of standard power-generating fuels (such as natural gas, coal, diesel, etc.) are waste oils, solvents, and plastics, which produce air emission problems when burned (Murray, 1999). In India and various other developing countries, the waste consists mainly of organic matter; for instance in Kerala, organic content varied between 30% and 75% of the total waste (see Table 1) and contains less paper, plastic, and cardboard, which makes it economically less viable to operate in developing countries. Furthermore, landfills are still required for the disposal of the ash, which adds to the operational cost of an incinerator. The increased concentration of toxins in fly ash makes it a hazardous substance, which requires deposition into a costly hazardous materials landfill.

2.4. Medical wastes

Incineration of medical and quarantine waste is not a safe solution. Only about 15% of medical waste is potentially infectious (Toxics Action Group, 2001). Although incineration certainly kills pathogens, it changes a potential biological threat into a formidable set of chemical problems by destroying not only the pathogens, but also the materials on which the pathogens sit, such as plastic, glass, paper, and metal, etc. (Franklin Associates, 2000). This is especially important, since many medical supplies are rich in PVC (polyvinylchloride), which is one of the worst materials in terms of producing dioxins when combusted. Coordinating initiatives with suppliers of medical equipment could help minimize the waste generated. Additionally, effective sorting of medical waste at its source could divert most of it for reuse and recycling. Alternative treatments for the remaining infectious waste include: autoclaving (high pressure steam treatment), microwaving moistened waste, and sterilizing waste with disinfectants (chemical sterilization).

2.5. Practice in India

In India, incineration is not a common practice, since the garbage tends to be low in calorific value and volumes are generally low for a central facility. The technology for incineration is not available domestically and import options are highly capital intensive. An incinerator plant was established in Delhi during the 1980s and was expected to generate power for the local grid. However, the operational experience was not satisfactory.

In summary, municipal solid waste in developing countries is not suitable for incineration and, thus, this solution is not economically viable. Countries like India do not find this method to be very favorable, especially considering the waste content and the high costs of setting up and running the plants (see Table 2).

3. Landfilling

A landfill is an area of land onto or into which waste is deposited. The aim is to avoid any contact between the waste and the surrounding environment, particularly the groundwater. Landfills can be classified into three categories, which are:

Table 1
Physical characteristics of solid waste in some Kerala towns

<table>
<thead>
<tr>
<th>Type of solid waste</th>
<th>Thiruvananthapuram city TPD (% of total)</th>
<th>Kottayam town TPD (% of total)</th>
<th>Palakkad town TPD (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic waste</td>
<td>151.6 (50.5)</td>
<td>39.5 (75.1)</td>
<td>(14.9)</td>
</tr>
<tr>
<td>Paper</td>
<td>31.6 (10.5)</td>
<td>4.6 (8.7)</td>
<td>(25.64)</td>
</tr>
<tr>
<td>Glass</td>
<td>7.2 (2.4)</td>
<td>0.9 (1.7)</td>
<td>(1.73)</td>
</tr>
<tr>
<td>Textile</td>
<td>7.7 (2.6)</td>
<td>0.8 (1.5)</td>
<td>(0.67)</td>
</tr>
<tr>
<td>Plastic</td>
<td>22.9 (7.60)</td>
<td>2.6 (4.9)</td>
<td>(6.35)</td>
</tr>
<tr>
<td>Metal</td>
<td>6.5 (2.2)</td>
<td>2.2 (4.2)</td>
<td>(1.12)</td>
</tr>
<tr>
<td>Ash</td>
<td>11.4 (3.8)</td>
<td>–</td>
<td>(20.77)</td>
</tr>
<tr>
<td>Sand</td>
<td>32.6 (10.8)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>25.2 (8.4)</td>
<td>2.0 (3.8)</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td>300 (1000)</td>
<td>52.6 (100)</td>
<td>(100)</td>
</tr>
<tr>
<td>Population</td>
<td>700,000</td>
<td>67,000</td>
<td>130,000</td>
</tr>
</tbody>
</table>

Source, Nair and Sridhar (2005).

Table 2
Sources of solid waste – some examples from Kerala

<table>
<thead>
<tr>
<th>Source of solid waste</th>
<th>Thiruvananthapuram city TPD (% of total)</th>
<th>Kottayam town TPD (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
<td>181 (60.3)</td>
<td>14.4 (27.4)</td>
</tr>
<tr>
<td>Shops</td>
<td>13 (4.3)</td>
<td>–</td>
</tr>
<tr>
<td>Hotels/restaurants</td>
<td>30 (10)</td>
<td>–</td>
</tr>
<tr>
<td>Hospitals</td>
<td>2 (0.7)</td>
<td>–</td>
</tr>
<tr>
<td>Tea shops</td>
<td>1 (0.3)</td>
<td>–</td>
</tr>
<tr>
<td>Workshops</td>
<td>1 (0.3)</td>
<td>–</td>
</tr>
<tr>
<td>Markets</td>
<td>40 (13.3)</td>
<td>7.6 (14.4)</td>
</tr>
<tr>
<td>Street sweepings</td>
<td>290.6</td>
<td>–</td>
</tr>
<tr>
<td>Construction work</td>
<td>10 (3.3)</td>
<td>–</td>
</tr>
<tr>
<td>Marriage halls</td>
<td>20 (6.7)</td>
<td>–</td>
</tr>
<tr>
<td>Establishments and</td>
<td>–</td>
<td>30.6 (58.2)</td>
</tr>
<tr>
<td>institutions</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td>300 (100)</td>
<td>52.6 (100)</td>
</tr>
</tbody>
</table>

Source, Nair and Sridhar (2005).
i. Open dumps or open landfills, which are the most common in all developing countries, involve the refuse simply being dumped haphazardly into low lying areas of open land.

ii. Semi-controlled or operated landfills are designated sites where the dumped refuse is compacted and a topsoil cover is provided daily to prevent nuisances. All kinds of municipal, industrial, and clinical/hospital wastes are dumped without segregation. This type of landfill is not engineered to manage the leachate discharge or emissions of landfill gases.

iii. Sanitary landfills are used in developed countries and have facilities for interception and treatment of the leachate using a series of ponds. This type of landfill also has arrangements for the control of gases from waste decomposition (Tchobanoglous et al., 1993).

3.1. Leachate

Municipal landfill sites produce leachate that contains concentrated toxic chemicals (Denison and Ruston, 2000). Leachate production is a result of rainfall and of surface water or groundwater entry into the landfill site. Leachate leakage is dependent upon the relative permeability of the landfill liner. Modern landfills must be constructed with an impermeable liner of compacted clay and/or geosynthetic material to contain the leachate. However, regardless of the liner’s nature and the guarantees offered by landfill operators regarding its durability, it is universally accepted that all landfill liners will ultimately fail (US Environmental Protection Agency, 1998). Landfill leachate has been responsible for contaminating groundwater supplies and surface water ecosystems in communities all over the world (Farquhar, 1989). Some of the hundreds of toxic substances found in landfill leachate are: lead, cadmium, chromium, mercury, toluene, dioxins, organophosphates, and PCBs. The extent of damage caused by leachate is largely unknown, given the complexity of leachate flows within landfills, the complex system of aquifers that may be impacted, and the lack of data. Although the impacts are uncertain, the precautionary principle should apply given the toxic nature of the materials involved.

3.2. Landfill gas

As waste decomposes, combination of chemical, thermal, and microbial reactions release gases (US Environmental Protection Agency, 1999). Landfill gas is a combination of methane and carbon dioxide in almost equal parts. The remaining 0.01–0.6% is composed of carcinogenic volatile organic compounds, such as benzene, toluene, xylene, carbon tetrachloride, etc. (Residua, 2000). Landfill gas may collect unevenly in pockets, gradually seeping out through the ground or waste mass, or building up pressure until an explosion or uncontrolled fire occurs.

3.3. Health impact

Several types of cancer have been reported in people living near landfills where landfill gas migrates through the soil (Montague, 1998). The Parkwood landfill site in Sheffield (UK) is a good example of the potential health impact of landfill sites. One study on that site focused on reported cases of diseases like bronchitis, chronic obstructive pulmonary disease (COPD), asthma-like symptoms, skin irritation, eye irritation, anxiety or depression, neurological symptoms, and liver problems in those who lived near the landfill site. However, the results of the study were not conclusive, as the researchers noted that all of the above-mentioned diseases do not necessarily have to be associated with landfills. There are also other studies that have examined the incidences of cancer, congenital anomalies and low birth weights in people living near landfills, but again, these studies were all inconclusive, thus indicating the need for further studies.

3.4. Patterns followed in developing countries

In India and other developing countries, most of the waste is landfilled, or dumped in yards. These methods are not in accordance with the practices of sanitary landfilling. The dumping is often done in low lying areas, which are prone to flooding, increasing the possibility of surface water contamination during the rainy season. The pollution of groundwater, though largely unassessed, is definitely a threat posed by the dumping of wastes. The daily cover techniques are poor, which makes leakage easier. This is mainly because of a lack of knowledge and skill on the part of the local authorities. A large portion of the funds allocated for waste management are used for collection and transportation, resulting in lower amounts available for disposal activities (Pickford, 1983). This forces local authorities to curtail the implementation of even known precautions and practices.

4. Composting

Composting is the controlled decomposition of organic matter through biological processes, resulting in nutrient-rich humus. The word ‘compost’ is derived from the Latin verb ‘componere’, which means to put together. Composting involves the putting together of a mixture of vegetable residue, animal matter, soil and water to form humus. The amount of compostable material in the waste of developing countries is 80–85%. The typical composition of municipal solid waste in India is given in Table 1.

The waste composition of developing countries makes it clear that composting is the best possible option to deal with municipal solid waste.

4.1. Reasons for failure

Composting has a long tradition in India (Howard, 1943), and is particularly widespread in the rural areas. The centralized, large-scale composting plants established in the urban areas of India in the 1970s proved to be economically unsustainable (Dulac, 2001). More importantly, studies have determined that composting is difficult because the waste arrives in a mixed form and contains a lot of non-organic material. When mixed waste is composted, the end product is of poor quality. The presence of plastic objects in the waste stream is especially problematic, since these materials do not get recycled or have a secondary market. In the absence of segregation, even the best waste management system or plant will be rendered useless. This raises a fundamental question: Who is responsible for the waste produced?

4.2. Targeting the source of waste

If we adopt the polluter pays principle, then whoever generates the waste has to take the majority of the responsibility for cleaning it up. In the context of mixed waste, the households, industries and establishments that generate the waste have to take the first responsibility for segregating the waste. Once segregated, the biodegradable items could be composted and the rest of the material could be recycled. Thus, participation is necessary to the resource recovery approach to waste management.
4.3. Decentralized approach

Citizen participation would naturally lead to a decentralized approach. Some of the advantages of this type of approach are:

i. Primary waste collection improves and the residents become less dependent on the collection of municipal waste.
ii. It can be implemented with reduced investment and low operating costs.
iii. Manual composting is easily integrated into the prevailing Indian socio-economic conditions, as it is labour intensive and offers employment opportunities.
iv. The compost can be sold to the farmers. With high quality compost, there would be a ready market.

5. Conclusion

In a world limited by resources, recovery is fundamental to sustainable development. The world has become aware of that need. A recovery-centric approach to municipal solid waste management cannot be functional, however, without active citizen participation and proper implementation of regulations. Small experiments have shown that it is possible to achieve a recovery-centric approach by altering citizen behaviour. Based upon the results of this paper, it is very clear that composting after segregation is the best possible option to address solid waste in developed countries. Although this conclusion is nothing new, the successive governments in India have not worked towards the establishment of composting plants, but have time and again experimented with the different technologies available. There have been instances where the Indian government has established composting plants like Villapilsala in the Trivandrum district of Kerala, but the plants have failed due to the lack of streamlined collection of waste by the municipality.

The lack of involvement of civil society in the management of municipal solid waste is a major problem. Municipalities should see to it that private participation is made attractive. Awareness campaigns should also be conducted so that the burden of the corporation for proper segregation of waste would be lessened by the participation of the people and recovery at the household or industry level.

References