

INTEGRATED MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM TO REALIZE SUSTAINABLE HABITATS

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Abstract

Unregulated urbanization and rapid population growth is overwhelming the capacity of the most of the municipal authorities which are struggling even to provide the most basic urban utility services. Solid waste which is a by-product of the swiftly changing consumption patterns and lifestyles of urban populace has huge negative output in the form of different forms of waste. The waste is being generated at distressing rate and has greater degradation impact not only on the immediate urban environment but beyond. Hence managing and handling the solid waste is of immediate concern to protect the urban environment from further degradation. Solid Waste Management (SWM) is invariably influenced by regional, social and environmental dimensions of the urban communities. Therefore strategies for SWM system should be environmentally operative, socially acceptable, technically feasible and most importantly economically viable. Against this backdrop, this paper attempts to analyse the prevailing critical conditions pertaining to Municipal Solid Waste Management (MSWM) considering Bangalore Metropolitan Area as a case study. Further, paper deliberates recommendations and strategies for promoting integrated municipal solid waste management system to become the fundamental tool in the planning of urban physical infrastructure to ensure advantageous atmosphere to realize sustainable habitats.

Key Words: Municipal Solid Waste Management, Urban communities, Utility services, Urban environment, Sustainable Habitats

1. Introduction

Swiftly changing consumption patterns and lifestyles of urban populace has huge negative output in the form of different types of wastes (in solid, liquid and gaseous forms) being generated at distressing rate

which has greater degradation impact not only on the immediate urban environment but beyond. Solid waste which is a by-product of human activities literally can be referred as valueless or useless materials and hence disposal may be preferred rather than use. The lack of usefulness or value is majorly due to the mixed and often unknown composition of the waste. The recyclable value of the waste decreases as the unsegregated mix composition increases (Refer Fig. 1). Solid waste generally includes domestic waste, organic and inorganic waste, non-hazardous and hazardous waste from different sources (institutions, commercial organizations, construction sites, factories, industries, etc.), sewage sludge, etc. requiring specific methods of collection, segregation, recycling, disposal and management.

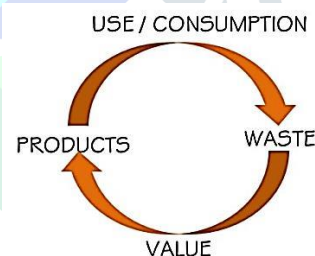


Fig. 1 Relationship between waste and value

Source: Authors

Across the globe, 1.3 billion tonnes of municipal solid waste (MSW) is generated each year and more than 70% of this waste is either unscientifically landfilled or incinerated. The composition of solid waste varies seasonally and geographically from place to place. Domestic solid waste is more heterogeneous in comparison with the more homogeneous accumulation of solid waste from other sources.

1.1 Solid Waste Management (SWM) System

SWM is invariably influenced by regional, social and environmental dimensions of the urban communities. Hence, strategies for SWM system should be environmentally operative, socially acceptable, technically feasible and most importantly economically viable. Thus SWM system is interconnected with the waste generation control,

collection, storage, segregation, processing, transporting, recycling and disposing with due considerations for societal attitude, public health, economy and environmental conservation. Structuring and operating the different functional elements of efficient SWM system is majorly impacted from the informed knowledge of the sources, types and composition along with the rate at which solid waste is generated and disposed is highly indispensable and vital (Refer Fig. 2).

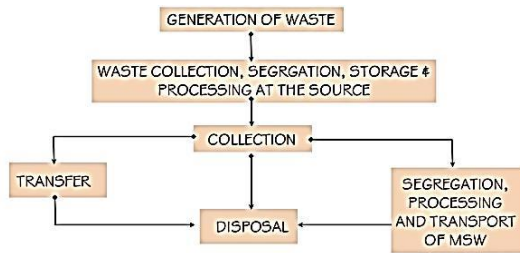


Fig. 2 Relationship between waste and value

Source: Authors

2. Current status of Solid Waste Management (SWM) in India

India, as one of the fastest growing economies in the world generates close to 65 million tonnes of solid waste on daily basis of which 75% remains untreated and it has infamously acquired the place among the top ten countries generating highest amount of Municipal Solid Waste (MSW).

2.1. Municipal Solid Waste Management (MSWM) - An Urban Challenge

Unregulated urbanization and rapid population growth is overwhelming the capacity of the most of the municipal authorities which are struggling even to provide the most basic urban utility services. At present the SWM is exclusively a service provided by the Urban Local Body (ULB) under its Health Department. But certain ULBs of greater metropolitan areas have established SWM departments to carry out SWM under the guidelines of Solid Waste (Management & Handling) Regulations, 2000. ULBs of the most cities are inadequately equipped to handle the most crucial issue of MSWM owing to inefficient implementation, operational and monitoring mechanisms at key areas (Refer Table 1).

Sl. No.	Key Area	Issues
1	Policy and statutory norms	Absence of guiding framework and regulations for effective enforcement and monitoring
2	Institutional organization	Non-existence of clearly defined roles and responsibilities of MSWM personnel and staff coupled with insufficient economic instruments. Absence of framework for capacity building and skill enhancement training. Unavailability of standards to assess quality of services and accountability. Non-favourable conditions for the private player in MSWM system.
3	Financial	Insufficient funds for developing MSWM infrastructure and absence of incentives for market development.
4	Different stakeholders	Inefficient means of communication to bring awareness among different stakeholders across all the levels.
5	Operational mechanism and Technical upgradation	Inappropriate standards and methods of MSWM and lack of facilities for treatment and resource recovery / recycling.

Table 1: Crucial issues pertaining to MSWM System in ULBs

Source: Authors

3. MSWM – A Case of Bangalore Metropolitan City, India

Over the past seventy years, Bangalore, the capital city famously referred as Silicon Valley of India has transformed from being a non-descript small town into metropolis. Bangalore, ranked as the most dynamic city in the world adds about 500 families and 80,000SqM of built up area per day owing to the economic reforms that are accelerating the pace of urbanisation. The transformation of the city has been exceptionally marked by several phases of investments/developments in various socio-economic sectors (public and private), remarkable demographic growth as well as flourishing informal economy. This rapid and dynamic urban growth is leading to high waste generation per capita and also increasing the unsegregated MSW from 650 Tonnes

per Day (TPD) in 1990s to 5200 TPD in 2017 from various sources (Refer Table 2).

Sl. No.	Source	Percentage of waste generated	Type of waste generated
1	Domestic	54%	Organic, inorganic (recyclable) and non-recyclable inorganic including debris, inert, bio-medical and hazardous waste
2	Educational & medical Institutions, Commercial Establishments	17%	
3	Market areas	20%	
4	Others	9%	

Table 2: Percentage of waste generated from various categories

Source: BBMP, Bangalore

The issue of unscientific solid waste disposal in landfills intensified in the year 2012 following the agitations that resulted in the closure order of Mavallipura landfill site from the Karnataka State Pollution Control Board (KSPCB) citing increasing hazardous conditions in and around Mavallipura rural area.

Cumulative effects of increasing demographic profile and consumerism pattern of Bangalore city is going to increase multi fold in the average MSW generated on daily base. In this situation, it is of utmost importance to understand and analyse the shortcomings of the current mechanism of MSWM system to develop integrated system to structure better MSW management in order to reduce the amount of waste disposed in landfills.

Table 3: MSW collection and disposal

Source: BBMP, Bangalore

BBMP has also attempted several SWM initiatives such as at source segregation at ward and city levels, dry waste collection centres, compost Development Corporation, etc. to facilitate destination bound processing of SWM. But these initiatives are neither correlated nor integrated into the entire MSWM system resulting in major inadequacies across different domains (Refer Table 4).

3.1 Current Practices

At present Bruhat Bangalore Mahanagara Palike (BBMP) manages 70% and the remaining 30% of MSW is outsourced to private contractors on contract base via primary and secondary collection and disposal (Refer Table 2 & 3). However, collection of MSW from bulk generators (such as apartment complexes, institutional and office campuses, etc.) is not part of the service contract. The outsourced service contract also outlines scope of work with respect to the importance of waste segregation both at the primary and secondary sources of collection.

Sl. No.	Primary Collection	Secondary Collection
1	Pushcarts and auto tippers are used for door-to-door collection	MSW from primary collection is brought to several identified secondary collection sites in each BBMP wards and is shifted to the transportation vehicles to transfer it to either treatment plant or disposal areas.
2	Sweepers appointed by BBMP (around 4500) and private contractors (around 13000) carry out primary collection.	BBMP and private contractors use MSW transportation vehicles such as tipper lorries, mechanical sweepers, dumper placers and compactors for secondary collection.

Sl. No.	General	Domestic	Other SWM sources	Administrative structure	Contract agreement	Process & monitoring systems	Policy initiative
1	Waste segregation is not enforced in an organised manner.	Considerable lack of awareness on the methods of waste segregation.	Restricted operation timings of collection and transfer of MSW generated results in decay of the wet waste as well as accumulation of added MSW till it is collected the next shift.	Absence of crucial and effective monitoring mechanism.	Lack of accountability and better monitoring systems to achieve desired results.	Lack of authentic data to measure the performance of the service provider.	Normative standards in policies continue to direct the performance of MSWM system.
2	No formal system to collect systematically segregated waste from the sources	In cases if the community is aware of the importance of segregation at source, the implementation of the same is not followed stringently.	Lack of system to address the problems of littering and the defaulters.	Organizational structure is not decentralised	Current system of contracts restricts the effective role of non-government organisations, self-help groups, resident welfare associations, etc.	Efficient monitoring systems for regularity and penalty system for defaulters are not in place leading to under performance of both BBMP and contract workers.	Policy of Integrated Solid waste Management, 2012 lacks the ways of both incentivizing or disincentivizing different stakeholders and inhabitants for carrying out the process of scientific management of MSWM.
3	MSW is transferred manually and the lack of complete door-to-door collection the segregated dry waste does not reach dry waste collection centres.	Aspects such as level of segregation at source, primary & secondary collection, etc. are not standardised across the jurisdictions.	Segregated waste is mixed during the process of collection and transfer.	Need to develop adequate training methods for capacity building.	Collection of segregated waste is non-incentive for the contractors as the payment is by weight of the MSW collected.	Absence of standards for collection, segregation, storage, recycling and disposal.	Policy lacks effective implementing mechanisms and the citizen participation in service delivery.
4	Restricted operation timings of secondary collection sites resulting in non-cleared MSW for the day.	Only 40% of the households segregate waste. However, this gets mixed during the process of collection owing to the fact of unscientific and inefficient	Non-participation and lack of awareness regarding MSW management initiatives.	Lack of role clarity and in house limited resources leading to inefficient performance of ULBs.	Technological interface is not being adopted adequately for monitoring on-ground performances.	Lack of training for the on ground workers and are not adequately equipped with safety gear to carry out the assigned tasks resulting in health	The policy does not include the standards to be followed for assessment and monitoring the service provider's performance.

		methods of collection.				hazard and decreased performance.	
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Table 4: Major inadequacies of the current MSWM system practiced by BBMP across different domains*Source: Authors*

Different inadequacies mentioned in the Table 3 indicate that the current MSWM system is inefficient and under staffed dysfunctional system owing to the organizational and technical issues. Absence of operating as well as implementing/monitoring mechanisms incorporating the effective use of progressive technology coupled with under trained personnel is adding to the already disadvantaged of MSWM system.

Relatively, most of the metropolitan cities and urban areas in India are facing similar types of issues pertaining to MSWM. Hence developing the infrastructure for efficient and effective MSWM plays a key role in protecting the urban environments and it is fundamental to achieving sustained economic growth and sustainable development in the holistic sense.

4. Integrated Municipal Solid Waste Management System (IMSWM systems) – Recommendations

Urban communities need to divert much of the MSW from landfills and incinerators through integrated, innovative and workable methods. Following are the recommendations with regard to the formulation, implementation and operational mechanisms for IMSWM system under different domains (Refer Table. 5).

Sl. No.	Domain	Recommendations
1	Key policy reforms	<u>Extended Producers Responsibility (EPR)</u> Regulations need to framed and implemented to enforce EPR so as to make the producers responsible for the waste generated from product packaging. <u>Institutional organisation reform</u> MSWM system should be re-structured to have trained professionals and staff performing clearly defined duties. These personnel should have

		incentives offered in the form of performance based career promotion options and professional skill upgradation programs at subsidized rates.
2	Financial Instruments	Adequate financial instruments are required for the efficient performance of MSWM system. The costs of operation and management can be met through the implementation of innovative means / sources of revenue. Revenue can be generated from sanitation services imposed on commercial establishments, various periodically held community activities, fines imposed on various violations, selling the recovered resources from MSW, compost generated from collected wet waste, etc. The foremost mode of cost recovery is through the generation of wealth from the waste. Capitalising on the methane generated from the dumpsites, a large number of landfill gas capture projects should be initiated. This can be monetized in the form of certified emission reductions or carbon credits. Besides the traditional sources of revenue (property tax, grants, user fee, etc.) new income sources are needed. Innovative sources of revenue such as the levy of MSWM

		<p>tax along with property taxes, separate solid waste user fee and charges linked to utility facilities (water & electricity) must be considered by ULBs.</p> <p>Biofuels and renewable chemicals from MSW: MSW can be used as a feedstock to produce biofuels and renewable chemicals. This particular method provides a sustainable alternative to the challenges associated with the disposal of non-recyclable as well as non-compostable waste and crafts value added products.</p>			<p>adequate staffing is essential but investment in periodic training is equally essential for both supervisory staff and field staff.</p>
3	MSWM System	<p>Upgrading Dry Waste Collection Centres (DWCC) to MSWM Centres These existing DWCC should be upgraded to MSWM Centres operating at ward levels in collaboration with municipal authority. These centres should have facilities for collecting scientifically collected and segregated waste for further sorting as recyclables and for final disposal of the waste which is beyond any sort of recycling. MSWM Centres should extend support to the urban community at various levels for handling MSW in the form of ready reference guidelines on MSW segregation, usage demonstration and sale of standardised materials/tools related to SWM, etc.</p> <p>Adequate Staffing and periodic training: MSWM system is highly labour intensive service and hence not only</p>	4	Employment	<p>Wastes are potential resources and extraction of the resources till the final stage is the key aspect for effective MSWM. This aspect supports many avenues of employment for skilled and unskilled labour at various scales. The professional experience of informal waste pickers could be capitalised on by organising and formalising them under certain associations. Once formally recognised, they can be provided with social security and health care facility not only improving their livelihoods but providing them with dignity of recognition.</p>
			5	Public-Private-Partnerships (PPP)	<p>PPP based on well framed contract and action plans should be encouraged at all the stages of MSWM system. Contracting models should preferably performance based and payment to the private player should be measured using quality of service as the benchmark. The contract should clearly outline the accountability of the private player for the efficiency and effectiveness of the service.</p>
			6	Involving different stake holders for better monitoring and accountability	<p>Citizens / Social Volunteers / NGOs / SHGs / RWAs / Associations / Schools & Colleges, etc. should be involved in consultation, planning and decision making processes</p>

		<p>through diverse modes such as periodic performance reports, digital mediums (social networking sites, mobile phone applications, etc.) to improve the MSWM system. Various innovative incentive schemes (such as free collection of MSW for a specific time period, redeemable coupons, recognition and rewards, etc.) can be provided as a token of motivation and encouragement to best performing individuals and communities in the management of MSW.</p> <p>Monitoring and tackling defaulters: Various modes such as awareness campaigns, personal and mass media should be used to generate accountability for citizens. Monitoring Information System needs to be developed at ward levels and should include schedule of MSW services, interactive maps, etc. to streamline the MSWM system while facilitating a better system to tackle the defaulters.</p>
7	Segregation is the key	<p>High positive impact of social value of segregation is inevitably linked to the greater extent of segregation. Segregation at source would help in resource recovery at the least possible cost. The quantity and composition of MSW generated determines the appropriate means of collection, segregation, processing, recovery and the final disposal options. Segregation at the source (domestic, commercial</p>

		<p>establishments, institutions, campuses, etc.) is vital as the segregation post the collection stage is highly labour intensive, difficult task and costly affair. Segregation can be made an easy process by standardising the collection bins and related signage. MSWM staff and private players should be allowed to take a share of returns from the recovery of recyclable waste.</p>
8	Promoting zero waste campuses and organizations	<p>There are no current industry standards for the term 'Zero waste'. But communities, commerce and industries that achieve more than 90% diversion of waste from landfills and incinerators are considered acceptable in achieving zero waste.</p>
9	Environmental Impact Assessment (EIA) of MSWM system	<p>Periodic EIA to develop long term strategy should be made mandatory for MSWM system to facilitate not only the analysis of service gaps but to mitigate the environmental consequences of inadequate functioning. ULBs must ensure to address the concerns and implement the recommendations the governing authority.</p>

Table 5: Recommendations for IMSWM System under different domains

Source: Authors

5. Way forward

Various significant challenges must be prioritized with short term and long term strategies. Scientific implementation of the recommendations under IMSWM could lead to the transformation of MSWM from being focussed on delivery of service to managing resources for the future. Three governance aspects namely Proactive policies along with structured institutions, inclusivity (both users and

service providers) and economic sustainability are critical for sustainable MSWM system. Further, waste should be considered as a largely untapped opportunity to recover resources, realize environmental-social-economic benefits. Reorganising MSWM on a life-cycle basis could lead to green economy. An IMSWM system if incorporated in MSWM will contribute in developing sustainable habitats by:

- Improving economic efficiency through resource extraction and use in turn reducing the budgetary requirements for MSWM system.
- Reducing adverse impact on public health and the local urban environment
- creating sources of employment
- Spatially and socially accessible urban environment.

IMSWM has to become the integral part of the urban environment and planning of the modern infrastructure to ensure a conducive atmosphere while promoting sustainable habitats.

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Bhagyalaxmi's professional as well as academic experiences prompted her to author and present papers (national & international) that deliberate on the crucial components and the strong relation among architectural education-research-practice. Workshops, competitions, research programs, discussions, conferences and professional training courses that feature architectural practice, urban, human habitat, ecological development and pedagogical issues interest her and hence she continues to participate in such undertakings.

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- Srinivasarao, A. P. & M., 2014. Municipal Solid Waste Management in India: A Review and some New Results. *International Journal of Civil Engineering and Technology*, 5(2), pp. 1-8.

7. References

- Asnani, P. U., 2006. Solid Waste Management. Chapter 8 in *India Infrastructure Report*. Oxford University Press, New Delhi
- Balakrishna, P. & H., 2014. Municipal Solid Waste Collection and Disposal in Bengaluru City - A Review. *International Journal of Engineering Research & Technology*, 3(7), pp. 137-141.
- Central Public Health and Environmental Engineering Organisation (2014), *Draft Municipal Solid Waste Management Manual*, Ministry of Urban Development, Government of India, New Delhi.
- Department of Environment Cell, 2012, *Policy on Integrated Solid Waste Management*, BBMP
- Gupta, N. G. & R., 2015. Solid Waste Management and sustainable cities in India: the case of Chandigarh. *Environment & Urbanisation*, Volume 27(2), pp. 573-588.
- Kaushal RK, Varghese GK, Chabukdhara M. 2012 Municipal solid waste management in India—current state and future challenges: a review. *Int. J. Eng. Sci. Technol.* 4, 1473–1489.
- Pandit, V. K. & R., 2013. Problems of Solid Waste Management in Indian Cities. *International Journal of Scientific and Research Publication*, 3(3), pp. 1-9.
- Parvathamma, G., 2014. An Analytical Study on Problems and Policies of Solid Waste Management in India - Special Reference to Bangalore City. *Journal of Environmental Science, Toxicology and Food Technology*, 8(10), pp. 06-15.
- PV, N. B. a. S., 2016. Solid Waste Management in Bengaluru - Current Scenario and Future Challenges. *Innovative Energy & Research*, 5(2), pp. 1-3.
- Ramachandra, T., 2006. *Management of Municipal Solid Waste*. New Delhi: TERI Press.