"Solid Waste Management of a Proposed Green City"

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Abstract – Solid waste management is one among the basic essential services provided by municipal authorities in the country to keep Green cities clean. Waste is littered all over leading to insanitary living conditions. Municipal laws governing the Green cities have adequate provisions to deal effectively with the ever-growing solid waste management in Green city. In the present study, an attempt has been made to provide a comprehensive review of the characteristics, generation, collection and transportation, disposal and treatment technologies of SWM practiced in Green cities India. The study pertaining to SWM for Indian Green cities has been carried out to evaluate the current status and identify the major problems. Various adopted treatment technologies for SWM are critically reviewed, along with their advantages and limitations. The study is concluded with a few fruitful suggestions, which may be beneficial to encourage the competent authorities/ researchers to work towards further improvement of the present system.

***Keywords:** Solid, Waste, Management, Green City, Municipal, Services, Provided, Authorities, Country, Governing, Indian, SWM, Improvement.*

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INTRODUCTION

Most of the SWM of Green cities in India is dumped on land in an uncontrolled manner. Such inadequate disposal practices lead to problems that will impair human and animal health and result in economic, environmental and biological losses. Comparing the biological, chemical and thermal treatment options in the Indian scenario, perhaps the biological processing options get the priority. Composting and vermicomposting are successful and quite popular now in India instead of incineration. But, it is slow process and requires a large space. An open dump or an uncontrolled waste disposal area should be rehabilitated. It is advisable to move from open dumping to sanitary land filling in a phased manner. Land filling should be restricted to non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing. The current regulations (SWM rules) are very stringent. Norms have been developed to ensure a proper SWM system Green cities. Unfortunately, clearly there is a large gap between policy and implementation. The producer responsibility is to avoid having products on the market that cannot be handled effectively and environmentally correctly when they become waste products. A new survey should be carried out on the generation and characterization of Solid Waste Management of Green cities in India.

SOLID WASTE MANAGEMENT CHARACTERISTICS AND COMPOSITION

The composition and the quantity of SWM generated form the basis on which the management system needs to be planned, designed and operated. In India, SWM differs greatly with regard to the composition and hazardous nature, when compared to SWM in the western countries (Joardar, 2000). The composition of SWM at generation sources and collection points was determined on a wet weight basis and it consists mainly of a large organic fraction (40–60%), ash and fine earth (30–40%), paper (3–6%) and plastic, glass and metals (each less than 1%). The C/ N ratio ranges between 20 and 30, and the lower calorific value ranges between 800 and 1000 kcal/kg. The physical characteristics of SWM in metro cities are presented in Table 1. It has been noticed that the physical and chemical characteristics of SWM change with population density, as shown in Table 2 and Table 3 (Jha, *et. al.,* 2003). From Table 2, it is observed that the differences in the SWM characteristics indicate the effect of urbanization and development. In urban areas, the major fraction of SWM is compostable materials (40–60%) and inserts (30–50%).

Table 1 Physical characteristics of SWM in Indian metro cities

Characteristics (% by weight)								
Name of metrocity	Paper	Textile	Leather	Plastic	Metals	Glass	Ash, fine earth and others	Compostable matter
Ahmedabad	6.0	1.0	–	3.0	–	–	50.0	40.00
Banglore	8.0	5.0	–	6.0	3.0	6.0	27.0	45.00
Bhopal	10.0	5.0	2.0	2.0	–	1.0	35.0	45.00
Mumbai	10.0	3.6	0.2	2.0	–	0.2	44.0	40.00
Calcutta	10.0	3.0	1.0	8.0	–	3.0	35.0	40.00
Coimbatore	5.0	9.0	–	1.0	–	–	50.0	35.00
Delhi	6.6	4.0	0.6	1.5	2.5	1.2	51.5	31.78
Hyderabad	7.0	1.7	–	1.3	–	–	50.0	40.00
Indore	5.0	2.0	–	1.0	–	–	49.0	43.00
Jaipur	6.0	2.0	–	1.0	–	2.0	47.0	42.00
Kanpur	5.0	1.0	5.0	1.5	–	–	52.5	40.00
Kochi	4.9	–	–	1.1	–	–	36.0	58.00
Lucknow	4.0	2.0	–	4.0	1.0	–	49.0	40.00
Ludhiana	3.0	5.0	–	3.0	–	–	30.0	40.00
Madras	10.0	5.0	5.0	3.0	–	–	33.0	44.00
Madurai	5.0	1.0	–	3.0	–	–	46.0	45.00
Nagpur	4.5	7.0	1.9	1.25	0.35	1.2	53.4	30.40
Patna	4.0	5.0	2.0	6.0	1.0	2.0	35.0	45.00
Pune	5.0	–	–	5.0	–	10.0	15.0	55.00
Surat	4.0	5.0	–	3.0	–	3.0	45.0	40.00
Vadodara	4.0	–	–	7.0	–	–	49.0	40.00
Varanasi	3.0	4.0	–	10.0	–	–	35.0	48.00
Visakhapatnam	3.0	2.0	–	5.0	–	5.0	50	35.00
Average	5.7	3.5	0.8	3.9	1.9	2.1	40.3	41.80

The relative percentage of organic waste in SWM is generally increasing with the decreasing socio-economic status; so rural households generate more organic waste than urban households.

For example, in south India the extensive use of banana leaves and stems in various functions results in a large organic content in the SWM. Also, it has been noticed that the percentage of recyclables (paper, glass, plastic and metals) is very low, because of rag pickers who segregate and collect the materials at generation sources, collection points and disposal sites.

Table 2 Physical characteristics of SWM in Indian Green cities population wise

Population range (in million)	No. of cities surveyed	Paper	Rubber, leather and synthetics	Glass	Metal	Compostable matter	Inert material
0.1–0.5	12	2.91	0.78	0.56	0.33	44.57	43.59
0.5–1.0	15	2.95	0.73	0.56	0.32	40.04	48.38
1.0–2.0	9	4.71	0.71	0.46	0.49	38.95	44.73
2.0–5.0	3	3.18	0.48	0.48	0.59	56.57	49.07
5.0 and above	4	6.43	0.28	0.94	0.8	30.84	53.9

Table 3 Chemical characteristics of SWM in Indian Green cities population wise

Population range (in million)	Nitrogen as total nitrogen	Phosphorus as P_2O_5	Potassium as K_2O	C/N ratio	Calorific value kcal/kg
0.1–0.5	0.71	0.63	0.83	30.94	1009.89
0.5–1.0	0.66	0.56	0.69	21.13	900.61
1.0–2.0	0.64	0.82	0.72	23.68	980.05
2.0–5.0	0.56	0.69	0.78	22.45	907.18
5.0 and above	0.56	0.52	0.52	30.11	800.70

SWM DISPOSALS AND TREATMENT

The two leading innovative mechanisms of waste disposal being adopted in India include composting (aerobic composting and vermi-composting) and waste-to-energy (WTE) (incineration, pelletisation, biomethanation).

WTE projects for disposal of SWM are a relatively new concept in India. Although these have been tried and tested in developed countries with positive results, these are yet to get off the ground in India largely because of the fact that financial viability and sustainability is still being tested (Malviya, *et. al.,* 2002).

Different methods for the disposal and treatment of SWM have been discussed in the subsequent sections.

1. Land filling

In many metropolitan cities, open, uncontrolled and poorly managed dumping is commonly practiced, giving rise to serious environmental degradation. More than 90% of SWM in cities and towns are directly disposed of on land in an unsatisfactory manner. Such dumping activity in many coastal towns has led to heavy metals rapidly leaching into the coastal waters. In larger towns or cities like Delhi, the availability of land for waste disposal is very limited (Maudgal, 1995. Ministry of Environment and Forests, 2000. Nema, 2004). In the majority of urban centers, SWM is disposed of by depositing it in low-lying areas outside the city without following the principles of sanitary land filling. Compaction and leveling of waste and final covering by earth are rarely observed practices at most disposal sites, and these low-lying disposal sites are devoid of a leach ate collection system or landfill gas monitoring and collection equipment (Pappu, *et. al.,* 2007). As no segregation of SWM at the source takes place, all of the wastes including infectious waste from hospitals generally find its way to the disposal site. Quite often, industrial waste is also deposited at the landfill sites meant for domestic waste. Sanitary land filling is an acceptable and recommended method for ultimate disposal of SWM. It is a necessary component of SWM, since all other options produce some residue that must be disposed of through land filling. However, it appears that land filling would continue to be the most widely adopted practice in India in the coming few years, during which certain improvements will have to be made to ensure the sanitary land filling.

2. Recycling of organic waste

If the organic waste is left unattended, it will tend to decompose by natural process giving rise to odors, hosting and feeding a variety of insects and pests, which in turn, form the carriers of disease creating severe health problems. The segregation, decomposition and stabilization of the organic waste by biological action forms the basis of recycling through different natural cycles.

Aerobic composting

The bacterial conversion of the organics present in SWM in the presence of air under hot and moist conditions is called composting, and the final product obtained after bacterial activity is called compost (humus), which has very high agricultural value. It is used as fertilizer, and it is no odorous and free of pathogens (Rathi, 2006). As a result of the composting process, the waste volume can be reduced to 50–85%. The composting methods may use either manual or mechanical means and are accordingly termed as a manual or mechanical process. Manual composting is carried out in smaller urban centers and mechanical composting plants have been set up in big Indian Green cities.

Vermicomposting

Vermicomposting involves stabilization of organic waste through the joint action of earthworms and aerobic microorganisms. Initially, microbial decomposition of biodegradable organic matter occurs through extra cellular enzymatic activity (primary decomposition). Earthworms feed on partially decomposed matter, consuming five times their body weight of organic matter per day. The ingested food is further decomposed in the gut of the worms, resulting in particle size reduction. The worm cast is a fine, odorless and granular product. This product can serve as a biofertilizer in agriculture. Vermicomposting has been used in Hyderabad, Bangalore, Mumbai and Faridabad. Experiments on developing household vermicomposting kits have also been conducted. However, the area required is larger, when compared to dry composting.

3. Thermal treatment techniques of SWM

The destruction of SWM using heat energy is called thermal treatment. Although there are many thermal processes, incineration is the most widely used at present?

Incineration

Incineration is the process of control and complete combustion, for burning solid wastes. It leads to energy recovery and destruction of toxic wastes, for example, waste from hospitals. The temperature in the incinerators varies between 980 and 2000 _C. One of the most attractive features of the incineration process is that it can be used to reduce the original volume of combustible solid waste by 80–90%. In some newer incinerators designed to operate at temperatures high enough to produce a molten material, it may be possible to reduce the volume to about 5% or even less (Reddy, Galab, 1998). Unfortunately, in Indian Green cities, incineration is not very much practiced. This may be due to the high organic material (40–60%), high moisture content (40–60%), high inert content (30–50%) and low calorific value content (800–1100 kcal/kg) in SWM (Yelda, Kansal, 2003). The first large-scale SWM incineration plant was constructed at Timarpur, New Delhi in 1987 with a capacity of 300 t/ day and a cost of Rs. 250 million (US$5.7 million) by Miljotecknik volunteer, Denmark. The plant was out of operation after 6 month and the Municipal Corporation of Delhi was forced to shut down the plant due to its poor performance. Another incineration plant was constructed at BARC, Trombay (near Mumbai) for burning only the institutional waste, which includes mostly paper and it is working as of this writing. In many cities, small incinerators are used for burning hospital waste.

Gasification technology

Incineration of solid waste under oxygen deficient conditions is called gasification. The objective of gasification has generally been to produce fuel gas, which would be stored and used when required. In India, there are few gasifiers in operation, but they are mostly for burning of biomass such as agro-residues, sawmill dust, and forest wastes. Gasification can also be used for SWM treatment after drying, removing the inerts and shredding for size reduction. Two different designs of gasifiers exist in India. The first one (NERIFIER gasification unit) is installed at Nohar, Hanungarh, Rajasthan by Narvreet Energy Research and Information (NERI) for the burning of agro-wastes, sawmill dust, and forest wastes. The waste-feeding rate is about 50–150 kg/h and its efficiency about 70–80%. About 25% of the fuel gas produced may be recycled back into the system to support the gasification process, and the remaining is recovered and used for power generation.

4. Recovery of recyclable materials

A number of recyclable materials, for example paper, glass, plastic, rubber, ferrous and non-ferrous metals present in the SWM are suitable for recovery and reuse. It has been estimated that the recyclable content varies from 13% to 20% (for example, in Mumbai 17% and in Delhi 15% of SWM is recyclables). A survey conducted by CPCB during 1996 in some Indian Green cities revealed that rag pickers play a key role in SWM. They work day and night to collect the recyclable materials from the streets, bins and disposal sites for their livelihood, and only a small quantity of recyclable materials is left behind them. In India, about 40–80% of plastic waste is recycled compared to 10–15% in the developed nations of the world. However, the recovery rate of paper was 14% of the total paper consumption in 1991, while the global recovery rate was higher at 37%. The role of governments in recovering secondary materials is small compared to the informal sectors. In Delhi, there are more than 100,000 rag pickers and the average quantity of solid waste materials collected by one rag picker is 10–15 kg/day. About 17% of Delhi waste handling is done by rag pickers, who collect, sort and transport waste free of cost, as part of the informal trade in scrap, saving the government Rs 600,000 (US$13,700) daily. In Bangalore, the informal sector is attributed with preventing 15% of the SWM going to the dumpsites. The municipalities in Pune save around Rs. 9 million/yr (US$200,000) on account of waste pickers. In Hyderabad, the cost of SWM per ton is less in the areas where THE private sector participated compared to the areas serviced by municipality. In Mumbai, it is found that the cost of per ton of SWM is US$35 with community participation, US$41 with public private partnership (PPP) and US$44 when only Municipal Corporation of Greater Mumbai (MCGM) handles the SWM. Hence, community participation in SWM is the least cost option and there is a strong case for comprehensively involving community participation in SWM. Many other studies that have been undertaken by different institutes and authorities revealed that the role of the informal sector in SWM is very important because it provides a livelihood to many immigrants and marginalized people. The informal collection avoids environmental costs and reduces capacity problems at dumpsites; also, rag pickers can provide excellent segregation of SWM.

CONCLUSION

Finally, the study concluded that the lack of resources such as financing, infrastructure, suitable planning and data, and leadership, are the main barriers in solid waste management of Green cities in India. The increase of service demands combined with the lack of resources for municipalities are putting a huge strain on the existing SWM systems. Most of the SWM in India is dumped on land in an uncontrolled manner. Such inadequate disposal practices lead to problems that will impair human and animal health and result in economic, environmental and biological losses. Comparing the biological, chemical and thermal treatment options in the Indian scenario, perhaps the biological processing options get the priority. Composting and vermicomposting are successful and quite popular now in India instead of incineration. But, it is slow process and requires a large space. An open dump or an uncontrolled waste disposal area should be rehabilitated. It is advisable to move from open dumping to sanitary land filling in a phased manner. Land filling should be restricted to non-biodegradable, or biological processing. The informal policy of encouraging the public to separate SWM and market it directly to the informal network appears to be a better option. The involvement of people and private sector through NGOs could improve the efficiency of solid waste management of Green cities in India.

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