Municipal Solid Waste Management in India: Present Practices and Future Challenge

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Abstract

Due to rapid urbanization and uncontrolled growth rate of population, municipal solid waste management (MSWM) has become acute in India. MSWM, though an essential service, is given low priority. Lack of financial resources, institutional weaknesses, improper choice of technology and public apathy towards MSW have made this service far from satisfaction. The current practices of the uncontrolled dumping of waste on the outskirts of towns/cities have created a serious environmental and public health problem.

The focus of the present paper is to evaluate the present situation of MSWM in India based on published information and NEERI's expertise towards MSWM. An approach to design a sustainable MSWM system to meet the future challenge is presented. The expertise of NEERI towards MSWM has provided extensive services to various municipal bodies in improving their MSWM system. Some of the best practices are also detailed. The efforts by a community-based organization to promote a sustainable integrated waste management in mega cities and lessons learnt from EXNORA's Zero Waste Management Scheme in South Indian cities has also been outlined.

1.0 Introduction

Urbanization is now becoming a global phenomenon, but its ramifications are more pronounced in developing countries. Natural growth of population, reclassifications of habitation and migration trends are important in urban population in India. The population of urban India was 285 million as per 2001 census, which accounts for 27 per percent of the total population. Global experience shows that when a country's urban population reaches almost 25% of the overall population (as in the case of India), the pace of urbanization accelerates (Kumar and Gaikwad, 2004).

Due to rapid urbanization and uncontrolled growth rate of population, SWM has become acute in India. Municipal bodies in India render SWM services. Though, it is an essential service, it is not attaining proper priority, which it deserves and services are poor. NEERI has provided extensive services to municipal bodies in India to improve their MSWM system.

The present paper aims to outline the existing situation of SWMS, problems associated with the system and also highlights some best practices and lessons learnt by NEERI's experience along with EXNORA's Zero Waste Management in two South Indian cities. An approach for design of sustainable SWMS compatible to Indian situations is also detailed.

2.0 Situation Analysis

MSWM is a part of public health and sanitation, and is entrusted to the municipal government for execution. Presently, the systems are assuming larger importance due to population explosion in municipal areas, legal intervention, emergence of newer technologies and rising public awareness towards cleanliness (Kumar *et al.*, 2004).

Except in the metropolitan cities, SWM is the responsibility of a health officer who is assisted by the engineering department in the transportation work. The activity is mostly labor intensive, and 2-3 workers are provided per 1000 residents served. The municipal agencies spend 5-25% of their budget on SWM, which is Rs. 75-250 per capita per year (Kumar and Gaikwad, 2004)**.** Normally a city of 1 million populations spends around Rs. 10 crores for this activity. In spite of this huge expenditure, services are not provided to the desired level.

Quantity and characteristics are two major factors, which are considered as the basis for the design of efficient, cost effective and environmentally compatible waste management system. The municipal corporation often depends on the vehicle trips record to estimate the waste quantity. This does not give the actual picture of waste generation. NEERI has conducted extensive studies on quantum of waste generation in various cities. Studies have revealed that quantum of waste generation varies between 0.2-0.4 kg/capita/day in the urban centers and it goes up to 0.5 kg/capita/day in metropolitan cities. Per capita waste quantity for various cities with different population is presented in Table 1.The physico-chemical characteristics of MSW in Indian Cities are presented in Table 2.

Characterization studies carried out by NEERI (1996) indicate that MSW contains large organic fraction (30-40%), ash and fine earth (30-40%), paper (3-6%) along with plastic glass and metal (each less than 1%), calorific value of refuse ranges between 800-1000 kcal/kg and C/N ratio ranges between 20 and 30. Presently, NEERI has again been retained by Central Pollution Control Board (CPCB), New Delhi in quantification and characterization of MSW in metro, class I & class II cities and towns to know the actual quantities as well as characteristics of solid wastes in designing MSWM system. The study would be completed in October 2005. Community bin collection system is usually practiced in India.

The collection bin and implements used in various cities are not properly designed. It has been observed that community bins have not been installed at proper location. This has resulted in poor collection efficiency. Lack of public awareness has made the situation worse. Various types of vehicles are used for transportation of waste to the disposal site. However, these vehicles are not designed as per requirement. In many urban centers, proper garages are not provided for the vehicles for protection from heat and rain. Preventive maintenance system is not adopted and as a result the life of the vehicle is reduced. Many of the vehicles used for transportation of waste have outlived their normal life.

Manual composting is carried out in smaller urban centres. Although in 1980's mechanical composting plants were set up in 10 cities, presently, only one plant out of them continues to be in operation. Over the years, a few more plants have been set up. Incineration has not been successful due to the low calorific value of the solid waste. Waste is disposed of in low-lying areas without taking any precautions and without any operational control. Solid waste workers handle the waste without any protective equipment and are prone to infection.

3.0 Future Scenario

The urban population of 285 million is concentrated in a few large cities and 32 metropolitan cities are accounting for 34.5 percent of the urban population that is expected to reach 341 million by 2010

(census of India, 2001). The waste quantities are estimated to increase from 46 million tonnes in 2001 to 65 million tonnes in 2010 (Kumar and Gaikwad, 2004).

The waste characteristics are expected to change due to urbanization, increased commercialization and standard of living. The present trend indicates that the paper and plastics content will increase while the organic content will decrease. The ash and earth content is also expected to decrease mainly due to an increase in the paved surface. Although, the organic content is expected to decrease, the material will still be amenable to biodegradation and the calorific value will continue to be unsuitable for incineration.

In keeping with the present practices and estimates of waste generation, around 90% of the generated wastes are land filled requiring around 1200 hectare of land every year with an average depth of 3 m. Due to rapid urbanization, prevailing land use regulation and completing demands for available land, it is desirable that adequate land be earmarked at the planning stage itself for solid waste disposal. The larger quantities of solid waste and higher degree of urbanization will necessitate better management involving a higher level of expenditure on manpower and equipment.

4.0 Problems Associated with the System

SWM systems exist in most of the urban centres since last few decades. However, these systems have yet to emerge as a well-organized practice. Although, the solid waste characteristics in different urban centers vary significantly, there is a meager effort to tailor the system configuration to the waste characteristics. The major deficiencies associated with the system are described in the following sections (Kumar and Gaikwad, 2004).

Rapidly Increasing Areas to be Served and Quantity of Waste

The solid waste quantities generated in urban centres are increasing due to rise in the population and increase in the per capita waste generation rate. The increasing solid waste quantities and the areas to be served strain the existing SWM system.

Inadequate Resources

While allocating resources including finance, SWM is assigned with a low priority resulting in inadequate provision of funds. Often there is a common budget for collection and treatment of sewage and SWM and the later receives a minor share of the funds. The inadequacy of human resource is mainly due to the absence of suitably trained staff.

Inappropriate Technology

The equipment and machinery presently used in the system are usually that which have been developed for general purpose or that which have been adopted from other industry. This results in underutilization of existing resources and lowering of the efficiency. A few attempts have been made to borrow the technology developed in other countries like highly mechanized compost plants, incinerator-cum-power plants, compactor vehicles *etc*. However, these attempts have met with little success, since, the solid waste characteristics and local conditions in India are much different from those for which the technology is developed.

Disproportionately High Cost of Manpower

Mostly out of the total expenditure, around 90% is accounted for manpower of which major portion is utilized for collection. Since citizens tend to throw the waste on the adjoining road and outside the bin, the work of the collection staff is increased. Hence, the cost of collection increases considerably.

Societal and Management Apathy

The operational efficiency of SWM depends on the active participation of both the municipal agency and the citizens. Since the social status of SWM is low, there is a strong apathy towards it, which can be seen from the uncollected waste in many areas and the deterioration of aesthetic and environmental quality at the uncontrolled disposal sites.

Low Efficiency of the System

The SWM system is unplanned and is operated in an unscientific way. Neither the work norms are specified nor the work of collection staff appropriately supervised. The vehicles are poorly maintained and no schedule is observed for preventive maintenance. Due to shortage of financial resources, the vehicles are often used beyond their economical life resulting in inefficient operation. Further, there is no co-ordination of activities between different components of the system. The cumulative effect of all these factors is an inefficient SWM system.

5.0 NEERI's Contribution towards MSWM in India

Since last three decades, at NEERI, SWM Division has been carrying research, development and expertise extension programme to improve the status of waste management in the country. In order to perform practice-driven research, NEERI has been consistently working with the partnership of related organizations in the country.

The prominent best practices evolved during the last five years, are described below:

- Preparation of strategy paper on SWM in India;
- Long term planning of SWM;
- Biomethanation of vegetable market wastes;
- Greenhouse gas inventory estimation for waste sector, its uncertainty analysis and formulated measures to mitigate the same;
- Utilization of landfill site for construction of Rail Car Depot;
- Site selection criteria for sanitary landfills;
- Utilization of residue from destruction of soiled currency notes;

NEERI has successfully developed strategic long-term plans for a number of cities including metropolitan cities like Mumbai, Delhi and Islands like Lakshadweep and Port Blair, among which many municipalities adopted the plan. NEERI is also assisting in implementation of the long-term plans. NEERI has been actively engaged in various ecosystems like Island areas such as Lakshadweep, coastal areas such as Mumbai and others metropolitan cities and towns having different geographical, climatologically and social environment in the country.

6.0 Lessons Learnt from NEERI`S contribution and EXNORA'S Zero's Waste Management Scheme

The involvement of NEERI in SWM activity emphasizes that the improvement of system needs to be developed addressing the following issues:

- Financial weakness of managing agency;

- Difficulties in changing the prevailing nature of infrastructure service;
- Low recycling potential of waste material;
- Non-availability of skilled labors;
- Societal and managerial apathy.

EXNORA, a local non-governmental organization (NGO) based on a 'zero waste management scheme' set up, run and financed by the residents themselves. EXNORA, which is an acronym for` Excellent Novel Radical `, has been driving the environmentalist movement for sustainable urban development In Chennai (INDIA) since 1989. It has been promoting community-based projects in areas where the local government is unable to provide sufficient service. EXNORA believes that area-based project led by the local community is an ideal way to spread environmental, social &civic messages resulting in a more equal and responsible society (Colon and Fawcett, 2005).

EXNORA identified SWM as a medium to promote a new model of society based on participative democracy. It places SWM at the core of society: its moral values, its social structure, its lifestyle, its economics and politics. The model itself raises the fundamental issue of governance. It is an idealistic model because if it were to work as originally envisaged it suggests that citizens would no longer need local government for the provision of basic needs such as a clean environment. It stresses the need for local bodies to be more aware of people's concerns and for citizens to be more involved in civic affairs. This model has been implemented in two communities *viz.* Chennai and Hyderabad. Results from two Indian cities, indicate limited success of the schemes both in saving a significant fraction of the generated waste from dumping, and in rehabilitating the local poor. However, they show that motivated individuals can successfully set up and manage waste collection systems that lead to overall environmental improvements. The system advocated by EXNORA seems to require significant local resources, and political and technical support which are hard to find and sustain without strong local leaders. This is based on triangular contracts between the municipality, the residents and micro-enterprises and may provide a good solution in dealing with the technical and commercial aspects which communities find difficult (Colon and Fawcett, 2005).

7.0 Design of Appropriate Waste Management System

An approach to design sustainable waste management system and operating guidelines is outlined below.

Quantity and Characteristics

Quantity and characteristics of the waste are the major factors, which decide magnitude of waste management problem. It is necessary to carry out weighment exercise regularly to assess the quantity of waste. Future per capita quantity can be estimated with the help of projected population and annual increase of per capita quantity. On the basis of the waste quantity, infrastructure requirement can be estimated. It is also necessary to carry out characterization studies frequently in order to assess the changes in waste characteristics due to ever-changing scenario. This data will also serve as a basis for selection of disposal/treatment option.

Collection of Waste

Properly designed collection bins and implements should be used for collection and storage of waste. Wastes should be collected frequently in order to avoid accumulation, which leads to degradation of environmental and aesthetic quality. Suggested collection frequencies for cities with different population ranges have been presented in Table 3. Suggestion from the citizen as well as workers for improvement in the design of bins and implements will be useful. Spacing and location of the bins

should be fixed on the basis of the waste load and public opinion. House to house collection system can be introduced gradually to ensure environment friendly collection practices.

Transportation of Waste

Selection of properly designed vehicles is important. Various factors like width of the road, transport volume, road conditions, *etc*. play important role in selection of vehicles. Proper garage should be provided to save the vehicles from wear and tear due to heat and rain. Preventing maintenance system should be introduced which is useful for longer life of the vehicles. Vehicle route should be properly planned for proper utilization of manpower, saving of fuel and reduction of time. Time and motion study should be conducted to reduce the non-productive idle time of the vehicles and increase productivity.

Disposal of Waste

Sanitary landfill technique should be adopted for disposal for waste. Compaction of waste should be carried out regularly preferably with bulldozer. A daily earth cover of 15 cm thickness and final cover of 60 cm thickness should be applied over the compacted waste. These practices will minimize migration of leachate through soil strata, suppress the foul odor and improve the aesthetic quality. Impervious clay liner/synthetic liner should be provided at the bottom of the landfill for protection of groundwater from environmental pollution. Perforate polyvinyl chloride (PVC) pipe can be provided for leachate collection. It is also desirable to install gas collection and flaring system to prevent continuous escape of methane in the surrounding atmosphere.

Treatment/Recycling of Waste

Composting is the process of decomposition and stabilization of organic matter under controlled condition. Since India is an agriculture-based country, there is a need for popularization of the product among the farmers and to exploit the manure value of the product. Waste minimization, through segregation of recyclable materials like plastics, glass, metals, *etc*. is another aspect, which needs special attention. NGOs may come forward to promote the activity. Waste pickers may be trained so that the segregation of recyclable items can be done in a more systematic and organized way.

Financial Structure

A new tax scheme can be introduced to meet the expenditure for modernization of SWM system and to improve the financial status of municipal corporation. Additional charges can be collected from the individuals availing house-to-house collection facility.

Community Participation

Community participation is essential for smooth and efficient operation of SWM system. In every area, citizen forums should be formed. These forums should comprise citizen’s representatives, social workers and municipal officers. Immediate action based on feedback from such forum will go a long way in improving the situation. Various programmes should be conducted for increasing public awareness.

8.0 Conclusion

SWM is a vital, ongoing and large public service system, which needs to be efficiently provided to the community to maintain aesthetic and public health standards. Municipal agencies will have to plan and execute the system in keeping with the increasing urban areas and population. There has to be a

systematic effort in the improvement in various factors like institutional arrangement, financial provisions, appropriate technology, operations management, human resource development, public participation and awareness, and policy and legal framework for an integrated SWM system. To achieve Cleanliness, which is next to Godliness, it is necessary to design and operate an efficient SWM system. Public co-operation is essential for successful operation of such a system. Finally, there is a also a need do develop a methodology of research for developing interactive techniques for system's design and operational control as indicated in Figure 1.

References

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Table 1

Per Capita Quantity of Municipal Solid Waste in Indian Cities (NEERI, 1996)

Population Range (in million)	Average Per Capita Value kg/capita/per day
1.0 – 0.5	0.21
0.5 – 1.0	0.25
1.0 – 2.0	0.27
2.0 – 5.0	0.35
> 5.0	0.50

Table 2

Physico-chemical Characteristics of MSW in Indian Cities (NEERI, 1996)

Population range (in million)	Number of cities surveyed	Paper*	Rubber*, leather and synthetics	Glass*	Metals*	Total* compos-table matter	Inert* material	Nitrogen^{+} as Total Nitrogen	Phosphorous^{+} as P_2O_5	Potassium^{+} as K_2O	C/N ratio	Calorific value in Kcal/kg
0.1 to 0.5	12	2.91	0.78	0.56	0.33	44.57	43.59	0.71	0.63	0.83	30.94	1009.89
0.5 to 1.0	15	2.95	0.73	0.35	0.32	40.04	48.38	0.66	0.56	0.69	21.13	900.61
1.0 to 2.0	9	4.71	0.71	0.46	0.49	38.95	44.73	0.64	0.82	0.72	23.68	980.05
2.0 to 5.0	3	3.18	0.48	0.48	0.59	56.67	49.07	0.56	0.69	0.78	22.45	907.18
>5	4	6.43	0.28	0.94	0.80	30.84	53.90	0.56	0.52	0.52	30.11	800.70

* All values are in percent, and are calculated on wet weight basis

+ All values are in percent, and are calculated on dry weight basis

Table 3

Collection Frequency of Solid Waste (NEERI, 1996)

Types of Locality	Frequency	
	Class I Cities (> 1 lakh population)	**Class II Cities (< 1 lakh population)**
Residential Areas		
Area with high population density	Once or twice a day	Once a day
Area with medium population density	Once or twice a day	Once in two days
High income and VIP area	Once or twice a day	Once a day
Area with low population density	Once in two days	Once in three days
Markets	Once or twice a day	Once or twice a day
Commercial areas	Twice a day	Once a day
Industrial areas	Once a day	Once a day

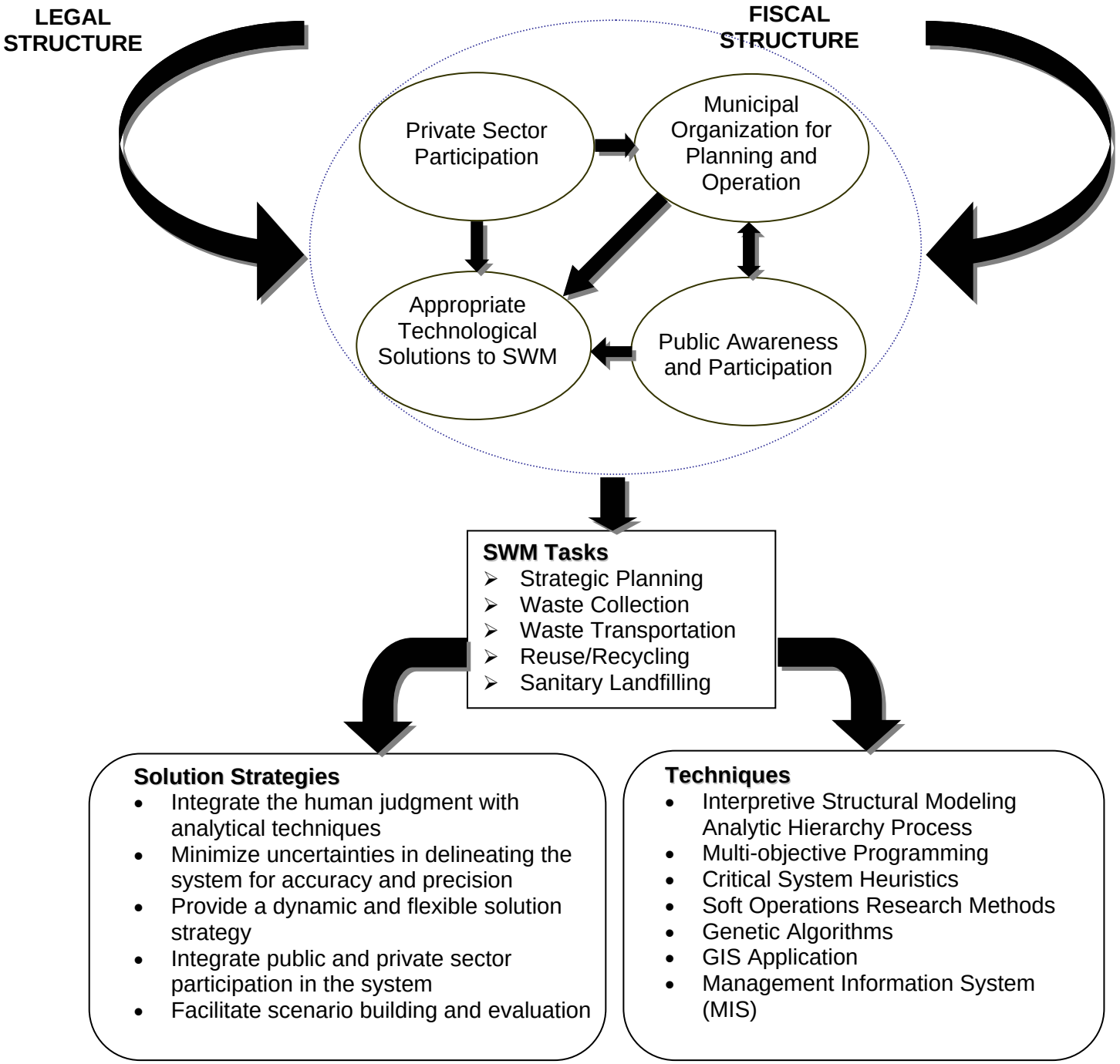

Figure 1
Methodology of Research for Developing Interactive Techniques for System's Design and Operational Control