





Swachh Bharat Mission - Urban

Guidance on EFFICIENT COLLECTION AND TRANSPORTATION OF MUNICIPAL SOLID WASTE



Central Public Health and Environmental Engineering Organisation (CPHEEO) Ministry of Housing and Urban Affairs Government of India

www.swachhbharaturban.gov.in | www.cpheeo.gov.in

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हरदीप एस पुरी HARDEEP S PURI



आवासन और शहरी कार्य राज्य मंत्री (स्वतंत्र प्रभार) नागर विमानन राज्य मंत्री (स्वतंत्र प्रभार) वाणिज्य एवं उद्योग राज्य मंत्री भारत सरकार Minister of State (IC), Housing & Urban Affairs Minister of State (IC), Civil Aviation Minister of State, Commerce & Industry Government of India



As per 2011 census, Urban India contributed 63 percent to the country's GDP that is projected to grow to over 75 percent by 2030 and more than 80 percent by 2050. An unfortunate fallout of this rapid growth, however, is that India's waste crisis is set to spiral, with the country set to generate thrice the amount of waste, that is, 165 million tonnes by 2030 and 436 million tonnes by 2050, leading to augmented public health and environment challenges.

Message

On the global platform, India is one of the signatories to Agenda 2030, the Sustainable Development Goals commitments. Aligned to this is our Hon'ble Prime Minister's commitment to address climate change issues and make India a nation free of single-use plastic. This implies that as a nation, we are committed to making our cities clean, swachh and garbage free for our citizens.

While the Swachh Bharat Mission (Urban) is primarily aimed at achieving these objectives, the challenges of proper collection and transportation of our municipal solid waste, especially in a segregated fashion assumes critical importance for making our cities clean.

This monograph contains various aspects of segregated waste collection and transportation systems with concepts, choice of equipments, manpower and staffing requirements, to be compared and analysed for selecting the best option for a particular ULB. It also contains case studies/practices of different ULBs for understanding various arrangements of collection and transportation being employed by each of them in their unique situations.

It is my firm belief that this booklet will go a long way in making ULBs and Waste Managers resourceful administrators in our collective journey towards a "Swachh, Swasth and Samridhh Bharat".

(Hardeep S Puri)

New Delhi 02 July 2020

दुर्गा शंकर मिश्र सचिव **Durga Shanker Mishra** Secretary





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Foreword

Cities and Urban Local Bodies (ULBs) are engines of economic growth, and any improvement in their working operations leads to a positive impact on the economy. The major expenditure on the part of ULBs, when it comes to solid waste management (SWM) is incurred towards waste collection and transportation.

To bring in efficiency in the management of solid waste, it is imperative to collect and transport waste in a scientific manner. It thus becomes crucial to have a systematic arrangement for collection and transportation of waste. Efficient collection and transportation of waste can effectively resolve and improve various issues in SWM. Conversely, the lack of it results in negative implications on human health, environment, economy and overall sustainability of the ecosystem. Recognizing the importance of this component of waste management, the SWM Rules 2016 have mandated door-to-door segregated collection, storage and efficient transportation of waste.

This booklet deals with upon different aspects of waste collection and transportation including primary & secondary collection coupled with storage and transportation of waste. It covers several best practices, details out the equipment available for collection and transportation and presents select case studies of practices in successful ULBs. It is an attempt by the Ministry to support ULBs and waste managers in taking well-informed and appropriate decisions for strengthening the system of collection and transportation in their areas of operation.

I hope that this booklet will equip various stakeholders of SWM, particularly the ULBs in identifying suitable collection and transportation systems, and customize the same for their respective jurisdictions as they move towards a Swachh, Swasth, Samarth, Samridhh and Atmanirbhar Bharat.

I congratulate the officers of Swachh Bharat Mission- Urban and CPHEEO for bringing out this Guidance Book which I am sure will prove to be of immense use to ULBs across the country.

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(Durga Manker Mishra)

<u>New Delhi</u> July 3, 2020

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Preface

As urbanisation in the country has gained pace, the issue of Municipal Solid waste has emerged as the foremost challenge faced by our ULBs, with an estimated 65 million tonnes of MSW generated by around 400 million urban citizens. The quantum is expected to rapidly increase to 165 million tonnes by 2030 and 436 million tonnes by 2050. Added to this magnitude of waste, there are quality of service issues such as mandatory door-to-door collection and segregation of waste, as laid down in the SWM Rules 2016. The present day collection and transportation (C&T) methods, which by themselves are the largest expenditure heads in waste management by the ULBs, are ill equipped to discharge the targeted, seemingly complicated functions comprehensively and efficiently. The need of the hour for the ULBs is to make their C&T systems resilient, efficient, streamlined, smart and citizen-centric to fulfill the basic door-to-door collection and segregation functions in fail safe manner. Such efficient C&T systems will not only enable and economize the C&T systems in ULBs but also divert more human and capital resources to other areas of waste management, towards sustainable Swachhta.

In keeping with this felt need, Ministry under the Swachh Bharat Mission (Urban) has prepared this Guidance Book on Efficient Collection and Transportation of Municipal Solid Waste containing various aspects of segregated waste collection and transportation systems with concepts, choices of equipment, manpower and staffing requirements, to be compared and analysed for selecting the best option for a particular ULB. It also contains case studies/practices of some successful ULBs for understanding various arrangements of collection and transportation being deployed by them in their unique situations. Our Municipal Commissioners, Chairpersons, City Managers and all stakeholders can benefit from this guidance book and by taking suitable actions, bring savings in the expenditure on C&T of municipal waste.

I take this opportunity to congratulate the CPHEEO team for bringing out this Guidance book and acknowledge the support of the National PMU and the Wash Institute.

New Delhi. 3rd July, 2020

(V.K. Jindal)

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BBMP	Bruhat Bengaluru Mahanagara Palike
CERC	Central Electricity Regulatory Commission
CFL	Compact Fluorescent Lamp
СРСВ	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organization
C&D	Construction and Demolition
E-Waste	Electronic Waste
GeM	Government e-Marketplace
GHG	Green House Gas
ISWM	Integrated Solid Waste Management
LA	Local Authority
LCV	Light Commercial Vehicle
MT	Metric Tonne
MIS	Management Information System
MoHUA	Ministry of Housing and Urban Affairs
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
0&M	Operation and Maintenance
PPM	parts per million
PA	Per Annum
PCC	Pollution Control Committee
PPE	Personal Protection Equipment
РРР	Public Private Partnership
PWD	Public Works Department
RDF	Refuse Derived Fuel
RCC	Reinforced Cement Concrete
RFP	Request for Proposal
RWA	Resident Welfare Association
SHG	Self Help Group
SWM	Solid Waste Management
SPCB	State Pollution Control Board
TPD	Tonnes Per Day
ULB	Urban Local Body

INTRODUCTION

Municipal Solid Waste Management (MSWM) is one of the main functions of all Urban Local Bodies (ULBs) in the country. Because of high visibility factor, MSWM has the highest public perception for cleanliness. Therefore, all ULBs are required to meticulously plan, implement and monitor all urban services delivery especially that of municipal solid waste. With stretched financial resources, limited technical capacities and scarce land availability, urban local bodies are constantly under stress in meeting this challenge. Notwithstanding good performance in other functions by the ULB, any deficiency in service by ULB, whether real or perceived, in MSWM leads to dissatisfaction among the citizens.

In 2014, a cleanliness assessment carried out by the Government of India ranked Indore city of Madhya Pradesh at a dismal 149th position, among 476 cities surveyed. However, three years later in 2017, Indore was adjudged the cleanest city in the country, taking Urban India by storm and setting a new benchmark in urban cleanliness. Over the next two years, Indore applied new practices in collection of waste through zero waste colony/ and zero waste ward by composting wet waste at community level and linking kabari wala with collection of dry waste, thus consolidating its pre-eminent position in Urban India's swachhata landscape, retaining its 'cleanest city' tag without a break since and reducing its burden of garbage processing.

Ambikapur, a small city in Chhattisgarh state had garbage littered everywhere in 2014. In a matter of two years, Ambikapur had not only emerged as Chhattisgarh's cleanest city, but had also set a national level benchmark in decentralized and cost-effective Solid Waste Management. Today, the 'Ambikapur model' has become one of the most well-known phrases in Urban India's 'swachhata' vocabulary.

The common thread in both the above examples has been highly efficient segregation of waste at source by all waste generators, coupled with segregated collection and transportation of the segregated fractions, for their final scientific processing and disposal which is the only way for cleanliness.

As per 2011 census, Urban India contributed 63% to the country's GDP that is projected to grow to over 75% by 2030, and more than 80% by 2050. Moreover, Urban India contributes nearly 80-85% of India's tax revenue. On the other hand, poor sanitation and waste management cost India 5.2% of its GDP. In fact, lack of access to sanitation wiped off US \$106.7 billion from India's GDP in 2015.iAs per a World Bank Report (2006) (the cost escalated to current prices), the per capita per annum burden of poor sanitation is estimated to be Rs. 8,700/-.

In India, In India, an estimated 62 million tonnes/year of Municipal Solid Waste is currently generated in urban areas which is set to spiral to thrice the amount, that is, 165 million tonnes by 2030 and 436 million tonnes by 2050, leading to amplified public health and environment challenges. India is losing 1,250 hectares of precious land every year to landfill the processed/un-processed municipal solid wastes. In fact, the National Green Tribunal has estimated that more than 10,000 hectares of valuable urban land is locked up in the legacy and current dumpsites in India.

While lack of proper Solid waste management affects everyone, the impacts are the hardest on society's most vulnerable poor sections and waste pickers, exposed to mountains of waste dumps, working in unsafe conditions, and suffering serious health repercussions. The environment also pays an unmitigated high price. In fact, indiscriminate disposal of solid waste is not only a threat to the environment but is also leads to various diseases and GHGs. An estimated 1.6 billion tonnes of carbon dioxide– equivalent (CO2-equivalent) greenhouse gas emissions were generated from solid waste management in 2016. This is about 5 percent of global emissions. Without improvements in the SWM sector, solid waste–related emissions are anticipated to increase to 2.6 billion tonnes of CO2- equivalent by 2050. Other adverse impacts of poor waste management include marine contamination, clogging of drains and flooding, transmission of diseases via breeding of vectors, increasing respiratory problems among humans and harming of animals, and affecting economic development, such as through diminished tourism.

In India, in addition to this magnitude of waste, there are quality of service issues such as mandatory door-to-door collection and segregation of waste, as laid down in the SWM Rules 2016. The present day collection and transportation (C&T) methods in Indian cities and towns, which by themselves are the largest expenditure heads in waste management by the ULBs, are not suited to carry out the targeted, seemingly complicated functions comprehensively and efficiently.

Collection and Transportation of municipal solid waste is the crucial component of MSWM as all other related processes can function efficiently only if the collection and transportation of waste is properly done. Collection efficiency is the direct measurement of cleanliness of any ULB and proper transportation represents the reliability and effectiveness of processing MSW and disposal. With emphasis on segregation of waste as mandated in SWM Rules 2016, the collection and transport needs to be of very high efficiency to conserve the gains of segregation till waste is delivered to processing facilities. Thus there is a need to re-engineer the existing collection and transportation system for MSW in Country's ULBs.

The need of the hour therefore is urgent transformation of the current C&T systems to become resilient, efficient, streamlined, smart and citizen-centric to fulfill the basic door-to-door collection and segregation functions. Such efficient C&T systems will not only enable and economize the C&T systems in ULBs but also divert more human and capital resources to other areas of waste management, towards sustainable Swachhta.

Under SBM (Urban), there has been a multi-pronged approach to manage the challenge of Solid Waste Management, with special emphasis on collection and transportation of segregated fractions of waste in unmixed state till their final disposal. Segregation of MSW at source (which also implies that segregated source is collected, transported and processed in a segregated manner), is the most crucial aspect of Solid waste management since this ensures that approximately 80% of the challenge of SWM is addressed. 50% of the waste is wet waste that can be converted into compost, while 20-30% can be recycled, 15-25% non-recyclable combustible can be used in cement industry/ Waste to Energy/ road-construction leaving a minimal quantity to be sent to landfills. In fact, when recyclables are separated from mixed

waste, the value of the waste goes up by about 35% earning decent addition to the meager income of waste collectors.

Towards this, Ministry of Housing and Urban Affairs(MoHUA) is actively encouraging 100% door to door collection of MSW in every ward of cities. To facilitate this, various technological and local governance issues such as app-based collection (e.g. Swachh Nagar app), GPS-enabled transportation vehicles, etc., and the Star Rating of Garbage Free Cities rating system and the Swachh Survekshan cleanliness survey have been put in place.

The last five years of the Swachh Bharat Mission have yielded significant learning, reinforcing the need for cities to have efficient Collection and Transportation systems for effective MSWM. With door to door collection being conducted across 96% of urban wards, a good number of best practices from across the country in efficient Collection and Transportation systems are available, across a wide range of population and geographic settings.

Solid Waste Management Scenario in India

The trend of significant increase in municipal solid waste generation has been recorded worldwide. This is due to population growth, industrialization, urbanization and economic growth. Consumerism and the culture of speed and disposability permeated the lifestyles, resulting in exponential increase in solid waste generation.

The scenario of solid waste management in India is getting complicated continuously but effective solid waste management practices have been lagging. Even today, only a little above half of solid waste generated is disposed through proper treatment. Lack of waste segregated collection is the biggest obstacle in implementing effective solid waste management. Though plastic, metal, glass and paper recycling sectors are growing due to market demands, the improper collection and unavailability of timely transportation are badly affecting their recycling potential resulting in unnecessary economic and livelihood losses.

Efforts are being made by many Local Bodies for creating awareness among the citizens for ensuring proper management of waste including systematic procedures relating to collection, segregation, storage and transportation of wastes. However, such efforts are yet to see established success across the country. Only a few ULBs have achieved success in 100% collection and transportation of waste by establishing waste collection, segregation, storage and transportation. Some ULBs have implemented door to door collection systems through tricycles and mini tippers etc., segregation at the source and separate composting and recycling facilities with great success.

EFFICIENT MANAGEMENT OF MUNICIPAL SOLID WASTE

[1] WASTE MINIMISATION - The MANTRA of AT SOURCE Reduction, Reuse & Recycling

Waste Minimisation at source through the principles of 3Rs (Reduce, Reuse & Recycle) is the first step for effective Municipal Solid Waste Management (MSWM). The onus is on every citizen waste generator to "STOP / Minimize" waste from being generated. The ULB should create public awareness for minimising waste generation and reusing waste to the extent possible. The

Integrated Solid Waste Management (ISWM) hierarchy of waste management prioritises waste minimisation (reduction at source and reuse) as the most preferred waste management strategy (Figure 1).



Figure 1: Waste Minimisation in the ISWM Waste Hierarchy

Waste minimisation succeeds in reducing the quantity and complexity of the wastes generated. It is the most preferred strategy in the hierarchy as it reduces the quantity of waste to be handled and the cost associated with its handling, storage, transport, processing, disposal and its environmental impacts. ULBs therefore should focus on waste minimisation through continuous IEC activities engaging the citizens, children, non-profits, informal sector, recyclers, packaging and plastic industry etc., and incentivisation.

It needs to be understood that efficient segregation and collection of waste by themselves minimize waste generated as significant part of waste is taken away for recycling during the processes. Several policies can be used for minimizing the waste generation. Various actions / methods for waste minimization are as under:

1. Enforcing User Fees/Charges for MSWM services leads to Waste minimization: User charges should be enforced for collection of waste on regular, monthly basis. These should be based on graded approach on quantity i.e. Waste generator of large quantity wastes should pay comparatively higher charges. Similarly, the charges should be graded on the footprint on MSWM service i.e., owners/tenants of big buildings/premises should pay higher charges as compared to hutments. Such gradation will lead to justified

application of the "polluter pays principle" on all categories of waste generators such as domestic/non- domestic, poor/rich, commercial, bulk etc. Once generators realize the cost of MSWM service, it will lead to conscious minimization of waste generation within the premises.

Specimen user charges have been given in the Advisory on Bulk Waste Generators published by the Ministry.

- 2. Enforcing Segregation at source of waste generation leads to waste minimization: Segregation of waste at source of generation when strictly enforced gives huge leverage to waste minimization. Segregation into three basic categories will influence human behavior firstly, towards restricting unnecessary generation (reducing waste) and secondly towards higher reuse and recycling. More items may get retrieved at generation level to be handed over to the kabadiwalas system, to generate some income. This is true for the waste collectors also. Further, the interplay of imposed user fee and segregation benefits will be well understood.
- 3. Changes in Government Policies: Policy of Extended Producer Responsibility (EPR) enforced and implemented by the State reverts the burden of unnecessary waste generation by the manufacturers, producers and packers etc. Strict implementation of Plastic Waste Management Rules such as pouches supplied with sanitary disposables will reduce contamination and enhance value of other wastes. It will reduce non-pickable non- recyclable wastes such as small sachets and packages or other items of insignificant value in waste recycling. Such waste generally gets channeled into water bodies or land and can lead to local and environmental disasters. Buy back policy may be put in place, especially for packaging materials dominated by polystyrene/thermocol. Manufactures, producers, E-Commerce and packaging companies can be made to introduce buy back policy.
- 4. **Government's strict implementation** of associated waste management rules such as the Construction & Demolition Waste Management Rules 2016 and the E-Waste Management Rules 2016 will also lead to waste minimization.
- 5. Process changes in Food and Hospitality Industry: Service/delivery of foods in re-usable/ returnable packing by hotels/ restaurants, street vendors etc. may be mandated. Extra charges for in single use packages may be imposed. Guest services such as toiletries presently in disposable forms may be provided as paid services / larger packages / ondemand at fee services.
- 6. **Strict Implementation of ban on single use plastics**: Ban on Single Use Plastic may be strictly implemented, except in specified cases as Medical requirement.

- 7. Garbage Free and garbage reduction efforts such as reusable steel cutlery in Bartan Bhandars; Donations / exchange of old items/ books (Neki Ki Diwar); Special Repair shop / camps for old items, Safe utilization of left over foods, Behaviour Changes such as my bag/my bottle campaign, Plastic free tourist places and mass-events etc., Utilization of green/food waste for animals etc., can be introduced, operated and serviced by the ULBs to ultimately reduce the waste generation.
- 8. **Reduction of waste load on ULB**: In view of ever increasing waste quantum and limited resources at the disposal of ULB, it should enforce processing of wet waste by bulk waste generators including RWAs, encourage home composting and streamlined on-site waste processing in mandis, markets, gardens, building construction projects etc.

While the aforementioned interventions are effective in waste minimization at the waste generation stage, maximizing value across all components of MSWM value chain will bring best possible efficiencies for the ULBs. Currently, Waste processors and transporters are paid tipping fee on the basis of weight of waste which results in malpractices including mixing of other waste particularly C&D Waste, to gain more tipping fee. At the end of the chain, landfills are attached to the waste processing plants contracted to the same vendor. This arrangement provides no incentive for efficient day to day operations of nether the processing plant nor the landfill.

To attain best efficiencies, there is need to re-engineer or re-configure the current waste management practices. The structural changes that can be introduced into MSWM are given below.

- 1. Landfills should be privatized and landfill user fee may be charged from anyone disposing their waste at landfill. being the last preferred method in waste management, landfilling charges should be higher than that of processing fee paid for the treatment of any waste.
- 2. Waste processor should be charged escalating charges for disposal of waste process rejects in landfill i.e. first 10%-20% may be normal rate and any incremental quantity may be charged higher rate.
- 3. Waste processor may be paid tipping fee based on the output quantity as per norms rather than the quantity of waste processed.
- 4. The Collection, transportation and processing components of MSWM can be contracted to a single vendor. Different vendors can also be contracted. However, landfill operating contractor should be unique in the ULB, without any stake in any other component of MSWM.
- 5. For smaller cities, say of less than 3 lakh population, SHGs can be entrusted all the MSWM activities based on Ambikapur Model of Chhattisgarh State.
- 6. Collection of User fee charges may also be given to the Contractor operating the door-to door collection system in the ULB. He may be paid separate commission based on collection of the user fee. However, payment of tipping fee to the

contractor should be paid directly by ULBs without any linkage to the collection of user fee.

In the meanwhile, efficient segregated waste collection and segregated waste transportation segment offers the best possibilities for efficient gains in MSWM by the ULBs.

After the steps of waste minimisation and recycling, the ISWM hierarchy indicates adoption of resource recovery strategies and composting/biomethanation/MRFs as the next preferred waste management practises, ensuring that waste is processed appropriately to facilitate further use of the material.

Examples – Practice of Reduce, Reuse and Recycle:

"No Food Waste", "My Shopping My Bag" initiatives in Coimbatore:

NO FOOD WASTE

No Food Waste is an excess food recovery network which collects the untouched excess food from marriage halls, parties, restaurants etc. and delivers it to hunger spots across the city. No Food Waste partners with Coimbatore city Municipal Corporation (CCMC) and feeds people at the dumpsite and hunger spots with the mission to reduce food waste and effectively repurposing it. No food waste also works with communities to train on composting and making biogas from the plate leftovers and preparation residue food waste.

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My Shopping My Bag

India generates over 5.6 million metric tons of plastic waste annually. Landfills and water bodies continue to choke on plastic waste. While plastic bottles take anywhere around 70-450 years to decompose, a plastic bag takes a whopping 500-1000 years. Even though plastic bags below 50 microns were banned across the country, several parts of different states continue to use it. One of the prime reasons for this is the lack of availability of a viable alternative to plastic bags. To cater to this existing void in the market, the CCMC launched its bio-compostable bags, an alternative to polythene bags in association with a Bengaluru firm. These bio-compostable bags have a shelf life of three months and are made using tapioca, a type of starch extracted from cassava root. In addition, when disposed of in hot water, they turn into ash. At large scale production, costs of bio-compostable bags are comparable or even lesser than the polythene bags.

[2] WASTE SEGREGATION AT SOURCE – at a glance

Segregation of waste refers to the separation of household waste into its various constituent streams, specifically separating the dry waste, including wood, metal, glass etc. from wet waste comprising of organic waste like food, vegetables, fruits and garden waste. Source segregation of waste is essential in order to:

- 1. Reduce municipal efforts and resources spent on the process of waste segregation post-collection.
- 2. Avoid soiling of recyclable materials with wet waste, domestic hazardous and sanitary waste due to haphazard mixing during discarding.
- 3. Increase recyclability and reusability of waste materials and reduce land-filling.
- 4. Reduce costs of waste processing and improve the quality and quantity of byproducts thereby enhancing sustainability of waste processing

Segregating waste at source ensures that the waste is kept at its near-original state, less contaminated and is collected and transported for further processing with minimal deterioration in its characteristics. Segregation at source has several environmental benefits.



Figure 2: Segregation of Solid Waste

Segregation at Source (SAS) of waste in the area of ULB's jurisdiction has to be implemented to channelize separate streams of waste for scientific management, as follows: -

I. From Domestic and Non-domestic waste generators:

- a. Biodegradable waste or WET waste
- b. Non- Biodegradable waste or DRY waste
- c. Domestic hazardous waste
- d. Sanitary waste like diapers, sanitary pads, etc.
- e. Horticulture and Garden waste

f. Construction & Demolition waste

II. From the ULB's designated / non-designated and licensed / non-licensed markets:

- a. Vegetable, fruits and flower waste etc.
- b. Meat, poultry and fish waste etc.

III. From temples and religious premises:

- a. Flower waste
- b. Fruit waste
- c. Food waste
- d. Dry waste

IV. From Street Vendors and Eateries:

- a. Food waste
- b. Vegetable waste
- c. Fruit waste
- d. Dry and disposable waste such as plates, cups, cans, wrapping material, etc.

V. From Street Sweeping and allied operations:

- a. Mostly inert waste but also containing mixed wet and dry waste (this street sweeping waste should be sent separately directly to the processing facility or landfill).
- b. Drain cleaning silt collection and transportation:

VI. Places of Public gatherings:

- a. Fruit waste
- b. Food waste
- c. Dry waste
- d. Disposable waste
- VII. Others (Hotels, restaurants etc. not mentioned separately as mostly coming under the definition of bulk waste generators)

Segregation of waste at source: Resolving Institutional Issues

It has been observed that to be successful in segregation of waste at source, all stakeholders should be partners in the segregated collection of waste. While initially citizens' awareness and capacity building are required, errant behaviour needs to be penalized. The policy of 3Ps (Plead, Persuade and Penalize) needs to be followed with citizens and waste generators in order to implement segregation of waste and to establish it permanently in the entire MSWM cycle.

On the other hand, Waste pickers themselves may not be interested in segregated collection as it is felt more time consuming. This misplaced concern can be removed by instilling the health & hygiene benefits, hygienic working conditions with improved productivity etc. Waste pickers can be encouraged by rewarding or recognizing their efforts. Some States & ULBs have authorized waste pickers to sell recyclable wastes and earn income for themselves. Also, any errant waste pickers may be removed from the collection mechanism. ULB officials entrusted with the solid waste management may also be recognized based on the segregated collection in each ward.



⁽Naturally Decomposable)

(Require Industrial Operations to **Process/decompose)**

Segregation at sources of waste leads to collection and storage of waste materials of several streams as per their characteristics and such management is notionally felt complicated. But in reality, for the scientific and sustainable management of waste (of different characteristics) such segregation is essential and becomes simpler and un-complicated due to continuous, on the process learnings.

The management pathways for characteristic wastes need to be distinct and as short (in time and distance) as possible and well-connected with the characteristic processing facilities.

Seven Steps in Solid Waste Collection and Transportation:

The Collection and Transportation segment of MSWM can be conveniently broken down into seven steps, beginning with segregation of waste at source and ending with bulk transportation / transfer of waste to the processing plants/landfills. It is not necessary that all the 7-steps are used/ deployed by each and every ULB. It is not even ideal that all the 7-steps need to be deployed. Several ULBs have found it convenient and efficient to use only some of the steps for completing the MSWM journey from waste generator premises to the waste processing/ landfilling facilities. These 7-steps are explained and demonstrated using the case studies of MSW collection and transportation models used by some of the successful ULBs.



Figure 3: Seven Steps to efficient Collection & Transportation of Municipal Solid Waste

• The common thread in all these steps is maintaining segregation of waste.

• Lesser number of steps in C&T if found adequate and economical leads to Bonus efficiency

For example, Pimpri-Chinchwad Municipal Corporation though fairly large geographically (185 Sq. Km) and in population (18 lakh), did not find it necessary to have the transfer stations and bulk transfer. It may be due to vertical urbanisation /high rise buildings whereby primary vehicles get fully loaded at 1-2 premises/gates. These need to be emptied as soon as possible and serve other premises.

PCMC finds it is advantageous that the large refuse compactor is in the vicinity. In fact, the primary and secondary vehicles approach each other to mutual advantage so that time cycles of both are reduced. It is a good example of converging logistics. Such logistics should be studied by every ULB to investigate how they can make the C&T chain, the most cost intensive of all MSWM operations, more efficient.



Figure 4: Example of efficient Collection & Transportation of Municipal Solid Waste in Pimpri-Chinchwad Municipal Corporation

Segregation of waste at source – Begin at the beginning

The many Avatars of waste – Lend your hand to segregation and help bring out the Shakti in waste



https://www.globalgiving.org/projects/creating-waste-segregation-awareness-in-bangalore/

Figure 5: Different categories of Solid Waste

As biodegradable waste starts decomposing at the point of generation itself (at any domestic and non-domestic premises), the rotting process sets off gases, leachate and strong odours which are highly undesirable pollutants in any location. The anaerobic conditions prevailing within the waste lead to methane formation which is 22-23 times potent GHG than CO₂.



Source: https://www.toronto.ca/services-payments/recycling-organics-garbage/

Figure 6: Use of two-bin System – (just like road traffic, a 2-way system is the minimum for segregation)

The biodegradable / wet waste starts decomposing right from the time of generation. The collection of such waste is done once a day by the urban local bodies or their authorised waste collectors. The timing of collection is mostly in the early morning hours, which means most of the biodegradable waste has already been decomposing for more than 8-24 hours. Therefore, it is essential that no further time is lost in the collection, transportation, transfer and processing. The biodegradable waste once collected from the premises should be ideally put into its treatment process within 1-2 hours. This makes it essential that the treatment facilities for biodegradable waste are decentralised and located close to the areas of generation. In the above scenario, the time lapse at the premises from the point of generation to the point of collection cannot be shortened (unless there is more than once in a day collection). The only path that can be shortened is the time between collection and putting it into treatment. The entire chain of events from waste generation i.e. biodegradable waste generation to its entering the treatment process can be manipulated only in the leg of transportation and that is the reason decentralised facilities for treatment of biodegradable waste are essential which will control to a certain extent, the emission of GHGs, and prevent the surrounding areas from being enveloped in bad odour. Therefore, after the mandatory segregation of waste in a municipal/urban area, the next logical managerial step would involve segregated waste collection & transportation arrangements and targeted waste processing facilities.



Figure 7: Solid Waste Collection, Transportation and Processing

The transportation arrangements provided by the ULB which is carrying out segregated collection of waste need to be well defined from end-to-end without any cross pathways i.e. without allowing any mixing of the non-segregated waste with segregated Wet/Dry waste.

Historically, the ULBs in India have been substantially successful in the transportation part of the management chain - but without any segregation. Thus, in the transportation link of SWM chain, there is the need to introduce a paradigm shift to segregated transportation, as a logical sequence to the mandatory segregated collection of waste.



Figure 8: Processing of Segregated Solid Waste

Principles of Solid Waste Collection and Transport

Effective & Efficient

As ULBs are vested with the responsibility of maintaining a disease-free environment for citizens, they should ensure proper solid waste collection and transport. All the waste collected from households and other establishments should be emptied and disposed of through a scientifically and environmentally acceptable practice. Failures in waste collection lead to public health hazards.

Cost Effectiveness

It is essential to assess the efficiency of the service and develop ways to reduce costs and/or increase services within the current budget.

Environmentally Appropriate

Efficient collection and transport of solid waste will provide citizens with a clean environment in which communicable diseases will be greatly reduced. All the waste collected from households and other establishments should be emptied and disposed of through a socially and environmentally acceptable practice.

Citizen Involvement

The successful collection and transport of waste material not only depends on the efficient operations of the ULBs, but also on the active involvement of citizens. The public must cooperate with the ULBs requirements and the ULBs must provide an efficient service, particularly for collecting waste on time and according to a set schedule.

Human Behaviour

ULBs should ensure that trash is collected and litter cleared regularly. When trash and litter accumulates in the environment, it encourages people to add even more to the pile. If the environment is clean, people are discouraged from dumping trash and scattering litter.

Capacity building of staff involved in collection and transport.

Though the waste is segregated at household level, during the process of collection and transportation, the segregated portions may be carelessly mixed by the staff themselves. This particular aspect along with other aspects should cause the ULBs to train the unskilled sanitation workers. Instilling pride and sense of duty in their work will enable them to be guardians of rules and byelaws. Skill development to the personnel working in the sanitation department will enable effective realisation of benefits of segregated waste and they may also come up with useful suggestions for improving the services.

Benefits of segregated transportation:

Segregated waste is a resource and not only brings in resource efficiency in waste management but also minimises pollution of environment due to indiscriminate dumping. Segregation of waste is the key to successful solid waste management. It follows that the benefits of segregated collection can be accrued only with segregated transportation.

Segregated collection & transportation is also integral to Segregation of waste at source, as without it, it leads to totally mixed waste at the door step of processing facility, completely negating the benefits of segregation of waste at source.

Keeping this in view, there is need for transformational change in the conventional methods of collection & transportation for scientific waste management.

BASIC SEGREGATION						
Wet waste	Dry waste (Blue bin)				Domestic	
(Green bin)	With further sub-segregation				Hazardous	
	BASIC+				(Black bin)	
Food wastes	Paper	Containers	Rags	Metals	E-waste*	
of all kinds,	cardboard	&	Rubber	Glass (all	Hazardous wastes**	
cooked and	and	packaging	Wood	kinds)	Household medical	
uncooked,	cartons	of all kinds	Discarde	Inerts	waste***	
including		excluding	d	House	Batteries from	
eggshells and	those		clothing	sweepings	flashlights and	
bones, flower,	containing		Furniture	and inerts	button cells.	
fruit and waste	hazardous			(not	Lights bulbs, tube	
including juice,	materials			garden,	lights and Compact	
vegetable peels	Compoun			yard or	Fluorescent Lamps	
and household	d			street	(CFL)	
garden/plant		packaging		sweepings	Aerosol cans	
wastes.		(tetra)	car care products	
Soiled tissues,		pack,			and	
food wrappers,		blisters			consumables	
paper towels;		etc.)				
fish and meat		Plastics				

 Table 1: Indicative List for Segregation of Household Wastes (Source: CPHEEO Manual on MSWM, 2016)

* E-waste: Printer & printer cartridges, electronic parts and equipment and others- totally separate

** Hazardous wastes: Chemicals and solvents and their empty containers, paints, oil, lubricants, glues, thinners and their empty containers, insecticides, pesticides and herbicides and their empty containers, photographic chemicals, bleaches and household kitchen & drain cleaning agents

*** Household Medical Waste: Thermometers and other mercury containing products, discarded medicines, injection needles and syringes (after destroying them), sanitary wastes and diapers (should be collected daily)

Bin colours mentioned are for ULBs own Waste Storage Depots, MRFs etc.

Note: Domestic Hazardous Waste: To be stored and handed over separately.

E waste is separate stream and should not be mixed with domestic hazardous waste. However, ULB or authorised agent may collect e-waste on call & payment basis. It can be deposited by citizens at specific e-waste collection points. **Domestic Hazardous Waste**: SWM Rules 2016 mandate collection of segregated and separately packed domestic hazardous waste. ULBs need to focus on this waste in addition to the WET and DRY wastes. Inflammable packages, medical sharps & wastes and sanitary wastes infested with human biological discharges are now regularly appearing in MSW, though in small quantity. Notwithstanding their meagre quantity, these domestic hazardous wastes are most damaging to the health and well-being of waste collectors and sanitation workers. Sometimes the diseases e.g. typhoid and hepatitis B in sanitation workers may be traced to contact with these wastes.

The present covid-19 pandemic has put the spotlight on the critical role played by our sanitation workers. Nation has come to recognise them as Swachhta Warriors. ULBs should use this opportunity to educate the citizens to segregate domestic hazardous wastes separately and handover to collection staffs as a distinct waste. Besides their civic duty, the social, ethical and moral side of segregating domestic hazardous waste as a humanitarian effort should be instilled in the society to establish the practice of third category segregation at source. All these efforts must be accompanied by strict waste management byelaws which could be used to penalise defaulters.

The Bruhat Bangalore Mahanagara Palike (BBMP) has set up dry waste collection centres in 164 wards, where citizens can deliver dry waste. These centres are also being designated as drop off points for household sanitary waste, packed and marked with a red cross to enable further segregation in addition to other dry recyclable waste. The collected waste is then sent for disposal through authorised vendors as per Biomedical Waste Management Rules, 2016.

Corporation of Panaji collects the sanitary waste separately on daily basis and sends it to the material recovery facility. Once it is collected in sufficient volumes at the material recovery facility, it is sent to the biomedical waste incinerator at the Goa Medical College for disposal.

[3] COLLECTION AND TRANSPORTATION

Waste collection and transportation refers to the transfer of solid waste from the point of generation and pick-up to the point of treatment or landfill disposal. It includes the door to door or kerb-side collection of waste by municipal, private, informal or other waste collectors. Collection of segregated municipal waste is an essential step in MSWM. Inefficient waste collection services impact on public health and aesthetics of towns and cities. Separate collection of wet, dry and domestic hazardous waste ensures maximum recovery of recyclables. It also enhances the cost-effectiveness of treatment of such wastes to meet the minimum quality criteria defined for different products, e.g. production of compost from organic waste or the refuse derived fuel (RDF).

Factors

- Quantity of waste and rate of generation
 Characteristics of waste
- •Climate
- Density and type of housing
- •Availability of space with in the premises
- Size and type of storage facilities
- •Skilling of workers

Services Delivery Standards

• Door to Door

management chains

Waste segregated at source
 Recovery of waste material Reduce,Reuse & Recycle
 Adequate Frequency of collection
 Streamlines waste collection &

Efficient Solid Waste Collection System

Benefits

- Cost effective collection, transportation and treatment of Waste
- •High quality of organic compost/ biogas
- •Protection of Environment and heath
- High degree recovery of recyclables

Challenges

- Lack of Awareness and education about
 Solid Waste Management
- •Law enforecment and rate of recovery
- Lack of treatment and disposal faciliity
- Lack of technical skillsLack of Route planing and proper bin
- collection.
- •ADDRESS THESE ISSUES FIRST

Waste collection services can be divided into primary and secondary collection. Primary collection refers to the process of collecting, lifting and removal of segregated solid waste from the source of its generation including households, shops, offices, markets, hotels, institutions and other residential or non-residential premises and taking the waste to a storage depot or transfer station or directly to the disposal site, depending the MSWM system prevalent in the city or town. Primary collection must ensure segregated collection of waste streams or fractions as described earlier.

Secondary collection includes lifting up waste from community bins, waste storage depots or transfer stations and transporting it to waste processing sites or to the final disposal site. At the secondary collection points, segregated waste must be stored in separate covered bins / containers / vats / vaults for further transportation. The secondary storage points should be serviced / emptied daily or before they start overflowing, especially critical for organic / bio-degradable waste.



A well synchronized primary and secondary collection and transportation system, with regular and well communicated intervals of operation is essential to avoid waste littering and overflow of containers. The transport vehicles should be compatible with the equipment design for the primary and secondary storages and should enable transport of segregated waste.

it should be ensured that waste collected from the doorstep in non-motorized / motorized vehicles is directly transported, as the case may be, either to the processing facility, material recovery facility, Or to the transfer station or waste storage depots for facilitating sorting and bulk transfer of waste. The vehicles used for transportation should be fully covered to prevent spillage of waste and leachate en-route to the processing or disposal facility.

It is essential to separate street sweeping waste and silt cleaned from drains completely from other municipal waste streams at all stages of collection, transport, and treatment, since street sweeping and drain silt is mostly sand, silt and inerts and spoils both the wet and dry waste fractions, if mixed with them.

{3.1} PRIMARY COLLECTION AND TRANSPORTATION

{3.1.1} PRIMARY COLLECTION AND STORAGE (FROM INDIVIDUAL HOUSEHOLDS/PREMISES)

Primary collection of segregated MSW from individual households and establishments (door-to-door collection) is accomplished through the use of containerised pushcarts, tricycles or small mechanised vehicles or tipping vehicles depending on the terrain of the locality, width of streets and building density.

Spacious and well-built neighbourhoods allow collection systems with compactor & tipping vehicles which are more efficient. Narrow streets and cramped neighbourhoods do not allow such vehicles hence handcarts or pushcarts, or tricycles or small mechanised vehicles (auto tippers) may be used for door-to-door collection of waste, which may then be

transferred to a larger vehicle or secondary storage operating in the vicinity. Where direct access to individual houses or establishments is difficult, handcarts or rickshaws could be stationed at designated spots for receiving / depositing waste.

In hilly areas, most houses are accessible only by footpaths or steps, thus restricting the use of even handcarts and tricycles. Segregated waste from households in the hilly areas should be collected using backpacks having small leak-proof containers up to 50 litres capacity or using local traditional methods like pack animals, shoulder poles, wheeler bags/bins etc. The waste collectors should ideally collect wet waste from each household in a bag or basket on their back and with another bag for dry waste. The waste collectors should be well equipped with personal protection equipment (PPE) and should also carry a whistle to announce their arrival for waste collection.

The basic collection & transportation services by the ULBs should be for the 3 segregated categories of waste – WET, DRY and the domestic hazardous & sanitary waste. The collection vehicles and the containers should be separate without any chance for re-mixing. Vehicles with 3 or more compartments have been fabricated and are being used successfully.

The frequency of door-to-door collection for WET waste should be every day/most days of the week as the WET waste creates problems due to putrification, decomposition etc.

Dry waste does not have such problems and can be collected once, twice a week or as service decided by ULB.



ULBs also must have segregated domestic hazardous & sanitary waste collection system.

Figure 9: Door to Door Collection of Waste – A music to the ears and the Environment

In the successful ULBs, collection service of all three categories of waste is provided daily to the citizens duly taking into consideration the volumes/quantities of each type of waste generated on daily basis. The storage of these three types of waste within the households / premises should be done in separate containers, domestic bins, bags etc. suitable for the purpose so that the handing over and collection can take place quickly and efficiently.



Door-to-door collection by SHG in Ambikapur, Chhattisgarh. The same vehicle goes to the processing facility. This arrangement is excellent for small ULBs.

{3.1.2} Vehicles and equipment for primary collection:

Primary collection vehicles should meet the local requirements for capacity, ease of operation, segregation and transfer as well as statutory requirements of MV Act as required. As maintaining segregation of waste is of utmost importance, the design and fabrication of container body / compartments etc. should not allow any cross-mixing of waste at any point of time during collection, storage in the vehicle, movement and transfer/unloading of waste. Before selecting a vehicle for primary collection, it is advised to assess the quantity of waste generated, local climatic conditions, topography of the area and the available facilities for repair and maintenance of vehicles.

All vehicles and equipment should be colour coded properly such as green/blue/black, along with partitioned areas/spaces etc., to signify the type of waste handled therein. All should have GPS enabled to trace their movements.

Some of the options are given below.

a) Handcarts or Tricycles with Containers or Bins: Handcarts should have a space to carry 4 to 6 containers of 40 to 60 litre capacity. The containers should be green for wet waste and blue for dry waste. Bins should be made of HDPE, injection or roto moulded, UV tested standard garbage handling bins. Containerised handcarts are suitable for door-to-

door collection of MSW from households, shops, and establishments in narrow lanes and hilly areas and also for collection of street sweepings. Bins or containers can be easily unloaded / transferred into secondary collection bins or secondary transport vehicles as per the collection and transportation system in the ULB. This transfer should be done without depositing/spilling the waste on the ground at any time, avoiding contamination and fugitive litter.

Vehicle type for primary collection	Number of households/premises covered in different kinds of areas (density of premises)				
	Congested areas	Well-planned / medium density areas	Scattered areas	Hilly areas	
Push Cart,	250-300	200	125	80*	
Wheel barrow					
Tricycle	300	250	200	125*	
E-Rickshaw	500-700 NA				
LCV up to 700 kg	1,000				
payload					
LCV > 700 kg up to	1,500-2,000				
1500 kg payload					

Estimated Deployment of Vehicles and Manpower for Primary Collection

Adapted from MSWM Manual, MoHUA 2016; For indicative purpose only.

* can be reduced in case of steep hilly areas. Manual headload collection can be for 50 HHs max. These estimates are for initial planning only. Real time data on time-duration model can be developed to make deployment more efficient both ways, either to increase the no. of premises served or decrease, depending upon the terrain, street congestion, storage volume and distance/time to empty the waste.

Municipal solid waste collection at Gangtok Municipal Corporation:

Gangtok Municipal Board (GMB) generates about 50 MTPD of the solid waste. There are 17 municipal wards in the Municipality. It is one of the youngest and smallest ULBs in India.

Collection and Transportation Process:

GMB has about 17 trucks of different sizes and about 82 staff for sanitation including drivers, supervisors and Safai Karamcharis. Also 9 NGOs involved in the solid waste management activities in Gangtok.

Good Practices in collection and transportation process in Gangtok:

- 1. Imposition of garbage collection fee from the waste generators
- 2. Linking of garbage collection fee to renewal of trade licenses.
- 3. Different rates of garbage collection fee for shops/hotels and restaurants depending on size/number of rooms
- 4. Removal of large community bins from critical areas
- 5. Collection of garbage by ringing of bells
- 6. Certain areas, especially peripheral wards outsourced to NGOs for collection of garbage
- 7. Use of Compactor vehicles





b) Tricycles with hydraulic tipping containers: These tricycles have painted mild steel tipping containers of 350 litres (140 kg per trip). The tipping containers should be mounted on a standard tricycle. These tricycles are suitable for door-to-door collection from small lanes and by lanes.



Tricycle with Tipping Container



c) Light Motor Vehicles (mini trucks) with hydraulic tipping containers: Light Motor Vehicles (LMV - Mini Trucks) with Hydraulic Tipping Containers are suitable for door-todoor collection of segregated waste from roads / lanes with less than 5m width. They have capacity of nearly 600–900 kg per trip. The loading height is approximately 1500
mm from the ground level. They should have a leak-proof MS load body with drainage tube and plug. The small tipper should be built on a suitable chassis. These vehicles should have four openings, two on each side to facilitate transfer of waste from a domestic bin to the vehicle. They can also have a central removable partition to facilitate storage of segregated waste. It is desirable to use such vehicles having up to 3 cu m capacity for door-to-door collection from large number of houses/premises in a single trip.





Source: South Delhi Municipal Corporation

(a) Auto tipper with Hydraulic Container (b) Direct transfer of solid waste from Primary collection vehicle to secondary Collection & transportation vehicle (c) Auto tipper with separate containers for collection of Dry and Wet Waste

Collection and Transportation in Leh (Hilly Area):

In August 2015, the Municipal Committee of Leh (MCL) inaugrated an initiative for cleaning up the town- undertaken under the Urban Infastructure Development Scheme for Small and Medium Town. Two dustbins were provided at the community level- one (blue) for dry solid waste and the other (green) for kitchen and biodegradable waste.

At present door to door collection is being carried out with the help of trucks. The trucks once reaches, it intimates with the help of a bell. The community people provide the waste to the waste collector. The same waste is being segregated and sent to the disposal centres.

{3.2} SECONDARY COLLECTION AND TRANSPORTATION

Secondary collection & transportation of waste involves collection from community bins, storage points or transfer station, and transportation to the final treatment facility or disposal site. It appears logistically much simpler than the primary collection & transportation. However, segregation of waste is hyper-sensitive to any failures in the secondary transportation stage as large quantities of waste are involved.

The secondary collection & transportation will be required in large ULBs or in those ULBs having processing and disposal facility far away from their core area. Only those having a population of more than 2-3 lakh and the cluster ULBs which have common processing and disposal facilities. It may not be required in ULBs having less than 2-3 lakh population. Even in large ULBs which have developed decentralised processing facilities all over their jurisdictional area, secondary collection & transportation may not be required.

{3.2.1} Concept of Bin-Less Ward or City:

Wherever possible, it is advisable to synchronise primary collection and secondary collection, thereby avoiding the need for secondary storage bins or storage depots. Segregated waste at the household level is collected by primary collection vehicles which directly transport waste to secondary collection vehicles. Secondary collection vehicles are either parked or reach specific locations at set times to receive waste from primary collection vehicles. Separate vehicles or chambers / compartments within a vehicle should be provided to ensure segregated transportation of waste.

Direct transfer of waste from the primary collection vehicles to secondary collection vehicles promotes a bin-less system of secondary waste collection and transportation. However, such systems are successful only when there is sufficient capacity and fleet of secondary collection vehicles to synchronise with primary collection and where good coordination systems exist. Without adequate management controls, such systems may fail, resulting in littering. It is also advisable to place backup community collection bins in commercial or high footfall areas to cater to unexpected and untimely waste generation.

Another approach is to start waste collection and transportation in conventional way involving primary and secondary collection and transportation and with enhanced control over system, over a span of time, bin-less system may be introduced and expanded to whole city/ULB over a time.

Organic waste Collection in Oki town, Japan:

In Oki town, Collection for kitchen / food waste is done using bin with strainer type of bucket inside the bin. Strainer removes the water content of organic waste, which ultimately reduces load on transportation and also reduces the chances of contamination. Separated liquid part is drained into house sewer and the collected kitchen waste is later converted into organic fertilizer.



Municipal solid waste collection at Mysuru City Corporation (MCC):

Mysuru has set one of the best examples for solid waste management in the country. Having a population of around 12 Lakhs, it generates close to 402 TPD of waste. A few years ago, the City initiated a major drive to educate its citizens on the importance of segregating dry and wet waste.

Primary Collection:

It is implemented in all 65 wards of the city. Out of 65 wards, 62 wards are handled by contract labourers, while the other 3 wards are handled by federation of Mysore City Wards' Parliament. There are 240 auto tippers and 396 pushcarts deployed for the collection of waste. Chicken and mutton market waste are being collected separately by 5 auto tippers and 1 canter – LCV.

Secondary Collection and Transportation:

For the collection of waste from 65 wards, 255 single compartment containers and 130 numbers of 4 compartments 4.5 cum containers are placed in all the wards. For the collection of bulk waste from markets and hotels etc., 66 numbers of 4.5 cum Skip Containers are placed in all 65 wards. For the transportation of secondary collected wastes, 20 numbers of Dumper Placers and 2 numbers of Compactors are used. For the transportation of street sweeping waste and silt, 55 numbers of Tipper Lorries are used by MCC. All SWM vehicles in MCC are monitored through a GPS system.

200 Tonnes of waste is being processed in centrally processed composting plant, 25 Tonnes of waste is sent to five Zero waste management plants for composting, 5 Tonnes of waste is being sent for cattle feed and a <u>part of the waste goes for material recovery</u>.

De centralised Waste Management in Bin Free Panaji:

The City of Panaji is 100% Bin Free City. The Corporation has removed more than 2000 nos. of community bins. Each society/ residential colony/commercial establishment is monitored on daily basis to ensure that all the stakeholders follow the segregation guidelines. To achieve this, Corporation of the City of Panaji (CCP) performed following key activities:

- The City has been practicing effective segregation and door to door collection of garbage since 2003 (through the BIN FREE campaign and Mission CHAKKA-CHAK).
 CCP involved school students and citizens to generate maximum impact.
- The implementation of door to door collection and transportation of waste to the de-centralized facility was simultaneously planned. With 65 composting stations set up in the City, the City utilises over 50% of the wet waste generated from the residential areas for composting.
- CCP collects an annual fee of Rs. 500/- per household for the door to door collection service provided.
- Waste is segregated into 5 fractions by bulk generators. Each bulk generator is given a number tag. Number tagging of wet waste is done to identify generators sending mixed waste to the waste processing facility. CCP collects anywhere between INR.600-11,000 per month for the door to door waste collection from bulk generators.
- The dry segregated waste collected is transported to the material recovery facility. It is further segregated into 20 fractions and auctioned off every week. The non-recyclable material is sent to cement kilns for co-incineration. So far, more than 7000 tonnes of non-recyclable waste was sent to cement kilns.
- A mulcher machine is used to shred the coconut shells, horticulture and garden waste for effective use in processing organic waste.

{3.2.2} Secondary storage:

The secondary storage of municipal solid waste (in bins) as defined in SWM Rules is allowed only in bins kept at MRFs, storage depots and designated, controlled points. The old method of placing bins all over the ULB is ruled out. Old arrangement should be replaced with the door to door collection system as soon as possible. However, since 2018, the door-to-door system has become mandatory. In these secondary storages, deposition of waste of other streams such as hazardous, E-waste, C&D waste, street sweepings, drain silt or dead animals etc. should not be allowed. Penalties should be notified and levied.

Disadvantages of secondary storage bins on roads:

- a) The secondary storages occupy the road and street places and cause traffic congestion. As segregated waste storage is a must, more no. of bins will be required, which also need to be monitored closely to maintain segregation of waste and penalise any action by anyone which spoils segregation.
- b) The secondary storages are prone to rummaging by animals and haphazard picking by rag pickers. The surrounding areas often become highly littered.
- c) The large volume of garbage storage in the secondary storages becomes a reservoir for pests such as rats and vectors such as flies and mosquitoes.
- d) Besides being a litter point, the secondary storages emanate bad odour and is often a permanent bad odour point. It affects the quality of life in the immediate surroundings in the homes and shops etc., even land and rental value.
- e) The leachate generated in the secondary storage often contaminates the ground soil and sometimes can contaminate the ground water. During rainy season the run off occurring may carry the leachate and solid waste itself to the water bodies and contaminate it. After the rain, the secondary storage point may become unbearably unclean sometimes for days together. Therefore, it is mandated that no secondary storages are allowed. If it becomes inevitable, special efforts such as twice or thrice emptying of the storage need to be carried out. Only closed containers which are animal proof can be used. They should not be too bulky requiring heavy machinery as any breakdown will cause undue delays in its lifting.
- f) The transfer stations for management of solid waste are required if the spatial extent of the city is too large, or it has huge population with heavy traffic. Any of such cases the movement of a single vehicle transporting a given large quantity of solid waste is more efficient than a number of smaller vehicles transporting an equal quantity of waste. Transfer stations require a large area of at least 1 acre or ½ acre. They need to be scientifically designed and built with complete enclosure to make it pest and odour proof and also it may be necessary to manage it at a partial vacuum to prevent emission of gases and odours to the surrounding areas. Well-designed transfer stations should have all its operations fully automated without any human intervention. Such a facility becomes a force multiplier in MSWM enabling the smaller vehicles to be used more efficiently and carrying out primary collection from large number of premises within the given working hours.
- g) The modern refuse compactors of 10-14 Metric tonne capacity etc. can theoretically carry the waste generated from approximately 3500 4000 numbers of households (with a compacting density of 0.5). These refuse compactors have waste receiving hopper attachments into which the smaller vehicle such as auto tippers and bins from cycle rickshaws etc. can be directly emptied. Thus a refuse compactor can be used as a mobile transfer station which is much more flexible and advantageous than a fixed

transfer station. It only requires proper route planning and coordination between the primary collection vehicle and the refuse compactors. Such coordination has been made easily possible by ICT solutions. Even simple mobile phone communications between the refuse compactor and in a primary vehicle enable the coordination in an efficient manner.

It is essential to synchronise the primary C&T system with the secondary C&T system, with real-time monitoring and interventions. ICT based tracking, monitoring and directions are imperative for a well-synchronised primary-cum-secondary collection and transportation system to achieve scientific, efficient and economical MSWM in a ULB.

{3.2.3} Vehicles and Equipment for Secondary Storage Collection:

a) Bins for Community Places on Public Roads and for Bulk Generators: Galvanised iron movable garbage bins ranging from 1.10 cu m to 7cu m capacity are available. The bins are designed to be lifted or emptied by mechanised container lifting devices such as compactors, dumper placers, etc. They can be used for storage and handling of biodegradable and recyclable waste. They can also be used for secondary storage of street sweeping and silt collected from drains. These bins are also suitable for bulk waste generators and for placement at waste storage depots, markets, tourist spots etc.

b) Stationary/Fixed Compactor Transfer Station (FCTS): The compactors are designed for transfer points on public places and are suitable for both biodegradable and recyclable waste. The containers are available at 7 cu m to 10 cu m, capacities or larger. They are designed for lifting by hook lift system mounted on heavy duty trucks.

Of late, the modern fixed compactors are being introduced as ideal replacement for the traditional dhalaos and act as mini transfer stations. Compared to transfer stations, the FCTs require much smaller area hence more number of them can be developed in a ULB.

{3.2.4} Criteria for sizing waste storage capacities:

Secondary waste storage capacities should be designed to accommodate at least double the expected daily in-flow of waste i.e. the storage capacity should be 100% more than the expected daily in-flow of waste, to take care of excess generation of waste due to any reason. It may be noted that this redundancy is only for the stationary waste storage equipment at the point.

{3.2.5} Maintenance of waste storage depots or containers:

ULBs should ensure that secondary storage bins are water washed after every emptying and thoroughly cleaned at least once a month and should be painted at least once a year. Periodic inspection of waste storage depots should be carried out once in three months and any damages to the flooring, walls, etc. should be repaired. The metal sheet of the containers might corrode if not well maintained. As a minimum requirement, annual painting of the container from inside and outside must be carried out for increasing the life of containers. Necessary replacements should be provided from stand-by equipment already planned and procured, so that breakdown of containers does not lead to breakdown of entire system leading to unhygienic conditions.

It should be monitored and ensured that only segregated waste is collected in these storage bins.

{3.2.6} Secondary segregation at Transfer Stations:

Unsegregated waste, which has not been sorted at primary level, should be sorted either at an intermediate stage (e.g., transfer station) or at storage depot or the processing plant, prior to treatment. Segregation may be accomplished through manual or mechanised segregation. However, multiple handling of waste should always be avoided. This intermediate segregation / sorting should not be treated as an exception to the SWM Rules 2016, but only as a coping measure. Handing over of mixed, unsegregated waste must be penalised every time.

Further, hazardous waste, E-waste old items waste, C&D waste, street sweepings, silt, dead animals etc. should not be allowed to be put in any of such bins. Deterrent penalty should be imposed.

{3.2.7} Secondary Transportation:

Large capacity vehicles should be used to transport waste from the secondary or tertiary collection point (depot or transfer station) to the processing and treatment facility or landfill. The types of vehicles should synchronise well with containers placed at depots or transfer stations, or other vehicles to prevent multiple handling of waste. The selection of the type of vehicles should reflect the quantity of waste to be transported, travel distance, road widths, road conditions and work shop & repair facilities etc., available at hand.

There should be marked vehicles for transportation of wet/ dry waste such green/ blue. All these should be GPS fitted and their movement is monitored to avoid mixing of waste an any stage.

Types of Vehicles and Equipment for transportation:

- a) Skip Truck (Dumper Placer): Skip trucks are used for transportation of skips (dumper bins) of different sizes to treatment or disposal sites. The usual skip sizes are 2.5 cu m, 3 cu m, 4.5 cu m, and 7 cu m. When a full skip (container) is lifted, an empty skip should be replaced immediately to prevent spillages.
- b) These are also appropriate vehicles for transportation of inert or construction and demolition (C&D) waste. The system could be used to lift waste containers with wastes having densities up to 1,000 kg per cu m. Skip truck should be able to make at least 5–6 trips in an 8-hour shift within a radius of 15 km. Twin dumper placers can also be used to lift twice the number of containers in the given time.



Skip Truck (Dumper Placer Machines)

- c) Rear Loading Compactor (Refuse compactor) Trucks Used for Transportation: Compactor trucks are used for transportation from smaller transfer vehicles/ points either to larger transfer stations or directly to treatment or disposal sites. Compactors can be of different sizes. Some features of the compactor trucks are as follows:
 - The loading hopper should be suitable for unloading by tipper vehicles and hand held bins, as appropriate for the primary collection.
 - Compaction capability to compress garbage or solid waste should be between 800 and 900kg/cu m.

The three sizes of compactor trucks used in India are:

- Small compactors of 5–6cu m for 4.5–5.5 tonnes of waste per trip;
- Medium compactors of 8–10cu m with a payload capacity of 7–7.5 tonnes of waste per trip; and Large compactors of 12–16cu m with a payload capacity of 10–12 tonnes of waste per trip.



Refuse Compactor Truck

d) Light Commercial Vehicle (LCV) with Tipping Floor: Wherever possible, municipal authorities should plan for direct transfer of waste collected from households to secondary collection vehicles. In such instances, mini trucks with a tipping floor are appropriate for secondary waste transportation. Door-to-door collectors and sanitation staff may be directed to transfer waste from primary collection vehicles or handcarts directly into these vehicles. In small cities with poor repair and maintenance facilities, where high-tech vehicles maintenance is difficult, tractor–trolley combination for lifting of containers or towing of containers may be used. In such cases, simple hydraulic tipping trailers are recommended to avoid manual unloading at processing plants or disposal sites. Tractor-trailers should be limited to ULBs with rural settings all around.

{3.2.8} Waste Transportation - Planning and Deployment of Equipment and Vehicles:

Secondary collection and transportation, along with the primary collection system is the major component of the cost of MSWM services. Vehicle productivity is the primary indicator of the efficiency of waste collection and transport system. Efficiency can be improved by optimising the collection and transfer operations. Collection routes should be planned to minimise transport distances and ensure equitable distribution of workload among staff. All vehicles may be utilised in at least two shifts, depending on waste generation, to lift all waste and containers, ensuring full utilisation of the fleet of vehicles, and to limit the total fleet size. Transportation of waste, especially bulk transfer may be done at night in areas prone to traffic congestion and also for ensuring empty storage containers / depots etc. at the peak morning hours of waste collection and deposition.

To facilitate efficient and cost-effective collection and transportation, ULBs should develop efficient plans for deployments of collection and transportation vehicles. Most suitable solutions need to be tailored according to the local conditions. It is important to design the collection & transportation system only on the basis of real data on waste quantities and waste composition, which means constant monitoring, evaluation and revision of route plans etc. becomes necessary.

{3.3.0} Different Methods of segregated Collection & Transportation

I. Route-Plan based dedicated Collection & Transportation

The ULB can draw the route plan for the two sets of vehicles. As the WET waste is collected every day/most days of the week, a larger fleet of dedicated vehicles and equipment would be required. Dry waste can also be collected regularly if two compartment systems are available in vehicles/ waste collection tricycles.

In case the DRY waste collection system is once or twice a week may require a smaller fleet as per volume, distance and time modelling. The DRY waste has the problem of excessive volume hence larger capacities by volume of collection system vehicles may be required. For more efficient management the entire ULB area may be **for example**, divided into 7 parts OR 7-colour coded areas (VIBGYOR – the colours being violet, indigo, blue, green yellow, orange and red) and DRY waste from each area may be collected on the designated dry waste collection days i.e., a particular day of the week.

II. Call Based Collection & Transportation:

The ULBs may introduce a call-based collection system for waste as a premium service on chargeable basis for those citizens and customers who want to give away their dry waste as per their convenience.

This premium service may also offer buy-in of WET and DRY wastes, classified waste such as paper, plastic, glass and metal etc., by the collection vehicle itself. Further, this kind of service can integrate the informal rag pickers with ULBs system.

IMPORTANT: The call based collection system is particularly suited for characteristic wastes such as flowers, animal dung, hotel/restaurant/chai waste/waste from functions/gatherings etc., from non-household areas/ activities. Express/Priority Call Services can also be introduced.

III. Bulky waste Collection & Transportation:

Waste items which are bulky in nature such as mattresses, furniture, plastic items etc. should not be allowed to become part of the common or general municipal solid waste. The ULBs should introduce a bulky waste collection system on payment basis to the citizens.

IV.User Charges: The sustainability of scientific solid waste management, including collection and transportation mechanism is entirely dependent on the ready availability of funds for meeting fixed and variable costs. User charges are essential because scientific SWM involves lot of local operations as compared to the old legacy model of street sweeping only. The SWM Rules 2016 mandates door to door collection of waste from every premises as opposed to erstwhile street side collection and the Rules have carefully inserted the provisions for user charges considering the higher level of services delivered. The Rules mandate ULBs to frame byelaws for levying of user charges and also penalties for non-compliance with the Rules.

The implementation of the user charges is still at nascent stage in the country. It is being imposed as a single charge for all the operations involved for collection, segregated transport, transfer, processing, treatment, disposal, etc. of waste entirely neglecting the environment costs for the country. In the near future user charges may need to be at least mentioned partwise for each of these operations though collected as a single charge as the scientific waste management requires unbundling of SWM services into segregated collection, segregated transportation, processing and treatment and disposal, each of which may have to run most efficiently and at each stage there can be an indicator for performance. For e.g., the processing facility should be delinked from the scientific landfill so as not to have the unfair advantage of dumping the waste whenever the plant is under maintenance or breakdown. Similarly, environmental costs may also be attempted to be imposed.

V. Construction & Demolition (C&D) Waste:

It should also be collected and transported as a separate stream. C&D Waste is a valuable resource ideal for recycling and reuse and for resource efficiency. For e.g. sand for construction purposes is being indiscriminately mined from river beds damaging the aquifers. As a replacement, it is possible to recycle 100% of the C&D waste in the form of manufactured aggregates and construction materials made out of the reuse of C&D waste such as bricks, tiles, pavement blocks, flowerpots, etc. Manufactured sand and reusable clay and silt can also be obtained. All this can happen only if C&D waste is kept as a valuable separate stream away from the MSW.





Figure 10: Segregated & piled Construction & Demolition Waste

Figure 11: Unsegregated Construction & Demolition Waste – A loss of resources

In the absence of separate C&D waste collection system, it will end up in the MSW by which the valuable characteristics of both the C&D waste materials and the MSW will get damaged beyond recovery hence such situation should not be allowed to persist anymore.

The C&D waste generated at new construction sites and projects can be easily managed as typically the ULBs have to approve the construction plans. While approving the plans and issuing construction permits, proper C&D waste management is also mandated within the permit. Large construction projects need to have onsite C&D waste processing units for improving resource efficiency.

However, the C&D waste generated in a retail manner typically in already built up areas due to remodelling and refurbishing are problematic to manage. For its scientific management, it requires participation from several stakeholders. Awareness and compliance by the citizens, alert monitoring and regulation by the local authorities, compliance by outsourced agencies like contractors and interior decorators - developers, C&D waste collection and transportation agencies, etc. are necessary.

Segregation of C&D waste generated in retail manner is essential such as separately storing the wood and wood products, glass, metals, ceramics, bricks, concrete and cement mortar, soil, gravel, pipes, wires, plumbing & electrical fixtures, etc. These are highly valuable for the recycling industry. In fact, some of these used materials can be cleaned, refurbished and reused immediately with full functionality of original uses (doors, windows, plumbing and electrical fixtures, etc.). It is 100% reuse indeed!

Steps for scientific C&D waste management:

- a) Setting up C&D waste helpline for citizens: ULBs can set up either a toll free or paid calling facility for citizens to call and request for C&D waste management services. The same services may be made available on the website of the ULB also.
- b) Designated transport vehicles: ULBs may maintain a fleet of transport vehicles which may be deployed to pick-up waste from citizen's premises on payment basis.
- c) Setting up C&D waste deposition centre/depots: ULB may set up designated places/depots for citizens to transport and deposit segregated C&D waste at the place either free of cost or with certain charges, displayed prominently at the place.
- **d) C&D waste storage equipment:** ULBs may provide storage bins for storing the C&D waste at construction sites at a rental fee.
- e) Sale of segregated C&D waste and its reprocessed products may also be facilitated at the same C&D waste storage depot, for the citizens to visit and purchase. The price list of various C&D waste and reprocessed products along with transportation cost may also be prominently displayed.

The collection and transportation system of MSW is a labour intensive operation. It has to function on all days of the year without any holiday, even on account of festivals and national holidays, which in fact require more efforts. The system has to work beyond capacity on certain days such as during Melas, festivals and public gatherings. Proper manpower, staffing and human resource management is therefore essential for successful running of collection and transportation system. The authorities responsible for the function may adopt any of the following manpower staffing arrangements or a combination of them, suiting to their requirements in discharging their mandatory functions successfully.

ULB's own staff: The ULB engages sanitation personnel / employees on its own pay rolls. This model is being adopted by many ULBs as they have sufficient or surplus sanitation staff. In order to make efficient use of the available staff and also deter non-professional behaviour, the ULBs need to adopt biometric attendance system, ICT based monitoring of work turn out such as number of premises serviced with door to door collection, or the areas (length X breadth) of streets and roads swept or the number of kilometres negotiated by the drivers and assistants etc. Key performance indicators may be developed and the work turned out by each employee may be verified against the indicators. The staff needs to be extended all facilities such as medical check-ups, personal protection equipment, and treatment during illness, etc. At the same time absenteeism and

non-performance should also be measured and sufficient deterrent and penal provisions implemented.

- Self-Help Groups (SHGs): the SHGs movement has grown in the country led by the women. These are small informal entrepreneur models of several individuals sharing the common mission of participation in the economic activities. Because of the innate entrepreneurship involved the SHGs based collection and transportation system in SWM, it can be said to be the most efficient model. By engaging the SHGs on the basis of a broad agreement, the ULBs are spared of repetitive day to day managerial activities and burden in managing the sanitation staffing, equipment and vehicles.
- **Contract model:** In this model, the entire sanitation personnel are outsourced through a contractor and the contract performance is monitored. The scope may include all kinds of vehicles also. The contractor based collection and transportation system is typically paid out on the tonnage of waste collected, transported and delivered to the treatment plants, dumpsite/landfills. The biggest drawback to efficiency in this model is a deliberate collection of all kinds of mixed waste especially C&D waste which increases the tonnage tremendously and at the same time spoils the waste recovery potential of the entire waste. Therefore, the more efficient model of contracting can be on the basis of totalling the segregated waste, C&D waste, street sweeping, drain silt, etc.
- Outsourcing the Vehicles for collection and transportation: In view of the sensitivity of collection and transportation system in scientific SWM, the legacy model of government owned vehicles, mechanics and workshops is passé. The more efficient model is by outsourcing the required vehicles and equipment procured entirely on the basis of operational distances and duration, which nullifies the losses due to downtime of the equipment.



Figure 12: Construction & Demolition Facility in Burari, Delhi

VI. Other categories of waste and their transportation – Streamlining waste:

- a. Waste from Markets: Waste from vegetable markets, flower markets and other leafy and green waste should be collected and transported in dedicated manner, and delivered to distinct processing facilities.
- b. The waste from meat, poultry and fish markets should also be collected separately in dedicated vehicles.
- c. Waste from Street Sweeping should also have linked transportation channels.
- d. Melas' waste
- e. Events' waste sports, religious, cultural etc.

{3.3.1} Implementing scientific Collection & Transportation of Waste

The collection and transportation of Municipal Solid Waste in the ULBs shall be planned and implemented in consonance with the aforementioned principles keeping segregation at the heart, both in collection and transportation.

The methodology and its implementation as described above will vary from ULB to ULB depending on the population size, the geographical extent, the economic activities, the floating and tourist population, industrial and trade influences, climate, topography, mining activities (especially in coal belt areas wherein ash contents could be significant in the waste), etc.

The planning for a scientific collection and transportation system is not a onetime intervention. It requires detailed investigations and well-researched layout of the system but at the same time keeping it open for re-engineering from time-to-time based on the feedback data of operations.

It requires a dedicated team of trained personnel along with technological interventions of ICT based monitoring to prove itself scientific and economical and at the same time, to be amenable for reconfiguration at short notice (for e.g. in the event of festivals, urban disasters and even religious and funeral processions of mass leaders, etc.).

Successful collection and transportation systems have been implemented by different cities which have good overall record of scientific waste management. The case studies are presented in this book are for all the ULBs and stakeholders to study the case or a number of cases and to adapt them suiting to their own requirements. However, it is reiterated that the collection and transportation system of ULB should always have flexibility to be able to manage scientifically in spite of any unforeseen circumstances.

{3.3.2} Management Information System for waste transportation:

Simple as well as advanced management information systems (MIS)— e.g., geographic information system (GIS), Global Positioning System (GPS), radio frequency identification (RFID), and general packet radio services (GPRS)—are important tools for ULBs to effectively manage MSW in large Cities.

It is essential for the head of the SWM department as well as the head of the ULB to be informed of the day-to-day performance of the SWM service, being very vital for maintaining the health and well-being of the people.

As part of the larger MIS, daily reports on some aspects of the MSW transportation system need to be complied in order to take stock of real time performance and take corrective measures as and when required, such as:

- The number of sanitary workers with their proper roles and responsibilities laid out, daily reporting of supervisors and drivers who are on contractual basis as well as prior substitute arrangements for those absent to avoid backlog of work;
- Vehicles and equipment reporting on duty and performing the expected function, number of vehicles off the road on account of breakdowns etc.;
- Quantity of waste transported, treated, and disposed at the treatment or processing facilities and at landfill; and
- Arrangements made or proposed for clearing breakdowns.



ICT in Solid Waste Management Collection & Transportation – a force multiplier

Surat has developed an Integrated Solid Waste Management Command & Control (SMAC) Centre. In this system, radio frequency identification (RFID) Tag is installed on all Door to Door collection vehicles. This automatically identifies the vehicles at transfer stations and records their weight automatically. 551 vehicles are tracked using this system. GPS provides real time location of all the vehicles. It also informs whether the vehicles have captured all the Point of Interest (POI) along the routes assigned to each vehicle. Door to Door waste collection contractors can be penalized according to the routes and POIs not covered. GPS also provides real time monitoring of all door to door vehicles at the SMAC centre which is a command and control centre for Surat Municipal Corporation.

Vapi has developed Digital House Identification (DHI) System in which tracking of Door to Door garbage collection is done with location based attendance using RF Tags outside all Properties. City has a Complaint Management System which is smartphone enabled helping to resolve citizens grievances effectively.

Swachhata App Mobile Application for Citizen grievance management - Swachhata App Application fuses together an ICT enabled mobile based complaint redressal platform with the opportunity for citizens to work together on civic issues. The next-generation mobile applications like Swachhata App are breaking new ground in allowing citizens to participate in Swachh Bharat Mission. The Ministry has partnered with Janaagraha for development, hosting and maintenance of the application. Swachhata App serves as an efficient platform to resolve complaints as well as provides the feedback from citizens.

Bhopal Municipal Corporation (BMC) has taken an ICT Initiative under Swachh Bharat Mission and launched city App called Swachh Map App. It is a city App. With this app a citizen can click a photo and tap on the red button to report any garbage site around. This will alert the respective ward supervisor in real time to take quick action. Using GPS, BMC team will arrive and clean the spot. After cleaning, the citizen will be notified with a photograph. A citizen can track their complaint on the app, give feedback and post it on Facebook and twitter to spread awareness. Also, BMC has installed GPS/RFID in more than 75% of garbage trucks/ auto tippers for real time vehicle tracking and fuel monitoring system. The GPS tracking helps in route planning for real time and historical location information, this system provides information about the driving speed and behaviour. BMC is among the cities that have ICT based attendance system which is being monitored at the head office level.

Bengaluru has developed an ICT Enabled Collection and Transportation System for Solid Waste Management. City has 4000+ Primary Collection Vehicles (PCV) and 500+ Secondary Transportation Vehicles (STV). Radio Frequency Identification (RFID) technology is used by the SWM Cell, BBMP to track the attendance of the large fleet of 4000+ PCVs at mustering points and 500+ STVs at transfer locations and has brought in better regulation and accountability into the MSW Collection and Transportation system. The RFID application also captures the weighbridge data at the processing plants and sanitary landfill as an essential field to complete the scanning process. This daily data forms the basis for calculating payments to be made to service providers based on vehicle performance. Each vehicle has been provided with RFID tags which are required to be read at the entrance of processing plants or sanitary landfill.

Swachh Nagar App: Integrated Waste Management Application

Collection and Transportation is the basic part of solid waste management. However, many challenges are involved such as lack of data on premises/households, mixing of waste, insufficient monitoring of workers, unavailability of household persons to hand over the waste, etc. The Swachh Nagar App is made to facilitate the entire process of Collection and transportation for all stakeholders, viz. citizen, waste collector and the ULB. There are separate citizen and Engineer apps for citizen/household and waste collector respectively, while the ULB can monitor the entire process on a web portal dashboard.

In order to achieve the objective of clean cities free of all kind of waste, it is important to strengthen the Urban Local Body (ULB) with the proven means of service delivery of sanitation services at doorstep and effectively monitor collection of solid waste. Keeping this view, Ministry of Housing and Urban Affairs (MoHUA) has developed a "Swachh Nagar App", a mobile based solution.

The objective of the App is to provide an integrated solution for collection of solid waste and monitoring for both citizens and ULB staff. The mobile application includes three components:

- i. Citizen App
- ii. Service Provider / Engineer App
- iii. ULB Web Portal.

Together, these facilitate the entire process of Collection and Transportation for all stakeholders, viz. citizen, waste collectors and ULB.

Swachh Nagar App features include:

- ✓ Mapping of households/ premises/ Gates / Scan QR code.
- ✓ Concept of Gate within a Gate for RWAs/ Societies/ other gated colonies
- ✓ Monitoring of waste collector and waste movement till collection centre
- ✓ Identification of defaulters by marking Segregation Status at household level
- ✓ E-Payment of user charges
- ✓ Route Summary & Route Mapping Details Waste Collector wise
- ✓ Notification to Citizens regarding waste collection
- ✓ Complaints & Feedback
- ✓ On- Demand Waste Collection
- ✓ Tracking the Waste Collector

Citizens can simply download and start using to avail the MSWM services. MoHUA is continuously improving the App.

Swachh Nagar Engineer App for Waste Collector



Swachh Nagar App for Citizen



Swachh Nagar Web Portal

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The Process Flow:



Advantages of Swachhata App:

This mobile based App made available free of cost by MoHUA for all ULBs comes with several advantages, such as:

(1) Cost effective – The APP and the dashboard serviced by SBM-U

(2) no separate GPS to be installed on vehicles – the mobile pf worker with the App fulfills the GPS function

(3) Similarly, can work as GPS on carts, tricycles or back-packs.

(4) can be modular as per requirement.

(5) weight of waste from each household can be known.

(6) routes within a route can be created etc. can be mentioned.

ICT based monitoring mechanisms of Nashik Municipal Corporation (NMC):

1). GPS tracking: This system of NMC is based on an accurate digital map of the city. The map is divided into a grid of blocks that are assigned to vehicles. These vehicles circulate within and outside these blocks on a fixed route. Each fixed route has 5 tracking points, which the vehicles have to reach in a given window of time. If any vehicle fails to reach these tracking points a penalty is levied and recovered from dues to the concessionaire. Access to this software is provided on a portal, available for all citizens of Nashik through website of NMC. Anyone can log on to the website and track the whereabouts of any waste collection vehicle.

2). Automatic Weighbridge: A weigh-bridge has been setup that measures weights of each vehicle and logs its weight automatically. All the vehicles have been fixed with an RFID device that is scanned at the auto weigh-bridge. The weight log is prepared for each vehicle that is logged into the system, without any manual interference. This weigh-bridge is monitored remotely, through a CCTV camera system as well.

3). Monitoring of waste tipping operations: A control room has been setup in the Head Office of NMC, to monitor all the vehicles involved in SWM.

4). Selfie based biometric attendance system: Attendance of all workers of the contractor is also recorded through a selfie attendance system. Photographs of workers from the site also include geographic co-ordinates of their location in the field. Penalties are levied on the concessionaire in case any worker/s do not report via this system of selfie attendance.

The customised software developed by NMC integrates GPS devices, selfie attendance, and auto weighbridge logs, etc. to monitor performance of the concessionaire and estimates dues accordingly.

{3.3.3} Management of contracts for waste collection and transportation:

Municipal authorities may involve private sector to ensure efficient service delivery and to bring in expertise and finances that may not be available with the ULB. Collection and transportation of waste can be entrusted to a private contractor partly or fully. It is essential to identify the exact services to be rendered through private sector. This can be done by determining the (i) number of households, shops, and establishments to be served; (ii) frequency of service; (iii) time of service delivery; (iv) type and level of service; (v) type and capacity of vehicles to be used; and (vi) distance from service area to transfer station or processing and disposal site. It is also essential to set up a mechanism for measuring the performance of the contractors and decide the payments to be made.

The contractor should keep all vehicles and equipment deployed in good working conditions. The contractor must also ensure efficient, inclusive, and fair treatment and wages of workers, keeping in view the health and safety aspects in conformity with statutory acts / rules, guidelines and standards. Specific requirements for women workers, such as provision of crèches (day child care centres) and linkages to Anganwadis in the nearby community, should be encouraged. It is necessary to develop a proper contract management and monitoring system before contracting to private parties.

{3.4.0} Transfer Stations

In large cities where disposal sites are often more than 15 km away from the collection area, it is economical to set up transfer stations as tertiary storage-cum-transfer depots to save transportation cost. The transfer station or tertiary storage depot can also be equipped with a material recovery facility, where DRY recyclables are sorted and recovered and sent for further processing or to recycler markets. Transfer stations usually consist of large containers of about 15– 25 cu m. A ramp can be provided to facilitate unloading by smaller vehicles or dumper placer containers directly into large vehicles or containers kept at a lower level just below the ramp. The transfer station can have the facility of a hopper, into which waste can be transferred, and then with the help of a static compactor, waste can be pushed into the large hauling vehicle or container.

Transfer stations are usually part of the waste management systems in large cities like Delhi, Mumbai, Bengaluru, Kolkata, Ahmedabad, Coimbatore, Chennai, etc. The smaller municipal authorities should consider setting up simple transfer stations having a ramp facility for transfer of waste from a small vehicle or container to a large hauling vehicle. Only large cities should consider setting up large transfer stations to handle over 300 tonnes per day (TPD) of waste using static compactor facilities.

Justification for Transfer Station:

- If the one-way travel distance to processing & disposal facility is over 15 km beyond the primary service area or over 30 minutes, the need for transfer stations should be assessed.
- Transfer stations should be setup only when the cost of direct haul by collection vehicles would outweigh the cost of supplemental large bulk-haul transfer vehicles plus the cost of the supporting transfer system infrastructure at the transfer station and disposal site.

{3.4.1} Types of Transfer Stations:

Waste is unloaded at a transfer station either directly into tertiary transport vehicles (direct unloading) or into a storage area.

Direct Unloading: A direct unloading system involves a two-level arrangement, wherein the collection vehicles drive up a ramp to the upper level to discharge waste into a transfer vehicle parked onsite or loading system as depicted in Figure 13. Direct unloading systems require limited civil works and stationary equipment facilities, and are thus low-cost solutions for implementation and operation. However, the direct unloading system requires the availability of transfer vehicles at the transfer station to keep pace

with the arrival of collection vehicles, so that no delays are caused in the collection operations. The direct unloading system is usually implemented only as a small-scale system, i.e., typically where the quantity of waste handled is less than 300 TPD. In most cities, collection vehicles arrive at the transfer station during 1 or 2 peak hours per shift. The size of the transfer fleet in a direct unloading system would have to meet these peak hour demands which can lead to overall costly surplus capacity in the transfer fleet.



Figure 13: Direct Transfer Station (Source: CPHEEO Manual on MSWM, 2016)

Unloading-to-Storage: An unloading-to-storage system involves collection vehicles discharging into a storage. From the storage area, wastes are subsequently loaded into transfer vehicles. The storage area may be a platform at the same level as the unloading level, in which case only a two-step arrangement of transfer is required.

The storage area may be a pit, below the unloading level and above the level on which the transfer vehicle is parked, in which case a three-step arrangement of transfer is required. The storage area is commonly designed to hold the peak quantity of waste generated in a day. In the unloading-to-storage system, waste unloaded to a storage platform is pushed by a bulldozer (or wheeled loader) into a hopper or onto a conveyor while the waste unloaded to a storage pit is picked up by an overhead crane or pushed up by a bulldozer to the receiving hopper. The crane or bulldozer operator visually inspects the waste during operation to set aside any waste which is potentially hazardous or could damage the transfer vehicle during loading.



Figure 14: Stationary Compactor Transfer Station Design (Source: CPHEEO Manual on MSWM, 2016)



Typical activities at the Transfer Station (Pictures taken from Municipal Corporation Faridabad)

Transfer Stations with Static Compactors at Kolkata:

The city of Kolkata generates about 5500MT of municipal solid waste (MSW) per day and is managed by Kolkata Municipal Corporation (KMC). In 2012, under Kolkata Environment Improvement Project funded by ADB, KMC has introduced the Modern Scientific Waste Compacting Stations (MSWCS). The MSW collected is taken to the nearest compactor station which houses around two to five compactors depending upon the area. In total there are 90 static compactors and 30 mobile compactors.

Compactors offer an economical means of transportation as they can help reduce the volume of garbage thus weight density get reduce and the same truck can carry more waste thus making the transportation more efficient. Typically, raw MSW has density between 300 to 500 grams/litre. Compactors are capable to compress the waste to more than 800 grams/litre density. (Also, the transfer stations containing these static compactors were constructed on land which was earlier used as open dumping grounds which were hotspots of all sorts of insects, dirt and pungent odour).

Each static compactor in KMC area has a capacity of 10MT capable of accepting waste from 40-110 number of hand carts daily (of 200kg max capacity). Once filled, the vessel is towed to a truck and heads toward the landfill site at Dhapa. The number of trips of a compactor varies according to the need, in some area it is taken for four to five times and in some area single time a day only.

Compactors can be either mobile or static ones; KMC uses both types of compactors.





A transfer station in Indore, Madhya Pradesh

[4] STREET CLEANING / CLEANING OF PUBLIC SPACES (Focussing on Segregation)

Street cleaning is a basic service essential for ensuring clean and hygienic urban conditions. In general, households and commercial entities, etc. should be made responsible for garbage minimisation on the streets. Street wastes include paper, plastics, dirt, leaves, and other vegetative matter. Manual sweeping is commonly practiced in India, as many streets are congested and narrow. Inefficient waste collection systems coupled with the nuisance of public littering contribute significantly to waste lying littered on the streets.

A wide variety of tools, equipment, and methods (both manual and mechanical) are available for street sweeping. By introducing efficient methods of combining manual and mechanical sweeping, municipal authorities can achieve significant savings in street sweeping operations.

{4.1} REQUIREMENTS ON STREET CLEANING AS PER SWM RULES, 2016

Clause 15 of SWM Rules, 2016: Duties and responsibilities of local authorities: -

- (k) direct street sweepers not to burn tree leaves collected from street sweeping and store them separately and handover to the waste collectors or agency authorised by local body;
- (n) collect separately waste from sweeping of streets, lanes and by-lanes daily, or on alternate days or twice a week depending on the density of population, commercial activity and local situation;
- (o) set up covered secondary storage facility for temporary storage of street sweepings and silt removed from surface drains in cases where direct collection of such waste into transport vehicles is not convenient. Waste so collected shall be collected and disposed of at regular intervals as decided by the local body;

Street sweeping is a distinct activity under the rules. The waste collected form street sweeping must be subjected to segregation to separate the leaves and other green, wet waste; the paper, plastic and such dry waste and finally the dust, gravel and inerts. Domestic hazardous and sanitary waste can also appear in street sweepings. Each type of waste may be segregated immediately after sweeping and sent to the suitable processing facilities or landfill.

Manual handling of wastes is prohibited. However, if unavoidable due to constraints, it should be carried out with PPE and precautions with due care for health and safety of workers. Workers should be provided with protective gear such as uniforms, shoes, masks, gloves and other implements etc., for their safe and easy working. They should be given periodic training and health checks and should be provided with social security benefits including health insurance.

{4.2} PLANNING FOR STREET CLEANING

It is necessary to have a well-planned, time-bound daily system for street sweeping including adequate staffing and equipment. Street sweepers should be instructed to report daily for duty at a designated location, which could be the nearest municipal ward office or an office space identified by the commissioned contractor. However, it should be ensured that such a location will have a provisions for storing street sweeping equipment. The location may also serve as an office for the supervisor. Table 6 below shows some important aspects in the planning of street cleaning and Table 7 gives the different areas in a city and their required cleaning frequencies and scheduling.

	PLANNING FOR STREET SWEEPING						
	Small town	Medium City	Mega city				
Equipment	 Long handled 	 Long handled 	 Long handled 				
	broom	broom	broom				
	 Metal tray and 	 Metal tray and 	 Metal tray and 				
	metal plate	metal plate	metal plate				
	 Containerised 	 Containerised 	 Containerised 				
	handcart or tricycle	handcart or tricycle	handcart or tricycle				
	 Tractor with 	 Secondary storage 	 Secondary storage 				
	covered trolley	bin	bins				
	Container lifting Oumper placer or Oumper placer or						
	device	compactor	compactor				
		 Container lifting 	 Container lifting 				
		device	device				
		 Mechanical street 	 Mechanical street 				
		sweeper	sweeper				
Staff	• High density roads:1 person per 300–350 running meters of road						
requirement	length						
based on	• Medium density roads: 1 person per 500 running meters of road						
road density	length						
	Low density roads: 1	. person per 750– 1,000	meters of road				

Table 6: Street Sweeping Norms for Small towns or Small Cities or Mega Cities (Source:CPHEEO Manual on MSWM, 2016)

Road density is the indicator of built-up properties adjacent to the road)	le (f
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Table 7: Typical Classification of Streets and Frequency of Sweeping (Source: CPHEEO	Manual
on MSWM, 2016)	

CLASS	CHARACTER OF STREET	FREQUENCY OF SWEEPING
Α	City centres – shopping	Daily or twice
	areas	
В	Market areas	Daily or twice
С	Minor streets	Daily
D	Sub-urban shopping streets	Daily
E	Residential streets	Daily
F	Roads and streets having	Once a week or less
	no households or	
	establishments on either	
	side	
G	Highways beyond municipal	Rarely necessary to sweep highways but
	Limits	the sides may be cleaned as required by
		the Highway owning authority.
Н	Suburban main streets	Twice a week or as required
I	Open spaces	Occasionally & whenever required

ULBs should ensure the safety of workers during night shifts by providing them with appropriate personal protective equipment (PPE) such as reflective wear. Should women be engaged, sufficient protection is to be provided to ensure that they are not harassed by strangers, law enforcers (mistakenly), or other members of the community and hazards of dogs and animals. Workers should be provided with proper uniforms with definite colour code, which have reflectors (for the night sweeping work), along with ID cards. Constant checking and regulatory mechanisms should be put in place to ensure that all workers are safe from any harassments, dangers, and accidents. Adequate protection should be given to women working at night through deployment of police or patrol teams who should be informed of how many women at any given time would be engaged in work on particular streets.



Source: http://www.worldsweeper.com/Country/India/NightInLifeSweeper3.18.html: Night Street sweeping by machine

Street sweeping in residential areas may be carried out in two spells—5 hours in the morning and 3–4 hours in the afternoon. Staff involved in street sweeping should also be responsible for cleaning drains (up to 450 mm depth), along the same "beat". Multiple handling of wastes should be avoided. The local sanitary inspector should be responsible for inspecting and maintaining records on the extent of service provision. ULBs can adopt different strategies for tourist places, where many people congregate almost at all hours. In such places, regular cleaning throughout the day (2–3 times or more as required) and additional cleanings during weekends and national holidays will become necessary.

Popula	ation) (All habitations	s and slums with small lanes to large ros	ads- all should be serviced. Universal coverage of	MSWM services in the ULB).		
S No	ULB Category	Recommended C&T System	Timing of basic D2D Collection	Vehicle Types & Tracking	Personnel	
1	ULBs with	System direct from D2D collection	Single shift with Set Time for collection,	Own Vehicles. Use only non- motorised, No-	SHGs preferred	
	current population less	to processing facilities.	preferably 6-8 AM for Domestic premises. Later timings for non-domestic, institutional.	maintenance venicies (E.g. Hand carts, Cycle Ricksnaws, etc. only).	No tvpical	
	than 1 lakh		RWAs, Offices, Shops etc.	Use minimum features Swachhnagar APP for vehicle	contracts	
				tracking, Citizen services		
		ICT: Use minimum features of Swach	hhnagar APP (mobile based) for vehicle tracking,	Citizen services		
2	ULBs with	System with Combination of non-	Single shift with Set Time for collection,	Use OWN non- motorised, No- maintenance vehicles	Own Staff /	
	current	motorised and minimum motorised	preferably 6-8 AM for Domestic premises.	(E.g. Hand carts, Cycle Rickshaws) + minimum motorised	Contracted	
	population 1-5	vehicles. Direct D2D collection to	Later timings for non-domestic, institutional,	vehicles by HIRE (E.g. Tata ACE, Mini Trucks, similar	Staff/ SHGs.	
	lakh	processing facilities. Least no. of	RWAs, Offices, Shops etc.	vehicles).	Combinations	
		secondary transport vehicles.		Transfer – only Vehicle to Vehicle, for transfer without	thereof	
		ICT: I lee mavimum features of Swach	hhnaaar ADD (mahilo hacod) far vehicle tracking	icaviig any gandage spins of reachate.		
			ווווומלמו ארד (וווטטווב טמזכט) זטו עבוווטב נומנאוווא			
ε	ULB with current	System with Combination of non-	Single shift with Set Time for collection,	Vehicles – Hired vehicles with AMC preferred	Own Staff /	
	population 5-20	motorised & motorised vehicles,	preterably 6-8 AIVI for Domestic & Later	Use the complete fleet, as warranted, from Carts, cycle	Contracted	
	Lakh	both primary & secondary vehicle	timings for non-domestic, institutional, RWAs,	rickshaws, small/mini vehicles to Refuse Compactors.	Staff/ SHGs and	-
		fleets.	Offices, Shops etc.	Fleet to have less complexity.	their	
			Evening Collection 7-8 PIM can be introduced for commercial areas as overtime measure	Iransrer – only venicle to venicle, for transrer without Jeaving any garhage snills or Jeachate	compinations	
		ICT: Use maximum features of Swach introduced. Public information dashl	hnnagar APP (mobile based) for vehicle tracking, boards.	Citizen services. GPS, RFID and call centres can be		
ll svsten	ns are to be made for	r segregated collection and transportati	ion. No collection without segregation. Byelaws w	vith penalties/fines for any littering and contravention of SM	WM Rules 2016	_
must b	se implemented.					
2. Use	of ICT intervention, ϵ	e.g. Swachhnagar App enables higher ef	fficiencies and outputs in the system.			
3. All F 4. Vehi	orimary collection ver icle to vehicle transfe	nicies snould allow waste deposition at er must ensure zero-spillage.	neight not more than 1.2-1.5m from ground/pav	ement/road.		
						_
C 13						
	D D D					

	S No	Description of	Recommended C&T System	Timing of basic D2D Collection	Vehicle Types & Tracking	Personnel	1
		ULB					
1	4	ULB with current population > 20 Lakh	System with Combination of non- motorised & motorised vehicles, both primary & secondary vehicle fleets	Single/Double shift with Set Time for collection, preferably 6-8 AM for Domestic & Later timings for non-domestic, institutional, RWAs, Offices, Shops etc. Evening Collection 7-8 PM combined with night sweeping to be introduced for commercial areas as a fixed measure. Streamlined Collection: For garden waste.	Vehicles - Hired, Owned or a combination, all under AMC Use the complete complement of fleet, as warranted, from Carts, Cycle Rickshaws to Refuse Compactors. Transfer – Designed Transfer Stations preferably with stationary compactors, receiving waste from all kinds of vehicles.	Own Staff / Contracted Staff/ SHGs and their combinations. Integrated Contracts.	
				temple (flower waste), Mandi waste, Mela waste, animal wastes, C&D waste should be mandatory.			
			ICT: Use maximum features of Swach redressal in entire MSWM services. G	hhnagar APP (mobile based) for vehicle tracking; 5PS, RFID and call centres are mandatory. Public	Citizen services OR ULBs own APP for complaint information systems., SMS alerts etc.		
			Integrated Contracts for Vehicle Fleet	:t + Staff, including Transfer Stations are preferre	d.	_	
ä	1. All 5 and cc 2. Use 3. All 1 4. Veh	systems are to be ontravention of S of ICT interventi primary collectior iicle to vehicle tra	: made for segregated collection a WM Rules 2016 must be impleme ion, e.g. Swachhnagar App enable n vehicles should allow waste dep ansfer must ensure zero-spillage.	and transportation. No collection without ented. es higher efficiencies and outputs in the s position at height not more than 1.2-1.5n	segregation. Byelaws with penalties/fines for an /stem. 1 from ground/pavement/road.	ny littering	
	62 P	С С С					

Collection and Transportation Case Studies

Annexures

Shillong Munici	ipal Board (SMB)	
Case Study 1	Collection and	
	Transportation	
Population	1,43,229 (census 2011)	
Municipality	Shillong Municipal Board	
State	Meghalaya	BHILLONG MUNICIPAL BOARD

Shillong Municipal Board, with population of about 1,43,229 (2011 Census) is the only municipal board in Mylliem sub district of East Khasi Hills district in the State of Meghalaya . Total geographical area of Shillong Municipal Board is 10 km². There are 27 wards in the city, among them Shillong Ward No 21 is the most populous ward with population of about 14 thousand and Shillong Ward No 09 is the least populous ward with population of 2145. Nearest railway station is Guwahati which is 103 km far from here.

Waste Generation Estimation:

The waste generation of Shillong Municipal Board is 120 TPD.

c	Processing Plant/Landfill	•	
– a Hilly Tow	Bulk Transfer	/oided bulk and transfer (Not	
cipal Board	Transfer Stations	SMB has av collection a	cks condary Tippers nvolved y of waste
<u>nsportation</u> Shillong Muni	Secondary Fransportation	•	Tippers and Tru carry out the se transportation Total 10 Nos of and Trucks are i in the secondar transportation to landfill site to landfill site
lection and Tra 1sportation in S	Secondary Storage	•	Secondary Bins of various sizes are placed at different locations
<u>Col</u> lection and Tra	Primary Transportation	•	20 Waste collection vehicles for primary collection of waste (Tata Ace)
Chart- Coll	Primary Collection		• able ed by the ed by the vehicle
Flow	Waste collection from door to door		 Door to door cc waste Only Biodegrad Waste is collect(Tata Ace small \ Tata Ace small \ Citizens deposit biodegradable v community bins separate vehicle

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Collection and Transportation Process:

Garbage in most residential areas is stored in personal bins and disposed of in the community bins. It is then taken/ collected by SMB with the help of collection trucks or other types of vehicles, from the community bins. Non-biodegradable waste is being collected using Tata 407 of capacity 1.5 Tonne-2 Tonne from the community bins. The waste collected by municipal trucks from collection bins are then transported to the disposal site. There is also a system of street sweeping.

Segregated WET waste is collected separately on a scheduled basis. Smaller vehicles (Tata Ace- 0.6 Tonne) capacity.

The garbage collection trucks alert the residents, through the use of a special horn or a bell, who come out and then dump their garbage into these trucks.

Collection and Transportation Equipment and Machineries:

There are 30 collection vehicles which are being used by the Municipal Board for collection and transportation of the waste. The vehicles used for collection and transportation are as follows:

- 1. Door to Door Collection: Tate Ace (0.6 Tonnes) for wet waste
- 2. Secondary Collection: Tate 407 (1.5 Tonnes-2 Tonnes)- for dry waste
- 3. Community Bins of various Sizes- for dry waste

Collection and Transportation in Hilly and Unreachable Areas:

Community bins are placed at specified areas where reach of vehicles is not possible due to topography. The residents themselves segregate the waste at source and deposit the waste in these bins. SMB services these bins with special arrangements.


Steps used by Shillong Municipal Board for Collection & Transportation of Municipal Solid Waste

Dowos	Municin	al Corr	oration	
Dewas	IVIUIIICIL	Jai Curi	Julatiuli	

Case Study 2	Community Driven	
-	Door to Door	
	Garbage Collection,	
	Monitoring &	
	Payment System	
Population	2,89,550 (2011	
	Census)	
Municipality	Dewas Municipal	
	Corporation	
State	Madhya Pradesh	

Dewas was facing challenges emanating from the rapid population growth. Overflowing dustbins, garbage dumped in empty plots and choked sewer lines were usual sights across the city. The residents disposed solid waste in drains and in open. Unauthorized garbage dumps were common and the situation was worse around slum areas.

Major challenges affecting DMC's door to door garbage collection program

1) Jagirdari system of sweepers dividing areas as their territories and not letting others, even garbage collection vehicles, collect garbage from their so called territories had been a major challenge.

2) Efforts towards systematic door to door garbage collection faced stiff resistance from majority of sweepers who used to earn money by collecting garbage from houses on hand carts and dumping/ burning on empty plots. A section of DMC workers and public representatives lobbied against changing old system and charging user fee from people. There were widespread negative remarks in the local media and series of Dharnas and demonstrations against this so called "illegal" collection of charges for door to door garbage collection.

3) Many vehicles used by DMC for door to door garbage collection were in poor condition and frequently under maintenance. As a result, it was not possible to deliver regular and timely door to door garbage collection services. In the initial stages people were not convinced that DMC would be able to regularize door to door collection and households refused to pay user charges.

4) DMC did not have sufficient vehicles to enable door to door collection from all the wards. Therefore, in the initial phases public refused paying user charges citing the system in other wards where no charges were being collected. Available vehicles were run in two shifts but households falling under second shift were not happy with the garbage collection in afternoon and did not pay for the service.

The project implementation involved detailed planning and intensive awareness drives across all wards in the city. <u>PRERANA team undertook the following measures</u>: -

- Door to door survey of all the households
- Assessment of actual status of garbage generation by the households & outline of door to door garbage collection
- Intensive awareness campaigns involving door to door jan-jagran, rallies and road shows
- Stakeholders consultations in all the wards involving all the stakeholders
- Formation and capacity building of Resident Welfare Associations (RWA)

- Intensive awareness drive with school children involving rallies, debates, presentations, drawing/ essay competitions
- Organizing training programs for the residents as well as DMC workers
- Route planning for door to door collection and monitoring of daily garbage collection
- Public sensitization on user charges, collection of user charges and depositing with DMC
- Setting up a 24x7 complaint redressal system for door to door garbage collection issues

Gradually public representatives also joined the efforts and positive vibes about the program started spreading. DMC purchased new vehicles for garbage collection and within three months, the program was extended to 25 wards, which further rose to cover all the 45 wards in December 2016. Teams from DMC and PRERANA made joint efforts to address various challenges that arose and ensured

continuation of the program. RWAs were made an effective instrument to handle the issues at local level and played active role in awareness generation and complaint redressal in their localities.

Results from the program

- General awareness on cleanliness and door to door collection has increased. School children have played major role in sensitizing their families.
- There have been marked improvement in the instances of sewage choking, dumping of waste in drains/ empty plots.
- There has been reduction in the number of stray animals feeding at garbage dumps.
- Health department had noted a decrease of around 40% in the cases of Malaria.
- Public in the wards not covered under door to door garbage collection program started demanding extension of the program in their areas also. Hence, 100% coverage was achieved.

Continuity

Initial success of the program has proved the applicability of citizens paying for door to door garbage collection services. DMC has defined the following things as utmost priority to further enrich its municipal solid waste management program.

- Segregation of waste at source and collection, transportation and disposal of segregated waste
- Separate system for collection, transportation and disposal of construction waste
- Land filling at trenching ground in the scientific manner, and provision of composting

DMC says that this program has contributed to the development of a very rich database of the city which can be further linked to GIS map and aligned with the collection of charges for DMC's other services e.g., water tax, property tax.

Navi Mumbai N	Municipal Corporation	
Case Study 3	Use of RFID and GPS	
	Technology in Collection and	
	Transportation System	T T
Population	11,20,547 (Census 2011)	
Municipality	Navi Mumbai Municipal	
	Corporation	
State	Maharashtra	



Navi Mumbai was the first municipality in India to use the RFID (Radio Frequency Identification Devices) and GPS Technology in daily waste collection and transportation system. It was piloted in December 2015 and achieved success. Now, the model has been recommended to other municipalities by Government of India, under Swachh Bharat Mission.

Issues with Municipality:

Prior to the use of the RFID and GPS Technology, Navi Mumbai Municipal Corporation was struggling with data gathering and monitoring. Manual collection of information on quantity of the waste generated and timing of waste collection was next to impossible. Monitoring of vehicles on day to day waste was a difficult task. Complaints were increasing regarding the irregularities in services of waste collection system.

RFID and GPS Technology System- the Overview:

The RFID and GPS technology system consists of the following:

- 1. Tags
- 2. Readers
- 3. Software
- 4. Middle ware.

Tags with unique identity no. are mounted on the waste bins. Geocoding of the tags are done manually by noting their location using GPS receiver. When the bins are loaded to the trucks, the reader logs the serial no. of the tags on the container. GPS system registers its location using satellite data. Serial No, Location, Date and Time are transmitted through GSM network and is fed into the communication gateway of control server which is then sent into the GIS terminal and live data can be accessed and evaluated from the desktop sitting in Corporation Office.

Implementation in Navi Mumbai:

The implementation of RFID and GPS technology in Navi Mumbai's MSWM was covered by Moba Mobile Automation Private Limited. The RFID tags have been mounted in around 12,000 bins which are used for primary collection waste from the households.

Around 6300 bins are given to various housing societies in Navi Mumbai. Navi Mumbai generates 650 Tonnes of waste per day. Around 110-120 collection vehicles are used for waste collection. These vehicles include- trucks and auto-tippers.

Cost of RFID and GPS Technology System:

The onetime cost for installation of RFID and GPS Technology System was 70,000-80,000 INR per vehicle and the cost of the chip was around 90-100 INR. It is a onetime cost with life cycle of 5-6 years. Thus, the cost of implementation is almost Rs. 1 Lakh per vehicle for every 5-6 years.

Benefits of the technology:

- 1. Real time monitoring of vehicles
- 2. Reduction in the no. of complaints
- 3. Improved efficiency in the collection and transportation system
- 4. Route optimization of vehicles
- 5. Savings in transportation cost
- 6. Enabling Data capture, storage and analysis

Flow Chart- Collection and Transportation Flow Chart- Collection and Transportation in Navi Mumbai Municipal Corporation (N Collection from Pinary te collection from Pinary te collection from Pinary te collection from Pinary te collection from Pinary the collection from Pinary te collection Pinary te collect	MMC)	ifer Processing Plant/Landfill	 Landfill site is located at the centre of the city in Turbhe Landfill Site
Collection and Transportation Collection and Transportation The Collection and Transportation in Navi Mumbai Municipal Noviem Image: Strain	Corporation (N	fer Bulk Trans	
Collection and Transportation in Navi Mu Flow Chart- Collection and Transportation in Navi Mu Collection in Navi Mu Image: State of the sta	<u>rtation</u> mbai Municipal	ndary Trans ortation Static	
Flow Chart- Collection and Transport Flow Chart- Collection and Transport Collection from Primary te collection	<u>ection and Transpo</u> rtation in Navi Mur	Secondary Secol Storage (Not Transpi Used)	ere is no secondary storage. pers are connected to the mpactors for onward condary transportation ere are about 60 compactors ich collect waste from the pers and transfer to the int/landfill site
Flow Chart- Colle Plow Chart- Colle Plow Chart- Colle Plow Chart- Colle Plow Chart- Colle Plow Chart- Colle Plow Primary Collection	<u>Coll</u> e ection and Transpo	Primary Transportation	 About 50 Tippers for door to door waste collection Th tip Pla
	Flow Chart- Colle	te collection from Primary door to door Collection	6 door to door collection tles blown by the vehicle ators to notify the ential areas is installed at the bins lied in the societies. Bins rovided by NMMC ing of vehicle is done by iystem



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Kolkata Munic	lipal Corporation	
Case Study 4	Use of Stationary Compactors for Improved Secondary Collection and Transportation in Kolkata	
Population	44,96,694 (Census 2011)	
Municipality	Kolkata Municipal Corporation	
State	West Bengal	

The geographical area of Kolkata Municipal Corporation is 185 km². Population density of the city is 24,306 persons per km². There are 141 wards in the city; among them Kolkata Ward No 66 is the most populous ward with population of about 98,000 and Kolkata Ward No 45 is the least populous ward with population of 8,394.

Efficiency in SWM collection and Transportation: Stationary Compactors

To improve the collection efficiency and transportation system for high volumes of waste generated in densely populated areas of Kolkata City, KMC piloted the use of stationary compactors for secondary waste collection under the Kolkata Environment Improvement Project of ADB. The stationary compactors, coupled with hook loaders, provide high transport efficiency for waste. The approaches that were adopted for installation and operationalization of stationary compactors are detailed below:

- KMC identified 78 sites for installation of stationary compactors.
- KMC procured portable compactors and prime movers (hook loaders).
- The waste compactors were specifically designed for each site based on the space availability and volume of waste generated in the catchment service area.
- To synchronize with the existing primary collection system, the portable compactors were installed with a tip cart mechanism. The tip cart mechanism is flexible for manual feeding, wheel barrow feeding, and feeding by small 1-2 m3 auto tippers (transfer from primary system).
- KMC provided training and capacity building of the municipal workers for the operation and maintenance of the compactor, as well as orientation for the primary collection workers.



Outcomes:

- Collection and transportation efficiency of the municipal solid waste system improved after introducing the stationary compactors.
- Municipal waste now transported in closed containers, minimizing odor and spilling of garbage.
- Open dumping and burning of waste at the secondary collection points stopped.
- It facilitated night transportation of municipal waste.

Success Factors:

- There was a strong political will to eradicate open dumping sites in the city.
- Disturbance to the established primary collection system in the areas was minimal.
- Use of stationary compactors led to increased efficiency of collection and transportation.
- Small space available was optimally used for installation of the compactors with minimal construction at the sites (custom built).
- KMC provided adequate training and capacity building for the municipal and primary collection staff.



Pimpri-Chinch	wad Municipal Corporation	
Case Study 5	GPS Enabled Tracking of Vehicles in Pimpri-Chinchwad Municipal Corporation	
Population	17,27,692 (As per census 2011)	
Municipality	Pimpri-Chinchwad Municipal Corporation	
State	Maharashtra	CL121

About Pimpri Chinchwad Municipality

Pimpri Chinchwad Municipal Corporation, with population of about 1727692 (as per census 2011) is <u>Haveli sub district</u>'s only municipal corporation located in <u>Haveli</u> sub district of <u>Pune</u> district in the state <u>Maharashtra</u> in <u>India</u>. Total geographical area of Pimpri Chinchwad municipal corporation is 185 km2. Population density of the city is 9353 persons per km2. There are 106 wards in the city, among them <u>Pimpri Chinchwad Ward No 75</u> is the most populous ward with population of about 41 thousand and <u>Pimpri Chinchwad Ward No 99</u> is the least populous ward with population of 6085.

Nearest railway station is Pimpri which is within the city. Pune is the district head quarter and the distance from the city is 17 km. Greater Mumbai is the state head quarter of the city and is 150 km far from here. Yearly average rainfall of the city is 710.7 mm. Maximum temperature here reaches up to 41.4°C and minimum temperature goes down to 5.9°C.



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Collection and Transportation in Pimpri Chinchwad Municipal Corporation

Pimpri Chinchwad generates 650 MT of waste every day. The waste collection efficiency in PCMC is near 100%. Door to door collection has been the strategy, with designated vehicles each collecting waste from 2000 households. PCMC has taken several steps which have become a successful case study and can be replicated to other cities of India.



Steps used by PCMC for Collection & Transportation of Municipal Solid Waste

1. Primary Collection:

Primary collection from each household is done by private contractors to whom the work has been outsourced. It is done using 300-310 Tata Ace vehicles. The strategy in PCMC is "Ghanta Garis/ Bell Vehicles" which whistles or ring to make citizens aware of the approaching collection vehicle. PCMC has given two bins to each household for segregation of the waste. The segregated waste is being collected separately by these vehicles.

Bulk generators have been identified by PCMC. The Bulk generators have to segregate their own waste and give it to municipality for the disposal. The Municipality charges 0.50 paise/kg of waste for disposal of waste. The bulk generator fees are defined as: Category A= Rs. 4000/Year Category B= Rs. 3000/Year Category C= Rs. 2000/Year Hotels and other commercial establishments= Rs. 13000-15000/Year

PCMC deployed GPS based vehicle tracking system due to low capital cost and ease of operation. PCMS's step by step implementation strategy included:

- Step 1: Selection of technology partner
- Step 2: Installation of GPS system on waste collection vehicles
- Step 3: Geo Coding of bins across the city
- Step 4: Development of web based application and public information system
- Step 5: Stabilization of system and training to stake holders

Geo coding (geo coordinates) of the all the bins (around 1279) across the city were marked on the GIS mapping database and real time vehicle movement (GPS location of the vehicle on which a GPS device was installed) were monitored against them as per route. Overall city wide 75 different routes were identified and geo coded on GIS map. An algorithm/logic was developed in web based application to flag the bin as "Served", when a waste collector vehicle stops near a bin within a specified distance for a sufficient period. Using this data, a web based application was developed to monitor the waste pick up performance by PCMC officials and an extended status view was also developed on the PCMC website for citizen to view the status (Bin served or not served) online for their neighbourhood/housing society.

2. Secondary Collection:

The disposal of the waste is done at a landfill which is located at Moshi. The waste collected from the primary households is kept in the stationary bins kept at different places. The bins are monitored every day through GPS-GIS enabled system. There are 44 compactors which are engaged for secondary transfer of the waste





Nammakal Muni	cipality	
Case Study 6	Nammakal Case Study for Effective Door to Door Waste Collection	
Population	119491 (As per census 2011)	
Municipality	Nammakal Municipality	
State	Tamil Nadu	

Aim and Purpose: Commitment of the making "Eco Village Town".

Nammakkal is a commercial town located in Tamil Nadu and is famous for Poultry and Transportation Body Building industry. It has a population of 119491 (as per 2011 census). The area of the municipality is 55.24 Sq. Kms.

Waste generation Pattern:

- 21 Tonnes of waste: Organic
- 14 Tonnes of waste: Recyclable
- 3 Tonnes of waste: Inorganic and Inerts.

Namakkal Municipality has become a zero garbage town since July 2003 and was the first town in the country which attained zero garbage level by implementing various initiatives. This was achieved through privatization of all components of solid waste management and cohesive efforts of various parties including waste pickers and self-help groups, residential and industrial associations, the local municipality and NGOs.

Municipality has already taken initiatives for collection, segregation, treatment & disposal of domestic wastes. No Dust Bins are placed in the Municipal Limit. There is 100% waste segregation at the source





Steps used by Nammakal Municipality for Collection & Transportation of Municipal Solid Waste

Solid Waste Management Process in Nammakal Municipality

Door-to-door waste collection is done in all its 39 wards by Municipal Sanitary workers and outsourcing agencies. Municipal *safai karamcharis* have been engaged for night sweeping on main roads, bus stand, markets and industrial areas. All dust bins from the streets, roads, markets, bus stand etc., have been removed. Now the town is dustbin free town.

Waste segregation is done at source, where coloured bins are used for different types of waste. The segregated wet organic waste is taken to the Bio Methanation plant, MCC and OCC centres. The key aspects of the system that has been put in place are:

- Door to door Collection with segregation at source in entire town.
- All waste segregated into wet compostable, dry recyclable and household hazardous waste.
- Biogas for power generation and Manure production from organic waste.
- Door to door collection and sweeping on all holidays and Sundays.
- 100% removal of garbage daily

Brubat Bongali	ru Municipal Corporation	
Case Study 7	Collection and Transportation of Waste in BBMP	
Population	85,20,435	
Municipality	Bruhat Bengaluru Municipal Corporation	
State	Karnataka	

Introduction of Bruhat Bengaluru Municipal Corporation:

Bruhat Bengaluru Mahanagara Palike is the administrative body responsible for civic amenities and some infrastructure of the Greater Bengaluru metropolitan area. It now has a population of over ten million, making it a megacity and the third most populous city and fifth most populous urban agglomeration in India. The administrative jurisdiction of BBMP comprises of 198 wards in 8 zones.

Primary Collection and Transportation:

BBMP was one of the first cities to adopt 3-way segregation of waste into wet, dry and domestic hazardous waste. The primary collection and transportation involves wet and domestic hazardous waste collection (daily), dry waste collection (bi-weekly) and street sweeping (frequency based on road type). Primary collection and transportation activities take place on a daily basis from 6:30 AM to 2:30 PM.

1. Wet Waste Cycle:

Wet and Domestic Hazardous Waste (including Sanitary Waste) is collected using Auto Tippers on a daily basis. One Auto Tipper is assigned per block for the collection of wet waste and colour coded yellow bags will be supplied for separate storage of Domestic Hazardous Waste. The process for collection of wet and domestic hazardous waste using an auto tipper and by pushcart along with normative standards are listed below:

Vehicle	1 Auto Tipper	1 Pushcart (only areas are inaccessible by Auto Tippers)		
Waste Streams	Wet, Domestic Hazardous	Wet, Domestic Hazardous (incl. Sanitary) and Dry		
Equipment	Colour Coded bag for Domestic Hazardous Waste	Coloured Bins		
Frequency	Daily	Daily		
Timing	6:45-10:45 am I 11:15 AM to 02:00 PM	6:45-10:45 AM 11:45 AM to 02:00 PM		
	(waste from commercial units can be collected between 10-11 AM)			

Coverage (4 Hrs)	750 HHs a establishmen classified as b	nd small commercial 120 HHs/Commercial Units ts which are not ulk generators		
Re-deployment (2 Hrs)	The vehicle collect street intensive cle collection is c	will be re-deployed to t sweeping waste or for leaning after primary completed.		
Additional Deploy	Additional Deployment (in case of Commercial and Market Areas)			
Timing		4:00 PM -10:00 PM		
Coverage (6 Hrs)		1000 Units		
Destination- Wet Waste		Ward Decentralized Processing Facility (DPF) or Wet Compactors at Lorry Point (LP)		
Destination-Mixed Waste		Mixed Compactor at Lorry Point (LP)		
Destination- Hazardous Was Waste)	Domestic te (Sanitary	Sanitation waste Collection Bin at Ward Dry Waste Collection Centre		

2. Dry Waste Cycle:

Dry waste is collected by the DWCC Vehicle on a bi-weekly basis. One vehicle is assigned per 1750 households/units for the collection of Dry Waste. The process for collection of dry waste and normative standards are listed below:

Vehicle	1 Auto tipper/Luggage Auto (modified Box Auto)		
Waste Streams	Dry		
Equipment	Jumbo bags		
Frequency	Bi-weekly from households		
	Daily from small commercial establishment generating large volumes of dry waste		
Timing	6:45-10:45 AM (household)		
	11:15 AM to 2:00 PM (Small commercial units)		
Coverage (6Hrs)	1750 HHs/Units (including commercial)		
Additional Deployment (in case of commercial areas)			
Timing	4:00-10:00		
Coverage (6Hrs)	1750 Units		
Destination	Ward Dry Waste Collection Centre		

Secondary Transfer and Transportation

PROCESS FOR THE SECONDARY TRANSFER OF WASTE BY STREAM:

Transfer of waste will be done at designated transfer points and DWCCs which have been identified at the ward level. The following are transported:

WASTE STREAM	DROP-OFF/ TRANSFER LOCATION	PICK-UP/ DROP OFF VEHICLE	DESTINATION
Domestic Hazardous Waste	DWCC	Picked up by Sanitary Waste Vehicle (Authorised Private Agency)	Sanitary Waste Processing Facility (Private)
Dry Waste	DWCC	Dropped off by dry waste collection vehicle	Aggregation Centres
Wet Waste	Transfer Point/Station	Transferred into Compactors	Integrated Waste Management Yards
Reject/Inert Waste	Transfer Point	Transferred into Compactors	Sanitary Landfill

For the secondary Transfer of Waste from the primary to the secondary vehicle, 2-3 points have been identified per ward as Garbage Transfer Points (GTP) – off road and on road locations. Each GTP has a defined work protocol to be followed on NGOG (No Garbage On Ground) and LNT (Leave No Trace) principle. However, these GTPs still result in several issues on ground, such as garbage on ground, creation of black spots, resident opposition, etc.

Therefore, the city aims to move from multiple informal points to a single built transfer station for every 2-3 wards.

Vehicle Allotment (Wet	14 Cu.M (8-10 Tonne) Compactors (allotted based on quanta and
Waste)	no. of trips)
	Destination: Wet Waste Processing Unit
Vehicle Allotment (Mixed	14 Cu.M (8-10 Tonne) Compactors (allotted based on quanta and
Waste)- Interim	no, of trips)
	Destination: Landfill (interim provision till 80% segregation is
	achieved)
Vehicle Allotment	14 Cu.M (8-10 Tonne) Compactors (allotted based on quanta and
(Reject/Inert Waste)	no. of trips)
	Destination: Landfill
Additional Vehicle	For Evening and Night Collection from:
Allotment	Natural Markets/Market Areas
	Commercial Areas
	Destination: Wet Waste Processing Unit
Vehicle and Manpower	8-10 Tonne Capacity (14 Cu.M)
Specifications	1 Driver, 1 Cleaner (Colour code uniform)
1	

	Signage with Ward Number
Location and Process for	 Vehicle to Vehicle Transfer (no garbage on ground)
Transfer (Lorry) Point	 Transfer Point on Roads or empty land (avoid major roads)
	 Without hindering vehicular movement
	 Concrete mat to prevent damage to the road surface and
	allowing for leachate run off

Proposed Mini Transfer Stations

Vehicle Allotment (Wet	16 Cu.M (10-12 Tonnes) Static Compactors (allotted based on
Waste)	quanta and no. of trips)
	Destination: Wet Waste Processing Unit
Vehicle Allotment (Mixed	16 Cu.M (10-12 Tonnes) Static Compactors (allotted based on
Waste)- Interim	quantity and no. of trips)
	Destination: Landfill
Vehicle Allotment	Infrastructure
(Reject/Inert Waste)	 Shed with Leachate treatment facility and Signage with Ward number
	10-12 Tonne Capacity (16 Cu.M) Stationary compactor
	Manpower: 1 Operator, 1 Cleaner
	Vehicle: Hook Loader
	Manpower: 1 Driver, 1 Cleaner (Colour coded uniform)

Collection and Transportation of MSW in BBMP:



Nashik Munici	ipal Corporation	
Case Study 8	C&T of waste in Nashik Municipal	
	Corporation	
Population	14,86,053 (Census 2011)	
Municipality	Nashik Municipal Corporation	
	(NMC)	
State	Maharashtra	

Background:

Nashik is the fourth largest city in Maharashtra. The city collects approximately 500 TPD solid waste. **Nashik was the first city to launch door to door collection of solid waste in India**. Nashik Municipal Corporation has been operating door to door collection since 1996.

MSWM measures taken by NMC:

> <u>Automatic Weighbridge</u>

An auto weigh-bridge has been setup that measures weights of each vehicle and logs its weight automatically. All the vehicles have been fixed with an RFID device that is scanned at the auto weigh-bridge. The weights log is prepared for each vehicle that is logged into the system, without any manual interference. This weigh-bridge is monitored remotely, through a CCTV camera system as well.

> Monitoring of waste tipping operations

A control room has been setup in the Head Office of NMC, to monitor all the vehicles entering the facility.

Selfie based biometric attendance system

Attendance of all workers of the contractor is also recorded in this log through a Selfie attendance system. Photographs of workers from the site also include geographic co-ordinates of their location in the field. Penalties are levied on the concessionaire in case any worker(s) do not report via the system of Selfie attendance.

The customized software developed by NMC integrates GPS devices, Selfie attendance, auto weighbridge logs, to measure performance of the concessionaire and estimates payment dues accordingly.

GPS tracking

A customized multi feature tracking software has been developed by NMC. Based on an accurate

digital map of the city. The map is divided into a grid of blocks that are assigned to vehicles. These vehicles circulate within and without these blocks on a fixed route. Each fixed route has 5 tracking points, which the vehicles have to reach in a given window of time. If any vehicle fails to reach these tracking points a penalty is levied and recovered from dues to the concessionaire. Access to this software is provided on a portal, available for all citizens of Nashik through website of NMC. Anybody can log on to the website and track the whereabouts of any waste collection vehicle.



Vijayawada Mu	inicipal Corporation	
Case Study 9	Technology Interventions for efficient C & T in SWM	
Population	14,76,931 (As per census 2011)	
Municipality	Vijayawada Municipal Corporation	
State	Andhra Pradesh	

CCTV based monitoring of secondary / garbage bins (for vulnerable points elimination)

The Vijayawada Municipal Corporation (VMC) has installed 147 CCTV Cameras which function on solar charging (with SIM embedded) across the city to monitor activities around Garbage Bins/depots. Identified as most vulnerable from cleanliness point of view. With the CCTV monitoring, the following benefits were realized:

- Effective Monitoring: Senior municipal Staff can review them through LCD/LED TVs
- Cost: The cost of maintenance is very low, post the installation costs



- 1. CCTV Cost/Camera 27000 Rs each + Minimal Maintenance
- 2. SIM cost/Camera is 100 Rs /month

Conclusion: This has been found to be good monitoring option which involves one-time expense and the maintenance cost is quite low. This should be adopted only for garbage vulnerable areas / bins /

locations, on case to case basis in a city.

RFID based D2D collection of segregated waste

The RFID based D2D collection of segregated waste features the following management steps:

Division of Households: Four to five lakhs household were divided in to Micro pocket and each micro pocket covers about 350 households and collected by 1 staff with a push cart. Each pushcart consists of 4 tubs with a capacity of 10 Kg each.

- **RFID on each Gate**: RFID tag (Cost Rs.100/- each) is placed outside each gate from which the waste collector is supposed to collect the waste.
- RFID on Litter Bins: RFID is also fixed on litter bins along streets
- One to Many One Gate can have multiple households (Residential, commercial)
- Device Cost Scanning device cost Rs. 27000/- carried by the staff
- **Pocket wise Report** Reports can be generated for each micro pocket / ward wise regarding the time of collection (whether serviced or not yet. Time of collection, quantity of wet and dry waste collected from the micro-pocket etc. these details get automatically logged to the central monitoring system



This ICT system can be utilized until an alternate and more economical scanning device could be developed, as technology keeps on developing.

It was mentioned by VMC officials that mobile-based scanning is found difficult to use by staff, tedious and time consuming. Procurement and O&M for mobile devices for such captive use is also an issue.

Annexure - II

DETAILS OF EQUIPMENT COMMONLY USED IN COLLECTION AND TRANSPORTATION OF MSW

Bins	
50 litre bin	Capacity: 50 litre
	Approx. cost: Rs. 1,000 Vendors: Available on GeM (Government e Marketplace)
60 litre bin	Capacity: 60 litre
	Approx. cost: Rs. 1,300 Vendors: Available on GeM
100 litre bin	Capacity: 100 litre
	Approx. cost: Rs. 1,700 Vendors: Available on GeM
120 litre bin with wheels	Capacity: 120 litre
	Approx. cost: Rs. 2800 Vendors: Available on GeM
240 litre bin with wheels	Capacity: 240 litre
	Approx. cost: Rs. 4,100 Vendors: Available on GeM

ECO litro hin with whools	Connecting CCO litro
	Approx cost: Rs 24 000
	Vendors: Available on GeM
1,100 litre bin with wheels	Capacity: 1,100 litre
	Approx. cost: Rs. 38,000 Vendors: Available on GeM
Hand Cart	
Three wheels hand cart	Capacity: approx. 60kg
	Approx. cost: Rs. 10,000 Vendors: Available on GeM
Tricycle	
With wooden trolley	Capacity: approx. 300 kg to 400 kg
	Approx. cost: Rs. 13,000 Vendors: Available on GeM
Tilting	Capacity: approx. 300 kg to 350 kg
632	Approx. cost: Rs. 18,000 Vendors: Available on GeM
With Bin arrangement	Capacity: approx. 200 kg to 300 kg
	Approx. cost: Rs. 18,000 Vendors: Available on GeM

E-Cart	
Fixed	Capacity: approx. 350 kg
	Approx. cost: Rs. 1.4 lakh Vendors: Available on GeM
Tilting	Capacity: approx. 350 kg
	Approx. cost: Rs. 1.5 lakh Vendors: Available on GeM
Auto Tipper / LCV	
Hopper Tipper 1	Capacity: 1.8 cum
	Approx. cost: Rs. 4.6 lakh Vendors: Available on GeM
Box Tipper 1	Capacity: 2.0 cum
	Approx. cost: Rs. 4.6 lakh Vendors: Available on GeM
Hopper Tipper 2	Capacity: 2.2 cum & 2.5 cum
	Approx. cost: Rs. 4.7 lakh for 2.2 cum and Rs. 5.15 lakh for 2.5 cum Vendors: Available on GeM

Box Tipper 2	Canacity: 2.2 cum & 2.5 cum
	Approx. cost: Rs. 4.7 lakh for 2.2 cum and Rs. 5.15 lakh for 2.5 cum Vendors: Available on GeM
Box Tipper 3	Capacity: 3.2 cum
	Vendors: Available on GeM
Hopper Tipper 3	Capacity: 3.2 cum
	Approx. cost: Rs. 6.12 lakh Vendors: Available on GeM
Refuse Compactors	Capacity: 14 cum
Compactor 1	Capacity: 14 cum
	Vendors: Available on GeM
Compactor 2	Capacity: 18 cum
	Approx. cost: Rs. 34 lakh Vendors: Available on GeM



Note: Details in the above list are indicative and may vary from the actual product.

Procurement through Government e-Marketplace (GeM)

Government has initiated the Government e-Marketplace (GeM) to cut down procurement difficulties and instill transparency. GeM provides the choice, transparency of market rates and ease of procurement. The procurement procedure through GeM is as for Administrative Officers. All Central Government and State Government Ministries/Departments including its attached/subordinate offices, Central and State autonomous bodies, Central and State Public Sector Units and local bodies etc. are authorized / integrated to make procurement through GeM portal.

REGISTRATION OF BUYER ON GOVERNMENT E-MARKET PLACE

HoD/Primary user cannot make any purchase activity on GeM. He/She can only authorize other officers as Secondary users who in turn can make procurement for their organization. He/She can see the various purchase activities being made by Secondary users.

Authorized officers of the rank of Deputy Secretary/Equivalent or Head of the Office at Sub Centre / Unit / Branch of Government Organization / PSU / Autonomous Bodies / Local Bodies / Constitution Bodies / Statuary Bodies can register as Primary User on GeM. HoD/primary user is required to fill online registration form after clicking the following link to get registered on GeM portal. <u>Https://gem.gov.in/register/org/signup</u>

For using GeM portal, first a Primary User needs to register on GeM portal. Requirements for Registration on GeM are as follows:

- Linking Aadhar along with mobile no. (To receive OTP for e-sign):
- Official Email ID (Preferably .nic.in OR .gov.in Email):

The HoD/Primary User is the representative of Buyer Organization. HoD is not to be confused with Head of Department in Government parlance. HoD / Primary user registration is meant for registration of that organization on GeM portal and for creation of roles and monitoring of activities of all secondary users of that organization.

The main role of HoD/Primary User in GeM is to create Secondary users for his organization i.e. Buyer, consignee, DDO/ Paying Authority. He/She can add secondary users after clicking on Manage Users tab after logging in the GeM portal. HoD/Primary User cannot perform Buying functions on the portal.

Once the Primary user has added the secondary user, User ID and password of Secondary user will be sent to the secondary user's Email ID and mobile number respectively.

Any officer of the organization can be made Secondary user. Secondary user should not be below the rank of a Section Officer.

Four types of roles are performed by Secondary users in GeM portal.

1. **Buyer:** Buyer will select the item for purchase and will place the order on behalf of his organization.

2. **Consignee:** Consignee will receive the item and will generate the **Provisional Receipt** Certificate (PRC) and Consignee Receipt and Acceptance Certificate (CRAC) certificate.

3. **DDO (only for PFMS payment mode users):** DDO will forward the bill to PAO of PFMS. (NOTE:-In case of PFMS payment method, there is no role of Paying Authority / PAO in GeM. PAO from PFMS just needs to login to PFMS portal to make the payment after the bill has been forwarded by DDO to PFMS portal. PAO from PFMS can see and verify on-line the various documents related to the procurement before making payment.)

4. **Paying Authority / PAO (for other than PFMS payment mode users):** Paying Authority / PAO will make the payment to supplier/vendor.

Aadhar No. is a must for using GeM for primary and secondary users. All online documents in GeM are e-signed through an OTP received on mobile no. linked with Aadhar.

Aadhar details collected by GeM are solely for user verification and to apply e-signing on the documents. The e-sign is at par with digital signatures as per Information Technology Act Amendment 2008 and it works based on details available in Aadhar database of UIDAI and there is no interference / intrusion in their personal details.

Only official email ID provided by government organizations can be used for registering on GeM.

Biometric attendance ID is not mandatory for using GeM. Applicant can fill their office ID/employee ID in the field of Biometric attendance ID in case they are not having BAS.

Any officer from administration of the organization who is authorized to verify the details of primary user can be the Verifying/authenticating officer. He/She must be at least of the level of Under Secretary/Equivalent or above.

In case, there is no order count on HOD's Profile (in other words, if no transaction has been done on GeM), concerned Primary User may send their duly filled application in the prescribed format to the GeM Buyer-Admin. HOD needs to **download** the form and send the scanned copy of the duly filled form to the GeM Buyer-Admin at I.steephen@gem.gov.in. Email shall be sent from the registered email ID of the Primary User only. The account will be deleted within three working days if request found to be in order, with an email notification to the applicant.

PROCEDURE TO MAKE PURCHASE ON GEM:

- 1. Login as Primary user/HoD in GeM portal and create secondary users (Buyer/Consignee/PAO/DDO) after clicking on Manage users tab available in Dashboard.
- 2. Buyer to login to GeM portal.

- Select and cart the product as per the requirement through application of various filters. Buyers should apply filters carefully to define their requirement without adversely affecting competitiveness.
- Select the proper buying method as per the GFR-149.
- Create Demand Generate Sanction order >> Generate contract.
- 3. Once order is placed, Seller to deliver the Goods/ Services to consignee within stipulated delivery date and generate on-line invoice on GeM portal.
- 4. Consignee to login after receipt of Items.
 - Generation of Provisional Receipt Certificate (PRC) within 48 hrs of receipt of stores.
 - Generation of Consignee Receipt and Acceptance Certificate (CRAC) within 10 days of receipt of stores.
- 5. Bill processing by buyer (within 2 days of generation of CRAC by consignee)
- 6. Bill to be forwarded to PFMS by DDO within 1 day of on-line receipt of bill from Buyer against e-signed Consignee's Receipt and Acceptance Certificate (CRAC) (In case of central government organizations paying through PFMS) >> Payment to be made by PAO from PFMS within 2 days of receipt of bill from DDO (total time limit for payment is 10 days from date of generation of CRAC). Or

Buyer to forward all documents for payment to Paying Authority and Payment to be released by Paying Authority / PAO within 10 days of generation of Consignee's Receipt (In case of users paying through SBI e-pay or Other mode of Payment.)

Above procedure may have undergone changes. For latest information visit <u>https://gem.gov.in/</u>

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RECO		siven helow is the quick indicativ	a guide to the systems for efficient collecti	ion and transportation of MSW for different classes	c of Citiac/III Rc
as pe	er current Populati	on) (All habitations and slums wi	ith small lanes to large roads- all should be	serviced. Universal coverage of MSWM services in	in the ULB).
S No	ULB Category	Recommended C&T System	Timing of basic D2D Collection	Vehicle Types & Tracking	Personnel
1	ULBs with	System direct from D2D	Single shift with Set Time for	Own Vehicles. Use only non- motorised, No-	SHGs
	current	collection to processing	collection, preferably 6-8 AM for	maintenance vehicles (E.g. Hand carts, Cycle	preferred
	population less	facilities.	Domestic premises.	Rickshaws, etc only).	
	than 1 lakh		Later timings for non-domestic,	Use minimum features Swachhnagar APP for	No typical
			institutional, RWAs, Offices, Shops etc.	vehicle tracking, Citizen services	contracts
		ICT: Use minimum features of S	Swachhnagar APP (mobile based) for vehicl	e tracking, Citizen services	
2	ULBs with	System with Combination of	Single shift with Set Time for	Use OWN non- motorised, No- maintenance	Own Staff /
	current	non-motorised and minimum	collection, preferably 6-8 AM for	vehicles (E.g. Hand carts, Cycle Rickshaws) +	Contracted
	population 1-5	motorised vehicles. Direct	Domestic premises.	minimum motorised vehicles by HIRE (E.g. Tata	Staff/ SHGs.
	lakh	D2D collection to processing	Later timings for non-domestic,	ACE, Mini Trucks, similar vehicles).	Combinations
		facilities. Least no. of	institutional, RWAs, Offices, Shops etc.	Transfer – only Vehicle to Vehicle, for transfer	thereof
		secondary transport vehicles.		without leaving any garbage spills or leachate.	
		ICT: Use maximum features of S	Swachhnagar APP (mobile based) for vehicl	e tracking, Citizen services	
Э	ULB with	System with Combination of	Single shift with Set Time for	Vehicles – Hired vehicles with AMC preferred	Own Staff /
	current	non-motorised & motorised	collection, preferably 6-8 AM for	Use the complete fleet, as warranted, from	Contracted
	population 5-	vehicles, both primary &	Domestic & Later timings for non-	Carts, cycle rickshaws, small/mini vehicles to	Staff/ SHGs
	20 Lakh	secondary vehicle fleets.	domestic, institutional, RWAs, Offices,	Refuse Compactors. Fleet to have less	and their
			Shops etc.	complexity.	combinations
			Evening Collection 7-8 PM can be	Transfer – only Vehicle to Vehicle, for transfer	
			introduced for commercial areas as	without leaving any garbage spills or leachate.	
			overtime measure		
		ICT: Use maximum features of S	Swachhnagar APP (mobile based) for vehicl	e tracking, Citizen services. GPS, RFID and call	
		centres can be introduced. Publ	lic information dashboards.		
All syst	tems are to be mai	de for segregated collection and	l transportation. No collection without seg	gregation. Byelaws with penalties/fines for any lit	ctering and
contr	avention of SWM	Rules 2016 must be implement	ed.		
2. Ust	e of ICT intervention	on, e.g. Swachhnagar App enabl	les higher efficiencies and outputs in the s	ystem.	
3. All 4. Vel	primary collectior hicle to vehicle tra	ו vehicles should allow waste de מוזלפר must ensure zero-spillage	eposition at height not more than 1.2-1.5n 	n trom ground/pavement/road.	

RECC	MMENDATIONS: (Given below is the quick, indicativ	le guide to the systems for efficient collecti th small broad to brade to brade be	ion and transportation of MSW for different classes	es of Cities/ULBs
S No	Description of ULB	Recommended C&T System	Timing of basic D2D Collection	Vehicle Types & Tracking	Personnel
4	ULB with current population >20 Lakh	System with Combination of non-motorised & motorised vehicles, both primary & secondary vehicle fleets	Single/Double shift with Set Time for collection, preferably 6-8 AM for bomestic & Later timings for non- domestic, institutional, RWAs, Offices, Shops etc. Evening Collection 7-8 PM combined with night sweeping to be introduced for commercial areas as a fixed measure. Streamlined Collection : For garden waste, temple (flower waste), mandi waste, mela waste, animal wastes, C&D waste should be mandatory.	Vehicles - Hired, Owned or a combination, all under AMC Use the complete complement of fleet, as warranted, from Carts, Cycle Rickshaws to Refuse Compactors. Transfer – Designed Transfer Stations preferably with stationary compactors, receiving waste from all kinds of vehicles.	Own Staff / Contracted Staff/ SHGs and their combinations Integrated Contracts.
		ICT: Use maximum features of S complaint redressal in entire MS alerts etc.	swachhnagar APP (mobile based) for vehicl SWM services .GPS, RFID and call centres a	e tracking; Citizen services OR ULBs own APP for re mandatory. Public information systems., SMS	
<u></u> В	1. All systems are littering and cont 2. Use of ICT inter 3. All primary coll 4. Vehicle to vehi	Integrated Contracts for Vehicle to be made for segregated collect travention of SWM Rules 2016 m rvention, e.g. Swachhnagar App rvention vehicles should allow was lection vehicles should allow was icle transfer must ensure zero-spi	e Fleet + Staff, including Transfer Stations a ction and transportation. No collection wust be implemented. enables higher efficiencies and outputs in ste deposition at height not more than 1.2 illage.	ire preferred. ithout segregation. Byelaws with penalties/fines f i the system. 2-1.5m from ground/pavement/road.	for any



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Swachhata Pledge

Mahatma Gandhi dreamt of an India which was not only free but also clean and developed.

Mahatma Gandhi secured freedom for Mother India.

Now it is our duty to serve Mother India by keeping the country neat and clean.

I take this pledge that I will remain committed towards cleanliness and devote time for this.

I will devote 100 hours per year that is two hours per week to voluntary work for cleanliness. I will neither litter nor let others litter.

I will initiate the quest for cleanliness with myself, my family, my locality, my village and my work place.

I believe that the countries of the world that appear clean are so because their citizens don't indulge in littering nor do they allow it to happen.

With this firm belief, I will propagate the message of Swachh Bharat Mission in villages and towns.

I will encourage 100 other persons to take this pledge which I am taking today.

I will endeavour to make them devote their 100 hours for cleanliness.

I am confident that every step I take towards cleanliness will help in making my country clean.



Ministry of Housing and Urban Affairs Government of India