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WASTE-WISE CITIES

Best practices in municipal solid waste management

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MESSAGE

Vice Chairperson, NITI Aayog

Over the past few years, India's waste management sector has received tremendous attention due to the widespread awareness generated under the flagship Swachh Bharat Mission. The mission touched every citizen in some way or the other and went on to become one of the largest cleanliness drives of the world. With mere 18 per cent waste treatment capacity in 2014, India's waste management efficiency was extremely critical and posed huge challenges towards the environment. From 18 per cent waste processing in 2014 to 70 per cent in 2021, we have come a long way. Exemplary coordination at all levels of government and massive citizen participation in the movement resulted in an environment of Swachhta never achieved earlier in the country.

With the launch of Swachh Bharat Mission (Urban) 2.0, the efforts for sustainable waste management are being further strengthened. It is important that we leverage the momentum attained during the first phase of the mission in order to achieve the next set of targets. Under the second phase, it is aimed that cities are made garbage free with efficient waste source segregation, 100 per cent door-to-door collection, and complete remedial treatment of the waste material. As urbanisation expands, the stress of providing quality urban service delivery on ULBs/authorities continues to rise. Therefore, it is crucial that these authorities are supported beyond financial assistance of the mission and their capacities are built to address the service delivery challenges. A comprehensive knowledge resource showcasing best practices of waste management sector will help and guide cities to develop their waste management plans with greater efficiency.

It is with this intent, NITI Aayog and Centre for Science and Environment (CSE) collaborated and developed this publication which showcases best practices for 10 different thematic areas of waste management. Waste management operations in 28 cities from 15 States have been studied and incorporated in the publication. It

aims to create greater capacities among officials of urban local bodies and other relevant stakeholders at the city level for implementation of efficient solid waste management systems. The book discusses multiple areas of waste management including source segregation, material recovery, biodegradable waste management, electronic-waste, construction and demolition waste, etc. I hope that this knowledge resource will guide stakeholders for planning robust waste management systems.

I compliment the efforts of CSE in the sector and their cooperation in the development of this document. I would also like to compliment the Managing Urbanization vertical at NITI Aayog led by Special Secretary, Dr K. Rajeswara Rao for coming up with the idea of developing this crucial knowledge product. His team including Deputy Advisor, Dr Biswanath Bishoi, and Young Professional, Mr Dhiraj Santdasani deserve appreciation for their consistent efforts.

Dr Rajiv Kumar
Vice Chairperson, NITI Aayog

FOREWORD

CEO, NITI Aayog

The government has recently released the second phase of Swachh Bharat Mission (Urban), emphasizing making cities Garbage Free. India has accomplished a significant feat by exponentially increasing the waste processing capacity by four times in the last six years. The announcement of the second phase of the mission will further mainstream the aspects of circular economy in waste management sector of India. While we are moving beyond the targets of ODF and embarking on the journey of making cities garbage free, robust strategies to implement 100 per cent source segregation, door-to-door to collection and complete waste processing need to be adopted by urban local authorities with the active support of urban dwellers.

With rapid population growth in urban areas, the capacities of the local authorities often fall short of achieving the set goals of urban service delivery. Therefore, sector stakeholders must be equipped with adequate knowledge resources to plan efficient waste management systems. Capitalising greater public-private partnerships, involving citizens to form a *Jan Andolon* and leveraging the latest technologies for waste processing can enable India to achieve the next set of goals that focuses on making cities garbage free.

Many Indian cities have shown remarkable progress in waste management by implementing robust models of service delivery coupled with innovative initiatives. To achieve the cleanliness targets in a time-bound manner and with utmost efficiency, Urban Local Bodies across India must have access to strategies and best practices of the waste management sector. With this aim, this publication has been developed, covering best practices of 28 cities categorized into ten thematic areas of the waste management sector. Local authorities can study different models and adapt them as per local conditions for implementation. This compilation of best practices would act as a vital knowledge resource for urban practitioners working in this sector.

I compliment the efforts of Centre for Science and Environment in development of this publication and for working alongside other stakeholders, helping them streamline solid waste management systems. My special appreciation goes to the Special Secretary, NITI Aayog, Dr K. Rajeswara Rao, for conceptualizing this publication and providing commendable leadership in its development. In addition, the team members of the Managing Urbanization vertical of NITI Aayog—Deputy Advisor, Dr Biswanath Bishoi and Young Professional, Mr Dhiraj Santdasani—deserve due recognition for their persistent efforts.

Amitabh Kant
CEO, NITI Aayog

FOREWORD

Special Secretary, NITI Aayog

Showcasing a true testament of *Jan Andolan*, the Swachh Bharat Mission brought significant transformation in India's waste management sector in the past six years. Not only the practices of waste segregation and door-to-door waste collection have come to centre stage, but the waste processing capacity of the country witnessed a steep rise from 18 per cent in 2014 to 70 per cent in 2021. The mission has benefitted the society with its participatory and inclusive approach. The government has recently announced the next phase of Swachh Bharat Mission urban, with an explicit focus on implementing efficient waste management services in the cities across the country.

Although the government at all levels has been diligently working towards achieving complete waste treatment, limited managerial and technical capacities, amid rapid urbanisation, have put pressure on Urban Local Bodies (ULBs) to deliver efficient municipal services. However, multiple cities across the country have implemented ground-breaking, workable, and resource-efficient models of solid waste management. It was felt that ULBs across the country should have access to knowledge resources that present strategies for different components of the waste management service chain. With this intent, this publication "Waste-Wise Cities" was conceptualised, and NITI Aayog collaborated with the Centre for Science and Environment to identify best practices in ten thematic areas of waste management, including material recovery, biodegradable waste, source segregation, construction waste, e-waste, etc.

The book is a knowledge repository compiling success stories of 28 cities across the country that achieved remarkable progress in various areas of waste management. In the process of developing this document, a series of consultations were held with selected ULBs, think tanks, academia, private players, NGOs/CSOs, etc. In addition, the research teams also visited these 28 cities to capture granular details by witnessing on-ground operations.

This publication will enable local authorities and other stakeholders involved in the waste management sector for designing efficient tailored waste management solutions relevant to their local conditions and in alignment with the guidelines. State urban development departments, the key stakeholders, may study this book for relevant initiatives and may also translate the book in regional languages for more effective use of stakeholders as needed.

I would like to compliment to the team of Centre for Science and Environment for their efforts in development of this publication. I would also like to appreciate the team of managing urbanisation vertical, particularly Dr Biswanath Bishoi, Deputy Advisor, and Mr. Sanjay Gupta, Economic Officer, for their efforts. Mr. Dhiraj Santdasani, Young Professional, deserves special appreciation for putting persistent efforts throughout the development of this publication.

Dr K. Rajeswara Rao, IAS
Special Secretary, NITI Aayog

FOREWORD

A paradigm shift is needed in learning and practice for garbage-free and waste-wise cities

Sunita Narain

India's tryst with garbage – the waste from the use of materials in homes, institutions and factories in its cities – is evolving sharply in policy and practice. This change needs to be recognised and disseminated, so that waste does not add to contamination and become a public health menace. Instead, waste should become a resource, to be reworked, reused and upcycled. This will minimise the use of materials in our world, as well as mitigate environmental damage. It is a win-win scenario. This set of case studies on best practices documents what is being done to make this change happen on the ground.

This, when we know that the 'nature' of solid waste changes as societies get richer and more urbanised. Instead of biodegradable (wet) waste, households generate more and more quantities of plastics, paper, metals and other non-biodegradable (dry) waste. The quantity of the waste (on a per capita basis) increases as well, as wealth increases in society. India has crossed the crux of this waste trajectory in many of its urban areas where waste generation has increased exponentially.

It is estimated that urban India generates between 1,30,000 to 1,50,000 metric tonne (MT) of municipal solid waste every day – some 330-550 gramme per urban inhabitant a day. This adds up to roughly 50 million MT per year; at current rates, this will jump to some 125 million MT a year by 2031. What is also of concern is that not only is the quantity increasing, but the composition of waste is changing – from high percentage of biodegradable waste to non-biodegradable waste. The waste characterisation determines the strategy for its management. And then there is the problem of legacy waste lying in dumpyards scattered across cities. It is estimated that some 800 million MT has been 'disposed of' in the 3,159 dumpsites across the country, according to data from the Central Pollution Control Board (CPCB).

But the good news is that there is complete transformation in the policy for waste management in the country. In the year 2000, when the first Municipal Solid Waste Rules were notified, they were based on the idea – prevalent in most countries of the world at that time – that waste had to be collected, transported and then disposed of in secure landfills. The objective was to 'clean' cities of waste by removing it from the vicinity. This policy failed in practice and mountains of waste grew in our cities. What could not be collected or transported because of paucity of municipal services fouled up our streets and neighbourhoods.

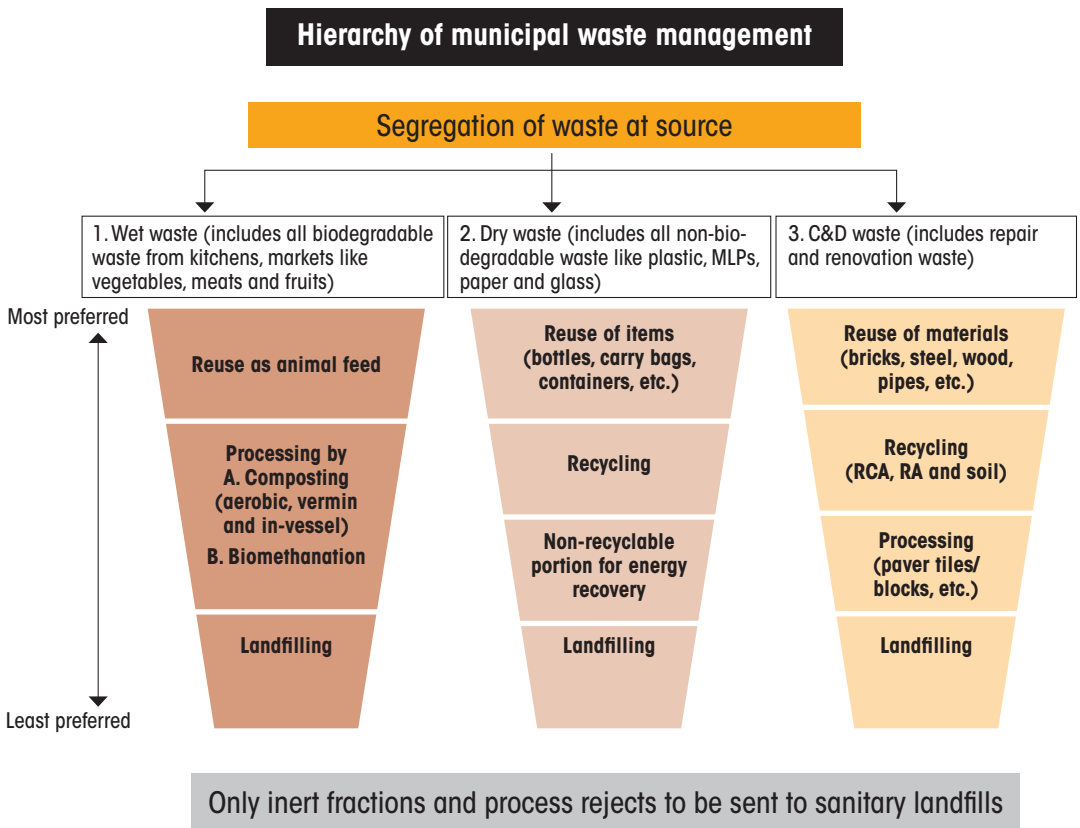
In 2016, Centre for Science and Environment (CSE) published *Not In My Backyard: Solid Waste Management in Indian Cities*; the book was released by then Union minister for urban development and currently the honourable Vice President, Shri M Venkaiah Naidu. This book, which researched the problem of municipal solid waste in the country, brought out the need for a paradigm shift in management. It recommended that India must not use scarce and prized land for disposing of waste. Instead, waste should be treated as a resource and a strategy must be designed for material recovery and reuse.

But what was also clear is that material recovery is not possible without segregation – and that this sorting of waste streams is best done at the household level or at source. The opportunity is to build safe livelihoods from processing of this material wealth. It was also found that whereas in the past, waste could be dumped in the backyards of poor communities as the richer sections of society said '*not in my backyard*'. This scenario was now changing – increasingly and rightly, the poor too were saying '*not in my backyard*'. This essentially meant that it is no longer possible for city planners to find new lands for landfill sites. This was the 'nudge' for correcting policy and practice, as waste needed now to be processed and recycled so that it would no longer be dumped in the backyards of the rich or the poor. We argued that this '*not in my backyard*' of the poor needed to be celebrated so that policy could be reworked.

Over the past few years, there has been a rapid shift in the strategic direction of waste management in the country. The flagship programmes of the Government of India – the Swachh Bharat Mission, the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and the Smart Cities programme – have all created an enabling environment to drive this transformation.

The Swachh Bharat Mission (SBM) 2.0, launched on September 1, 2021, is now based on a clear strategy for solid waste management in cities – a strategy that focusses

Components of MSW management – the hierarchy



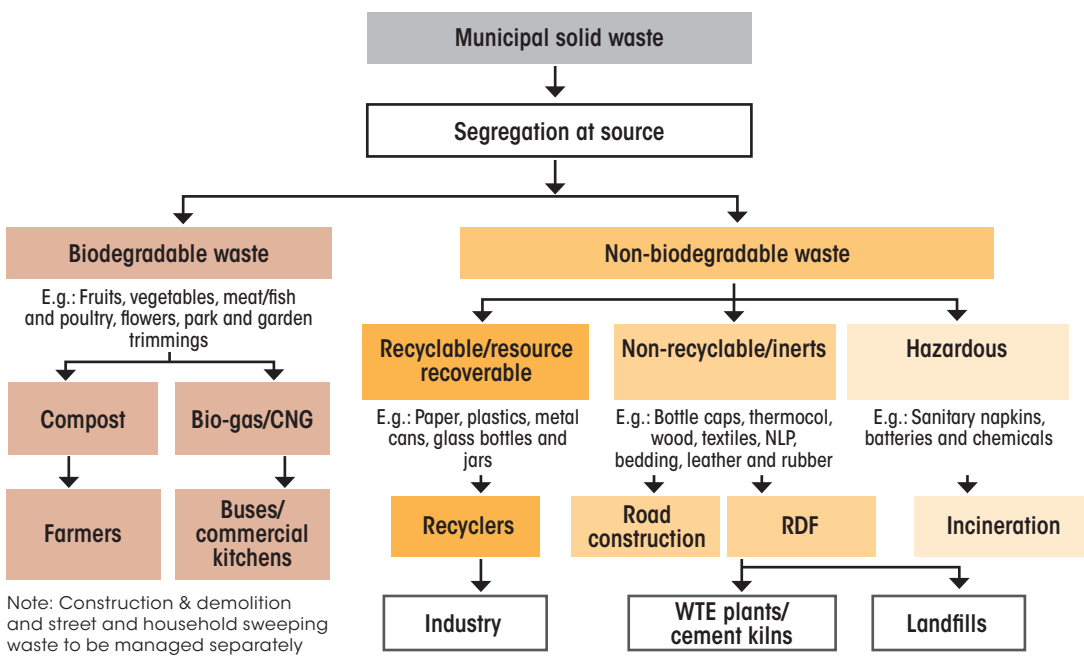
Source: Guidelines for Swachh Bharat Mission (urban) 2.0, 2021

on source segregation, processing of waste (biodegradable and non-biodegradable), and minimising the waste that is sent to landfill sites. According to the guidelines of SBM 2.0, only the inert waste and process rejects – in no case to exceed 20 per cent of the total waste – which are not suitable for either biodegradable and non-biodegradable waste treatment, can be sent to landfill sites. It, therefore, works towards a zero-landfill city concept in the country (see Figure: *Components of MSW management – the hierarchy*).

In terms of management of waste, the guidelines stress that waste-to-energy projects are financially and operationally viable only with assured input of a minimum 150-200 tonne per day of non-recyclable, high calorific value segregated non-biodegradable waste. This has also been our learning as waste-to-energy (WtE) plants are not the silver bullets that they promise to be. The experience in setting up these plants has shown that it is critical that the waste that is sent for incineration for energy generation is high quality; this requires high level of segregation – best done at source. Without this, the plants end up working below their operational capacity and become defunct.

SBM 2.0 also emphasises the need for plastic management – working towards minimising single-use plastic, and operationalising recycling and reuse through processing. This remains an area of further work as it is clear that the scourge of plastic waste needs effective strategies for identification of single-use and non-recyclable plastic. This then needs to be phased out. We also need a better understanding of what recycling of plastic waste entails. This requires cities to provide enabling conditions for safe and environmentally friendly recycling facilities.

Components of MSW management – different types of waste and where they end up



Source: Guidelines for Swachh Bharat Mission (urban) 2.0, 2021

The other big opportunity – but a challenging one – lies in remediating the legacy waste in dumpsites. There is much to learn from city experiences on what is being done and what more is needed to ensure that not only are existing dumpsites cleared of their waste, but also that new dumpsites are not created – these mountains of waste in our cities are unacceptable.

Swachh Survekshan – India's benchmarking and ranking tool – has also evolved to capture the measures that take a city towards source segregation, material reprocessing and zero-landfills.

India's solid waste management strategy is now designed for material recovery and reuse. It is an approach towards a truly circular economy. The fact is that as we learn what we cannot recycle, we will have to work towards minimising its use – this will make policy and practice even more environmentally friendly as it will demand full reutilisation of materials and no waste.

This said, it is clear that while policy has evolved, practice has still to catch up. We need to upscale this paradigm shift across the country: every small or big city and village must be waste-wise.

This needs learning. This needs sharing of experiences on what is working and what is not. Currently, we know that source segregation remains an Achilles' heel – it does not happen at the scale and pace needed. Even if waste is segregated at the household level, it does not get transported in a segregated manner to the processing facilities. In fact, processing happens incidentally, only because there are people who need our waste for their livelihoods – ragpickers, as we call them. City managers are still working through the different options for processing, and to manage these effectively for revenue generation. Worse, plastic waste – particularly much of the packaging waste – is growing and filling our cities. We certainly need a course correction.

The fact also is that we are in an exciting phase of development, where city managers and leaders are indeed learning from ground experience; they are reworking their strategies and implementing change at scale. These cities are our inspiration, as well as our textbooks for learning.

In 2017, CSE started the 'Forum of Cities that Segregate' to create a platform for showcasing city-wide success stories and to develop a knowledge-exchange hub. This then works to build internal capacities, to assess progress, to provide handholding support and to document the best practices to use as an effective instrument for training and exposure.

We are delighted to have had this opportunity to partner with NITI Aayog to take this initiative forward and to ensure that constant learning of best practices and their application will make our cities garbage-free and waste-wise.

Sunita Narain
Director General
Centre for Science and Environment
New Delhi

INTRODUCTION

This book is about the winds of change. Over the past few years, Indian cities have witnessed a steady departure from the traditional practice of managing municipal solid waste to a more environment-friendly and financially sustainable system.

There is greater emphasis on source segregation for sustainable solid waste management and to moving from 'linearity' to 'circularity'. The focus is on:

- Remediation of all legacy dumpsites;
- The well-being of sanitation and informal waste-workers;
- The need to phase out single use plastic;
- The opportunity to introduce technological innovation through digital tracking; and
- Most importantly, on the absolute need for source segregation as the way for material recovery and recycling. Waste is no longer waste for our waste-wise cities.

ABOUT THE STUDY

For driving the change through knowledge and evidence-based learning, NITI Aayog and CSE have collaborated to capture best practices in various facets of municipal solid waste management.

The process of identifying best practices was based on the implementation experience of the flagship Swachh Bharat Mission 1.0 and performance of the cities in the Swachh Survekshan assessment in 2018–20. Through this, 28 cities were identified from 15 states of India in 10 thematic areas of municipal solid waste management. These cities aligned with the current priorities on sanitation and solid waste management as laid out in Swachh

Thematic areas

Priorities/thrust areas for practice and innovation	Cities
Source segregation	Indore, Alappuzha, Panaji
Biodegradable waste management	Mysuru, Vengurla, Bobbili
Material processing	Bhopal, Surat, Jamshedpur, Dhenkanal
Plastic waste management	Gangtok, Bicholim, Kumbakonam
C&D waste management	North Delhi, Gurugram
Sanitary waste management	Pune, Karad
Landfill	Taliparamb, Chandrapur, Ambikapur
Technological innovation	Bengaluru, Leh, Vijaywada, Keonjhar, Kakinada
Innovative model	Paradeep, Thiruvananthapuram, Panchgani
E-waste	Jamshedpur

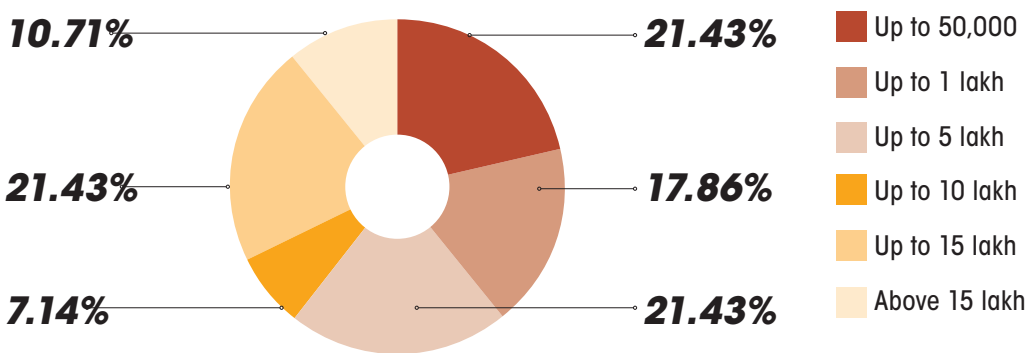
Source: CSE

Bharat Mission (SBM) 2.0, Atal Mission for Rejuvenation and Urban Transformation 2.0 (AMRUT) and Swachh Survekshan 2022 Toolkit. Key thematic areas were picked up for this exercise (see Table: *Thematic areas*).

While each city has been identified on the basis of a specific thematic area, the following is a snapshot of the key solid waste management parameters in the cities selected for the study.

The 28 cities selected for this study have populations in the range of 50,000 to above 5 million (see Graph: *Population-wise distribution of cities*).

Population-wise distribution of cities

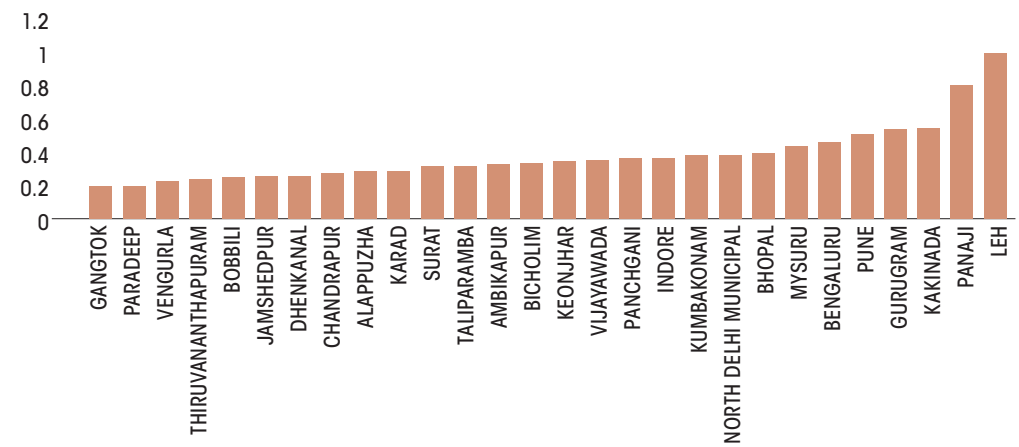


Source: CSE compilation

1. Per capita per day generation of municipal solid waste

The per capita per day solid waste generation has been estimated using the current (2021) estimated population and daily floating population. The per capita per day solid waste generation in the 28 cities is in the range of 0.19–0.99 kg and the average for all 28 cities is 0.39 kg. This is representative of the country-wide per capita waste generation, with bigger and more affluent cities adding more waste per day. For instance, Leh and Panaji, both tourist towns, have a much higher waste generation footprint than the country's average of 0.3–0.5 kg/day/person.

Per capita per day generation (in kg) of municipal solid waste



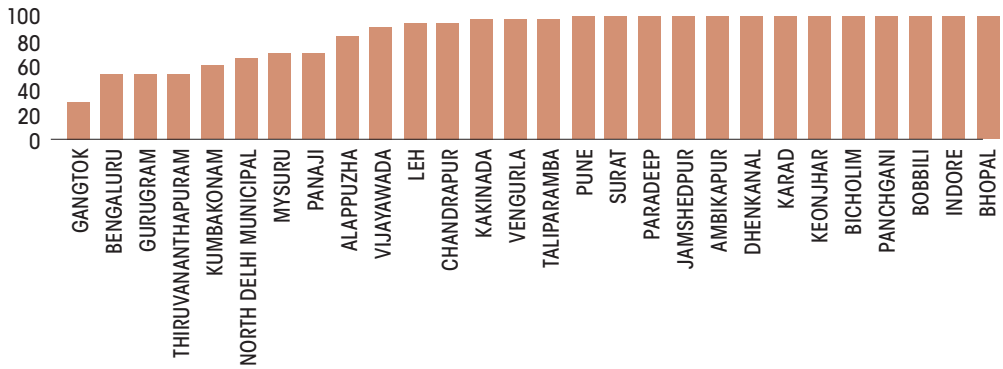
Source: CSE compilation from data provided by ULBs

In the 28 cities, deployment of sanitation workers for managing one tonne of municipal solid waste was in the range of 0.04–0.9. Significantly, cities with a decentralized system in place needed significantly lesser humanpower for managing their solid waste.

2. Processing rate of municipal solid waste

The 28 selected cities are working to close the gap to achieve 100 per cent waste processing efficiency. But it is a work in progress and cities like Gangtok, Bengaluru, Gurugram, Kumbakonam and North Delhi are in the process of improving their processing efficiency.

Percentage of waste processed by cities



STRUCTURE FOR DOCUMENTATION

The report for each city has focused on the thematic area while presenting the overall state of municipal solid waste management. The structure of the report comprises the following key elements:

TRANSFORMATION	The section speaks about what triggered the change in the city to ameliorate solid waste management by adopting appropriate measures for addressing the challenges.
HOW THE SYSTEM WORKS	This section has covered the implementation strategy and operational elements that has helped the city to emerge as a model on the thematic area.
WHAT HAS WORKED	This section has highlighted the specific actions taken by city government in line with the adopted strategy and plan that has been pivotal to drive the change.
LESSONS LEARNT	The section focuses on the key learnings emerged from the study in terms of inclusivity, strategy, plan and implementation model for practitioners to improve their waste management systems.
REPLICABILITY	This section highlighted the elements to substantiate whether the model instituted by the city is replicable – what are the prerequisites to replicate the model in any city.

BEST PRACTICES: HIGHLIGHTS

The documentation focusses on each city's strengths so that learning is based on best practice, its experience and its innovation.

Source segregation

Allappuzha (Kerala), Indore (Madhya Pradesh) and Panaji (Goa)

Source segregation is a fundamental and non-negotiable condition for a sustainable waste management ecosystem. Mixing waste at source creates a myriad of problems. Mixed waste also increases the risk of contamination of recyclables and significantly reduces their economic potential. Even if waste is to be incinerated to generate energy, segregation is key. It has been proven time and again that cities that segregate their solid waste have been able to realise the actual value of waste.

Alappuzha: Alappuzha embarked on a project called Clean Home Clean City that focussed on source segregation as the first and foremost step towards effective waste management. This decreased the operational cost of dealing with waste as well as created a source of revenue. Awareness campaigns by the city government to promote source segregation led to remarkable changes in the attitude and practices of the citizens. This involved all the stakeholders to work for a common cause to improve the overall solid waste management in the city.

Indore: The city had a robust communications strategy to bring about behavioural change at the mass level. The aim was to motivate citizens to embrace segregation. This was followed by a robust monitoring system and enforcement through a series of by-laws. Once segregation was achieved, the city undertook a study to ascertain the population and the amount of waste generated in each ward, based on which a route plan was developed. Vehicle and staff demand was arrived at to meet the waste collection demand of each ward. Through source segregation, participation of all stakeholders and good governance, Indore has become a champion and number one city in the waste management sector in India.

Panaji: Panaji has worked over the last 15 years to achieve 99 per cent segregation. Primary segregation was done in two or four bins by the households. In 2021, the city implemented 16-way segregation at source – this was done along with adopting several technologies and initiatives for waste management. The model provides significantly higher revenue from the sale of recovered goods, increasing the income of the workers involved in the value chain.

Biodegradable waste management

Bobbili (Andhra Pradesh), Mysuru (Karnataka) and Vengurla (Maharashtra)

On an average, organic waste consists of more than half of the solid waste that we generate as a country. This means that if we take care of our organic waste, half of our

waste woes will go away. Moreover, three quarters of the organic waste is water. Indian cities have been known to spend most of their budget on collection and transportation of solid waste. This means that we are spending our tax payers' money and burning fossil fuels to transport water from one point to another. This calls for the need to manage our organic waste as close to the source as possible. That is exactly what these cities have been able to achieve.

Bobbili: Bobbili's municipal administration decided to overhaul the town's solid waste management system, and immediately and rightly turned their focus to source segregation as the lynch-pin of the whole exercise. Over the years, they have been able to make good use of the information, education and communication (IEC) programme and the Andhra Pradesh government's real-time monitoring system to improve source segregation to 100 per cent. The town produces a substantial quantity of wet waste, and composting, whether at the household level or at scale in the form of windrow and vermicomposting, has worked well in Bobbili. In tandem with the biogas plant, the various means of composting have proved adequate to process all of the town's organic waste.

Mysuru: The game changer for Mysuru was the zero-waste management plants in each zone that received segregated biodegradable fractions of solid waste from five wards on an average. The city is the torchbearer in the field of biodegradable waste processing. Collected biodegradable waste is converted to compost by means of scientific methods. Appropriate infrastructure has been developed for proper processing of biodegradable waste. The compost is then packaged and sold to nearby farmers and the horticulture department.

Vengurla: Vengurla adopted a two bins-two bags – green for biodegradable waste and blue for non-biodegradable waste – approach for source segregation. Sanitary waste and domestic hazardous waste were collected separately. The council's choice of technologies and systems – from vermicomposting and bio-biomethanation for kitchen waste and organic waste converter for fish or meat and fibrous wastes, to briquetting for biomass and green foliage waste – can be easily incorporated in any kind of urban centre, irrespective of the size of the population or the area. The city processes 100 per cent of the organic waste that is generated.

Material processing

Bhopal (Madhya Pradesh), Surat (Gujarat), Jamshedpur (Jharkhand) and Dhenkanal (Odisha)

Municipal solid waste comprised a wide variety of materials that we use in our daily lives. Materials in our solid waste range from biodegradables to plastics, papers, metals, glass etc. The value of these materials is a function that is inversely proportionate to the degree of mixing of waste. Solid waste usually leaves our homes in not more than three fractions – biodegradable, non-biodegradable and domestic hazardous waste as mandated by the rule, but at the secondary sorting-cum-material recovery facility, the collected three fractions have been proven to contain over 50 different materials that need to be channelised to specific facilities for scientific processing and converted to new products.

Bhopal: The change happened due to the cooperation of citizens who had to manage their waste properly and hand it over to the municipal workers who provided daily waste collection

services. This was made possible by several initiatives focussing on behaviour change. With an array of well-designed systems, the city has achieved 100 per cent source segregation, 100 per cent collection and 99.6 per cent treatment facility. The 85 municipal wards have been divided into 19 zones with each having four to six wards for ease of planning, monitoring and implementation. With efficient integration of the informal sector and setting up a robust monitoring system, the city has made a complete transformation to count among the best 10 cities in the country.

Surat: Surat doubled in size between 1981 and 1991, and faced a massive challenge to manage their solid waste to keep pace with the increased population. It adopted a multi-pronged approach of achieving 100 per cent source segregation, investment for construction, operation and maintenance, channelization of recyclables and refuse-derived fuels to achieve a high material processing efficiency. This resulted in substantial reduction of the waste received in the landfill.

Jamshedpur: Jamshedpur has proved to be a model of material recovery by establishing Dry Waste Collection Centres (DWCCs) to manage its non-biodegradable waste, where the waste is further segregated into paper, metal, wood, cloth, non-recyclables and packaging materials. Nearly 1,400 ragpickers are employed at the DWCCs as they are expert in extracting recyclables and reusable materials from waste, and act as a critical workforce in managing recyclables. In addition, the decentralised biodegradable waste processing units complement this system. In addition, Jamshedpur has constructed more than 20 km of roads using non-recyclable plastic waste collected from plastic from the DWCCs. The concept of eco-bricks has been popularised in schools and residential societies in Jamshedpur to promote the storage of non-recyclables at the household level.

Dhenkanal: The Odisha state government took a leap towards implementation of decentralised waste management and made it mandatory for all the urban local bodies in the state. Following the directive, the Department of Housing and Urban Development shared a standard operating procedure as a guideline to develop decentralised waste management units. The city councils then involved the local self-help groups, who were trained. They in turn built capacity of every household, resulting in behaviour change amongst the citizens. By political will, realising the importance of public awareness, involvement of the local community and importance of converting waste to resource, Dhenkanal achieved 100 per cent material processing.

Plastic waste management

Bicholim (Goa), Gangtok (Sikkim) and Kumbakonam (Tamil Nadu)

Over the last few decades, plastics have become an inherent part of our lives. They have replaced all conventional materials because they are cheap, lightweight, durable and versatile. Unfortunately, these properties also turned the wonder substance into a cause for concern for most urban local bodies. Management of plastic waste has turned out to be a massive challenge due to its versatility and low awareness among consumers and authorities alike. This means that we don't know what type of plastic goes to which kind of facility and how it gets – if at all it does – recycled. A handful of Indian cities have shown the way ahead to face this challenge head-on.

Bicholim: Bicholim is especially focussing on managing non-biodegradable waste and continues to act proactively to reduce the impact of plastics on the environment and human health. Bicholim has not only managed to process its own waste but is also accepting waste from neighbouring urban local bodies, hence dealing with the non-biodegradable fraction of the entire taluka.

Gangtok: Gangtok adopted an alternate strategy to minimise the environmental and health hazard of plastic waste pollution. Sikkim was the first Indian state to ban disposable plastic bags as early as June 1998. In 2016, the city also banned the use of packaged drinking water in government offices and offices. This was in addition to the ban on disposable plastic plates and cutlery. The ban was effective because the city government followed it up with awareness and enforcement activities on the ground. All the stakeholders were capacitated to understand the impacts of plastic waste on their city and were thus able to effectively contribute to curbing the use of plastic.

Kumbakonam: Kumbakonam recognised and mandated source segregation as the most important step to creating a city free of plastic waste. Following the ban on plastic by the state government in 2019, the city was quick to set up a resource recovery facility. While the recyclable fractions were being sent to the recycling industries, non-recyclable plastic was converted to refuse-derived fuel and channelized to cement factories for co-processing. In its endeavour to become a bin-free and a garbage-free town, Kumbakonam has not resorted to any shortcuts focussing on a holistic model of waste management instead.

Construction and demolition (C&D) waste management

North Delhi (Delhi) and Gurugram (Haryana)

India generates an estimated 150 million tonne of construction and demolition (C&D) waste every year out of which it is being able to recycle merely about 1 per cent. C&D waste is bulky in nature and a significant proportion of this waste stream can be potentially recycled and reused and brought back to construction to replace the dependence on virgin raw material. In addition, recycling C&D waste can help reduce the environmental footprints of buildings and infrastructure.

North Delhi: Delhi produces nearly 5,000 tonne of construction and demolition (C&D) waste out of which North Delhi region generates nearly 2,000 TPD daily. The illegal dumping of C&D waste leads to choking of water drains and polluting Yamuna River. Nearly, 37,000 m^3 of debris was found lying near the eastern bank of Yamuna and 53,000 m^3 of debris on the western Yamuna bank. To address the issue, a C&D processing plant with a capacity of 2,000 TPD was established in Burari, Delhi in 2009. The plant is currently scientifically processing 2,000 TPD of mixed C&D waste and converting it into aggregates, which in turn is converted to ready mix concrete, cement bricks, hollow bricks, pavement blocks, kerbstones, concrete bricks, and manufactured sand, thereby reducing the consumption of virgin construction raw material and minimizing the environmental hazard due to C&D wastes. Over 16 lakh recycled concrete blocks from the plant have been utilized in the new Supreme Court annex building.

Gurugram: Gurugram generates approximately 1,200 TPD of C&D waste. Additionally, the areas governed under the Haryana Urban Development Authority (HUDA) also generate a substantial quantity of C&D waste. In order to address the hazards due to dumping C&D waste, a C&D waste processing facility with a capacity of 300 TPD was established. This became functional in 2019, ensuring proper collection, transportation, processing and disposal of C&D waste. Gradually, the processing capacity of the plant has increased to 1,500 TPD. Due to this initiative, nearly 12 lakh tonne of C&D waste has been collected from unclaimed dumpsites and transported so far through doorstep collection and enforcement activities. Out of this, nearly 3.5 lakh tonne has been processed.

Sanitary waste management

Karad (Maharashtra) and Pune (Maharashtra)

Sanitary waste management has been the least explored and debated of all the streams of solid waste that is generated at the household level. As per the Solid Waste Management Rules, 2016, sanitary waste has to be handed over along with the dry waste bin. The handling and channelisation of this stream of waste involves occupational hazards and is a matter of concern for most cities.

The following two cities of India are showing the way to deal with this stream of waste:

Karad: Karad struggled initially to manage its sanitary waste due to a number of social and technical issues. By managing to break the taboo around sanitary waste, the city administration has achieved a 100 per cent sanitary waste collection rate. The city also ensures that sanitary waste is transported and processed separately in the local Common Biomedical Waste Treatment Facility (CBWTF). All this was achieved through minimal investment on infrastructure and higher accountability amongst citizens and city government through a combination of communication and enforcement strategy.

Pune: The city introduced the Red Dot campaign, a one-of-its-kind initiative, where citizens, workers and administration unanimously accepted their responsibility, making it a lesson for other cities in India. This was achieved through a well-planned mechanism of collection, channelisation and disposal. The city administration is in the process of exploring a state-of-the-art technology to make value added products from their sanitary waste.

Zero-landfill city model

Ambikapur (Chhattisgarh), Chandrapur (Maharashtra) and Taliparamba (Kerala)

A zero-landfill model offers a technically appropriate, environmentally and economically sustainable and socially acceptable model that is based on resource recovery and principles of circular economy. It advocates the need for continuous effort to phase out the dependency on landfills for waste disposal. A zero-landfill city ensures that maximum quantities of waste is subjected to scientific treatment and recycling measures and negligible waste is generated as residual solid waste or rejects, thereby minimising the need to construct new landfills. It is a holistic and multi-stakeholder approach that ensures that waste is segregated at the source itself, recyclables are extracted and channelized to the recycling industries for various gainful applications, and biodegradable waste is treated in a decentralised manner.

Ambikapur: Before 2015, Ambikapur displayed the usual manifestations of a town – overflowing community bins and waste dumped indiscriminately near roads, streets and a garbage mountain containing legacy waste. With the intervention of the local administration and women self-help groups and inspired by the concept of the Garbage Clinic Model, the city is now able to achieve 100 per cent segregation, collection and processing of waste. The waste is brought to the Solid and Liquid Resource Management (SLRM) Centre, where the recyclables are first extracted into 20 inorganic fractions by secondary segregation, followed by 156 categories in the tertiary segregation. The legacy waste dumpsite is cleared by the urban local bodies and now being used as waste recycling centre.

Chandrapur: The city, even five years ago, collected mixed waste and dumped it indiscriminately in the Ballarpur dumping ground. There were 800 garbage-vulnerable points and 110 community bins haphazardly receiving mixed waste. In 2016, Chandrapur achieved 85 per cent source segregation and nearly 95 per cent waste processing by sensitising all the stakeholders through extensive Information, Education and Communication (IEC), capacity-building programmes and awareness campaigns. Parallelly, the existing dumpsite containing 68,593 cubic metre of legacy waste is also remediated by biomining. The land recovered has been converted into an integrated waste treatment facility with a sanitary landfill constructed only for receiving the rejects generated from various waste treatment units ensuring that only negligible waste fraction is disposed of in the landfill.

Taliparamba: Till 2012, the town was sending all its waste to a 2.5-acre dumpsite, affecting the local population and environment. The city reinvented its waste management practices and adapted a decentralised system after 2012, with the help of women self-help groups. Today, 85 per cent of Taliparamba's households adhere to the door-to-door collection process and almost 99 per cent of waste is processed in a scientific manner. The city has also reclaimed the dumpsite land which is now the town's material recovery facility. In addition, the city has provided bio-bins to about 9,500 households for practicing home composting thereby ensuring that wet waste is treated in decentralized manner significantly reducing the transportation cost and burden on landfills.

Technological innovation

Kakinada (Andhra Pradesh), Leh (Ladakh), Bengaluru (Karnataka), Keonjhar (Odisha) and Vijaywada (Andhra Pradesh)

Application of innovative technologies in waste management is essential in order to make the system more sustainable by ensuring efficient collection and transportation of waste enhancing recycling efficiency, minimising energy and resource requirement in waste treatment and most importantly monitoring of waste management-related activities. Technological innovation in waste management and treatment in India is currently mostly in the nascent phase. The transformation of the waste management sector in India should be aligned with innovative technology options which can be replicated all across the country to recover wealth from waste. The cities selected under these segment have made efficient use of technologies like global positioning system, radio frequency identification, global system for mobile communications, machine-to-machine communication and

internet of things, along with innovative mobile and web-based applications to improve and smoothen ground-level mechanism for collection and efficient processing and recycling of waste.

Kakinada: In July 2020, when the city reopened after a prolonged lockdown due to the Covid pandemic, the streets and roads were full of garbage. The city was struggling with complaints in connection with waste management from all corners. After a series of deliberations to deal with the situation, the city introduced advanced Information, Communication, and Technology (ICT) solutions such as Radio Frequency Identification (RFID)-based technology to improve the city's door-to-door waste collection efficiency and GPS technology to track the movements of its waste collection vehicles. Concurrently, several awareness campaigns were conducted across the city to sensitize citizens on the need for source segregation and no littering. Within a year, the city achieved 100 per cent door-to-door collection, 60 per cent waste segregation, and 51 per cent of waste processing.

Leh: Till 2019, Leh did not have a proper mechanism for the treatment and scientific disposal of waste generated in the city. Waste remained untreated because of lack of funds for a treatment facility and to buy machinery to segregate and treat waste as well as to pay for the electricity needed to run the machinery. Due to a constant influx of tourists, Leh faced a growing problem of waste disposal. However, in 2020, with the help of Ladakh Autonomous Hill Development Council (LAHDC) the municipal committee installed a 30 tonne per day capacity solar power-based solid waste management plant which is running successfully. Leh has achieved 100 per cent source segregation and 90 per cent material recovery at the facility to generate revenue from recyclables and compost have been successful and the system works efficiently.

Bengaluru: Monitoring of waste management practices has been one of the significant challenges in Bengaluru for the past few years. In 2020, to monitor the services and synchronise coordination among different waste management concessionaires, Bruhat Bengaluru Mahanagara Palike (BBMP) employed several Information, Communication, and Technology (ICT) solutions, including an RFID-based attendance system and geotagging of collection routes to monitor the waste management services. In addition, a mobile-based application called Ezetap has been designed to monitor garbage-vulnerable points and impose penalties on offenders. With the intervention of these ICT-based technology solutions, BBMP has achieved 100 per cent door-to-door garbage collection and has made the entire city completely free from garbage-vulnerable points.

Vijaywada: The city adopted a decentralised waste management system with state-of-the-art technologies for treating various fractions of waste and a real-time monitoring system, which significantly contributed in achieving 100 per cent source segregation and more than 90 per cent processing efficiency. In addition, 52 out of 64 wards in the city have been declared bin-free. The remaining 12 wards consisting of bins are closely monitored through closed-circuit cameras that are connected to the Command Control Centre in the Corporation. The city also adopted QR (Quick Reference) Code-enabled RFID tags for monitoring the waste collection. At various locations, 45 smart bins and 32 smart semi-underground garbage collection bins are also installed that sends alerts to authorities as

soon as they are full. Waste from these bins are collected and cleaned as soon as they are filled. In addition, mechanised sweeping is also introduced to avoid spilling of garbage and for saving time. The collection vehicles are fitted with GPS devices for effective route monitoring.

Keonjhar: To make Keonjhar garbage-free and promote source segregation with the help of women's self-help groups, the city adopted several innovative technological measures to improve its waste management system. GPS-enabled vehicles and transportation has been introduced for monitoring waste collection and segregation. The city has made the system more robust and transparent by putting details of fees and fines collected and the finances of micro-composting centres and material recovery facilities on a publicly accessible mobile-based app (Ama Sahara app). Littering is monitored, and penalties are imposed through CCTV cameras installed at public places. The city has achieved 100 per cent source segregation and processing with no garbage-vulnerable points largely due to technological and policy-related interventions.

Innovative models

Paradeep (Odisha), Panchgani (Maharashtra) and Thiruvananthapuram (Kerala)

Paradeep: Paradeep has adopted a decentralised and community-driven model with micro-composing centres and material recovery facilities. With active involvement of women groups, third-gender groups and ragpickers' associations, the city has shown a new waste management model that is inclusive as well as economically sustainable. The model for this initiative is based on economic sustainability. The revenue generated or collected from user fees and from selling of recycled product is always higher than the budget expenditure. The total expenditure incurred in waste management (February–July 2021) was found to be Rs 20.5 lakh while the revenue generated was found to be Rs 23.3 lakh, reflecting a net profit of Rs 2.8 lakh. The major source of revenue is user fee collection, fines, selling of recyclables from material recovery facilities and compost. The city successfully processes 100 per cent of its waste generated.

Panchgani: In 2001, after the declaration of Panchgani as an 'eco-sensitive zone' by the Central government, it became mandatory for the Municipal Council to ensure source segregation and processing of the waste generated in the city. The city conducted extensive information, education and communication (IEC) programmes to sensitise citizens. This has helped them to secure 100 per cent source segregation and processing. The town has invested in constructing material processing and recovery systems, using the pollution tax levied on tourists to create and operate these systems. The city's waste infrastructure has matured to gain the ability to process almost all of the city's waste. The centralised organic waste processing unit works along with decentralised composting at the household and bulk waste generator levels. The total revenue generated is Rs 17.2 lakh. Capital investment for the processing centre was either through corporate social responsibility (CSR) or local donations accounts for Rs 16.2 lakh, thereby leaving a difference between expenditure and revenue for about Rs 1 lakh per month. The council however hopes to plug this gap going forward.

Thiruvananthapuram: TMC adopted a sustainable economic model and supported long-term economic growth without adverse social, environmental or cultural impacts on the community. Segregated wet waste such as chicken or meat waste is turned into fertiliser and has a reasonable market value. It also has a service charge – the agencies provide fees to the municipality. Like biodegradable waste, non-biodegradable waste that is segregated and recyclabled is sold. Income is thus generated from proper management of both biodegradable waste and non-biodegradable waste. Expenditure on collection and transportation is nil. Expenditure is incurred only for disposal. Revenue is generated from selling recyclables and non-biodegradable waste.

E-waste management

Jamshedpur (Jharkhand)

The use of electrical and electronic equipment has witnessed an explosive growth and so is e-waste. The UN has termed this phenomenon a "tsunami" of e-waste. While e-waste is a problem, it can easily be moulded into a solution. It is the most valuable of wastes, as it contains many rare and precious metals and materials. E-waste typically does not feature in the list of municipal solid waste and therefore not a direct mandate for the cities to collect, transport and manage. However, looking at its exponential growth, it is now time to rethink the policy framework and recognise the city government as one of the key institution to spearhead e-waste management. While most of the cities are not considering e-waste in their solid waste management portfolio, some cities did walk the extra distance to create an example.

Jamshedpur: Before 2018, hundreds of local kabadiwalas and recyclers in Jamshedpur collected e-waste and burnt it to obtain valuable metals from it. During the process, they would expose themselves and the environment to toxic fumes and chemicals. As is the case with other cities in India, this was an unsustainable situation. The city administration decided to step up and take the initiative to deal with e-waste challenges. The city embarked into engaging a company as the producer responsibility organization (PRO) to manage its e-waste. The city has been able to establish a very efficient e-waste collection mechanism already. Out of the 230 tonne of e-waste collected so far, 95.5 tonne have collected in 2021 alone. The collected waste is channelized to the authorized e-waste recycler. The cost of collection, transportation and channelisation is entirely borne by the hired agency thereby leaving no financial burden on the city government.

The compendium of the best practices is a good resource book for the developing cities to get new ideas, learn about the strategies, institutional arrangement, technologies and implementation modalities that has made things possible for the best cities to emerge as a stand out performer. These cities could well be a learning laboratory through exposure visit and the evidences needs to be showcased at appropriate forum and scale to reach the masses. One of the better ways to build capacities of the city government in managing municipal solid waste management is to, going forward, showcase these models in a way that they get replicated all over the country.

WASTE-WISE MAP

28 cities from 15 states of India in 10 thematic areas of municipal solid waste management

(The figures in brackets indicate the population of the respective cities)

SANITARY WASTE MANAGEMENT

PUNE **(4.29 million)**
KARAD **(86,000)**

SOURCE SEGREGATION

INDORE **(2.6 million)**
ALAPPUZHA **(0.18 million)**
PANAJI **(45,800)**

LANDFILL MANAGEMENT

TALIPARAMBA **(45,600)**
CHANDRAPUR **(0.41million)**
AMBIKAPUR **(0.14 million)**

MATERIAL PROCESSING

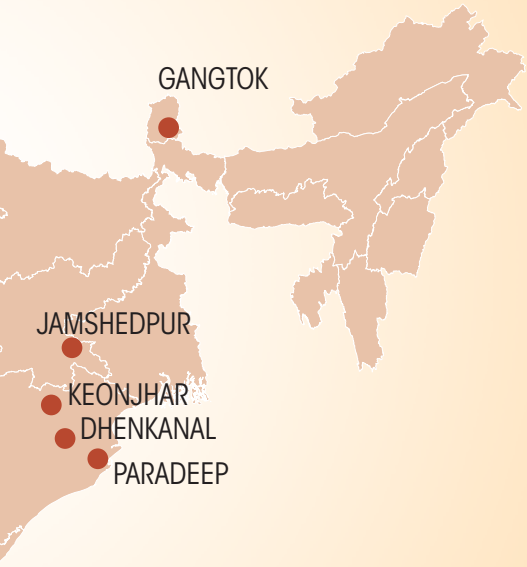
BHOPAL **(2.1 million)**
SURAT **(5.73 million)**
JAMSHEDPUR **(0.78 million)**
DHENKANAL **(83,200)**

PLASTIC WASTE MANAGEMENT

GANGTOK **(0.26 million)**
BICHOLIM **(18,700)**
KUMBAKONAM **(0.14 million)**

BIODEGRADABLE WASTE MANAGEMENT

MYSURU **(0.98 million)**
VENGURLA **(12,400)**
BOBBILI **(67,500)**



TECHNOLOGICAL INNOVATION

BENGALURU **(13.48 million)**
LEH **(43,500)**
VIJAYAWADA **(1.19 million)**
KEONJHAR **(67,000)**
KAKINADA **(0.38 million)**

E-WASTE MANAGEMENT

JAMSHEDPUR **(0.78 million)**

C&D WASTE MANAGEMENT

NORTH DELHI **(10.89 million)**
GURUGRAM **(1.9 million)**

INNOVATIVE MODEL

PARADEEP **(82,000)**
THIRUVANANTHAPURAM **(1.34 million)**
PANCHGANI **(18,000)**

*Map is not to scale

1

SOURCE SEGREGATION

Source segregation is a fundamental and non-negotiable condition for sustainable waste management. Only through efficient source segregation have cities been able to treat their waste scientifically and reduce dumping in landfills; prevent land, water and air pollution; and realise economic benefits from processing waste.

Alappuzha: The city embarked on the 'Clean Home Clean City' project focussed on source segregation.

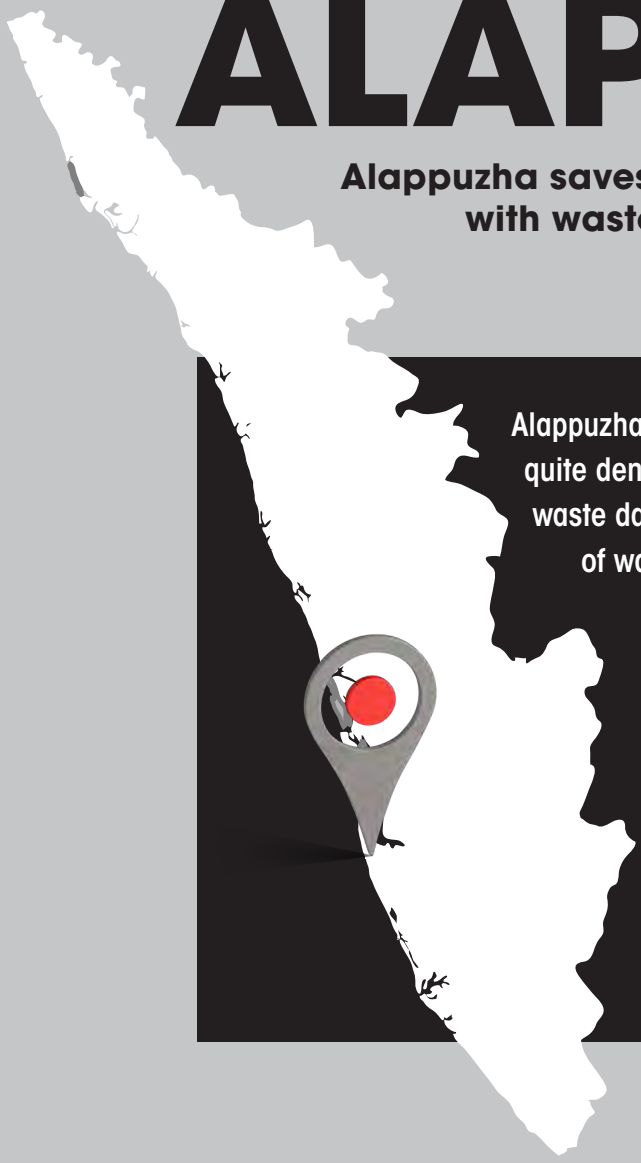
Indore: Through source segregation, participation of a wide array of stakeholders and good governance, the city has become a champion of waste management.

Panaji: A true pioneer in solid waste management with its sheer focus on source segregation, the city has achieved 99 per cent source segregation.

KERALA

ALAPPUZHA

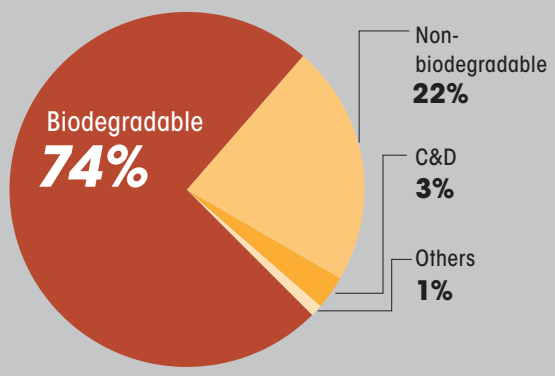
Alappuzha saves its water bodies from clogging up with waste by practicing source segregation



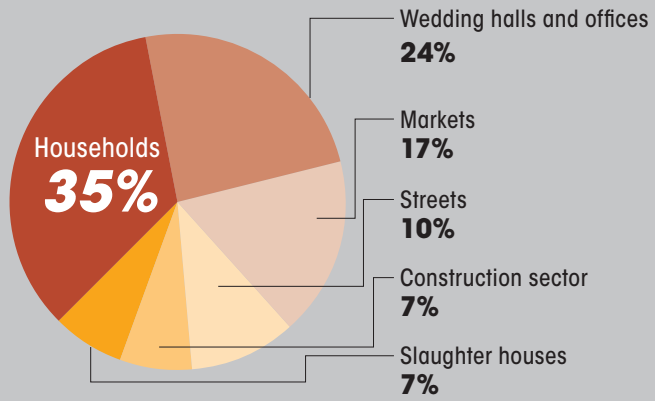
Alappuzha, a city with an extensive network of canals, is quite densely populated. It generates about 56 tonne of waste daily (311 g per person per day). While clogging of water bodies due to excessive dumping of waste is a problem across India, it was particularly accentuated here. The Alappuzha Municipal Council (AMC) has distinguished itself by its success in source-level segregation coupled with decentralised waste management. For its sustainable waste management practices, Alappuzha received recognition from the United Nations Environment Programme in 2017.

Waste composition in Alappuzha

Total waste **56.5 TPD**



Sources of waste



Source: Alappuzha Municipal Council

Population (in million, as per 2011 Census)
0.17

Estimated current population (in million)
0.18

Estimated floating population (daily)
20,000

Area (sq km)
46.77

Number of households (2021)
48,000

Number of wards
52

Number of zones
5

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
56

Number of sanitation workers
214

Number of community bins
0*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
57

Percentage of households covered under door-to-door waste collection
76

Percentage of households segregating waste
100

Percentage of waste processed
84

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Alappuzha Municipal Council

THE TRANSFORMATION

Before 2011, Alappuzha was in severe distress because of mismanagement of waste. The municipal corporation used to dump waste in a six-hectare plot it owns in Sarvodayapuram, a village located in the nearby Mararikkulam panchayat. There were no centralised or decentralised waste treatment plants in the city. Rotten garbage had piled up on roadsides, and canals and drains were clogged with bags of stinking waste from hotels, markets and meat shops. Dirt used to spread everywhere in the heavy rains. Swarms of mosquitoes and flies invaded the city every year spreading chikungunya and dengue.

To deal with its mounting waste problem, the city embarked on a project called 'Clean Home Clean City' under the guidance of the then MLA of Alappuzha. This project focused on source-level segregation as the first and foremost step towards effective waste management. Initially, the project was implemented in 12 wards. After achieving positive results in those, it was extended to all 52 wards. Nearly 100 per cent of the waste is now segregated at source. That has decreased the cost of dealing with waste as well as created a source of revenue.

Alappuzha Municipal Council has received national as well as global recognition for its performance in waste management. Some of the awards are mentioned below:

- Kerala State Government Energy Conservation Award – 2013-14, 2014-15
- Kerala State Pollution Control Board Award – 2014-2015, 2015-2016, 2016-2017
- CSE award for Clean City 2016
- Kerala State Pollution Control Board Award for Best Waste Management Practice, 2018
- First position in Kerala in Swachh Survekshan Survey 2019
- Award for the best small city in 'innovation & best practices' in Swachh Survekshan Survey 2020

To achieve source segregation, the municipality recognised that it needed the active participation of citizens. Thus, it undertook massive awareness drives explaining how the city's waterbodies would not survive without successful segregation of waste at source. Through different Information, Education and Communication (IEC) methods adopted to reach different strata of the society, the importance of scientific waste disposal strategies reached everyone. Both households and institutions enrolled with the project and brought about major changes that led to the rejuvenation of Alappuzha's waterbodies and its tourism sector. The Alappuzha model of waste management received recognition in Kerala, then nationally, and finally in global circles.

HOW THE SYSTEM WORKS

To begin with, AMC targeted unnecessary generation of waste at source. Fines and penalties were implemented to make citizens careful about their waste practices. Awareness programmes have been launched to both reduce and segregate waste at the household and institutional levels.

AMC has ensured citizen participation in the project: 48,000 households from 52 wards were issued notices mentioning the importance and need for the project. Ward-level health sanitation committees have been formed which hold monthly meetings. At the zonal level, a meeting is held every two months. The municipality has conducted 44 programmes in educational institutions, 1,600 programmes for SHG members, 12 programmes for drivers of sanitation vehicles, 16 programmes for arts and sports clubs, 22 programmes for Student Police Cadets (SPC) and National Service Scheme (NSS) volunteers, and more than 50 programmes as part of Canal Rejuvenation Program (CANALY). Groups like Kerala Shastra Sahithya Parishadh (KSSP) have also played a significant role in increasing public awareness by conducting upwards of 100 programmes.

Door-to-door collection of waste in all 52 wards is done by a women-run self-help group (SHG) called Haritha Karma Sena. About 76 per cent households participate in this initiative by segregating non-biodegradable waste and paying user fees. The SHG only collects non-biodegradable waste while biodegradable waste is handed over to the community aerobic bins by people who don't have bins in their households. Non-biodegradable waste is collected once a month from households and once a week from commercial establishments. Fifty mechanised vehicles and seven non-mechanised vehicles are engaged in transportation of waste. Of the mechanised vehicles, three are auto-tippers and four are covered tippers. Six vehicles have compartments for collecting segregated waste.

Non-biodegradable waste is collected at 32 mini-material collection facilities (MCFs), each with a capacity of 1.5 tonne. From the MCFs, the waste goes to four centralised material recovery facilities (MRFs), each with a capacity of 13 tonne. There are three plastic shredding units and one baling unit to process non-biodegradable waste. At the MRFs, Haritha Karma Sena members segregate plastics into eight categories and sell recyclables to an organisation called Green Worms.

There are 36 aerobic composting units with 426 bins where people can deposit their biodegradable waste. At full capacity, the units are able to treat about 80 per cent of the biodegradable waste generated in Alapuzzha, producing 9 tonne of compost daily.

Biodegradable waste disposal center at Alappuzha district collectorate

Bio-waste generated from hospitals, clinics, laboratories, etc. is being handled by Indian Medical Association Goes Ecofriendly (IMAGE), the biomedical waste treatment and disposal project of the Indian Medical Association's Kerala branch. They have established a state-of-the-art common biomedical waste treatment and disposal facility at Palakkad.

WHAT HAS WORKED

Awareness campaigns to promote source-level segregation led to remarkable changes in the attitude of citizens. Waste is not seen as someone else's problem but as the problem of the entire community which requires everyone to come together. Barriers of caste, class, etc. have been broken under the concept of 'unity in fraternity' so that change can be made and sustained.

This environment of communal togetherness has led to an increase in social entrepreneurship as people are more willing to trust each other and start new initiatives. Many people have been able to find jobs and improve their quality of life. Through scientific treatment of biodegradable waste, about 9,000 households have also been able to make fertiliser at home, which has led to improvements in agriculture.

With this initiative, AMC was not only able to control and reduce unnecessary expenditure caused by improper waste management but also generate additional revenue. This allowed some aspects of the waste management to become self-sustaining.

The most important step in waste management is source-level segregation, as that makes it easier to handle the waste in the later stages. Scientific management of waste is necessary to prevent pollution but it is the responsible handling of garbage at source that plays a vital role in the holistic development of a cleaner and healthier environment.

LESSONS LEARNT

Creating awareness about source segregation: The core element of proper recycling is segregation which gradually grows into effective waste management. The only way to achieve source-level segregation is to adopt effective communication strategies to inform and educate people about the costs of disposing unsegregated waste and the benefits to the environment and to public health that accrue from segregating waste. Till the people actually understand this and adopt it in their daily lives, no waste management strategy can be successful.

Involving the community: Participatory Rural Appraisal (PRA) has been very effective in getting to know people's needs and addressing them. The community has to be involved in the whole process so that they have a sense of ownership over the waste management system. Involvement also brings about changes in attitudes towards waste management and a willingness to take up ever larger portions of responsibility to conserve the habitat. Vulnerable members of the community are able to find means of livelihood in the waste management process if their involvement is encouraged, and this also provides them with additional incentives to make the system sustainable.

Plastic shredding unit, Alusheri

Bottle booth centre, near the urban local body office

Impacts

- The informal sector engaged in waste picking has been integrated into the new waste management system. It started with 15 SHG members but has now reached 93 SHG members.
- Through extended producer responsibility (EPR) initiatives, multilayered plastics are disposed of in a way that SHG members could earn an income by selling them. They are making around Rs 300–500 per day from user fees and by selling the recyclables to Green Worms.
- Through source-level segregation, the amount of waste dumped in the water bodies has decreased remarkably, thus polluted water bodies have been rejuvenated.
- By reducing pollution, the spread of water-borne diseases has been controlled and the overall health of the community has improved.
- Generated compost is being given to local farmers free-of-cost.

Importance of leadership and organisation: The whole project originated under the leadership and guidance of the local government. The initial push provided by the authorities was much needed to get the process off the ground. After that, their guidance proved invaluable to take the project over significant hurdles. With this organisation the government set up and made sustainable, waste management became a source of income for many. Political will coupled with a methodological approach can change the face of any city.

REPLICABILITY

Source-level segregation and decentralisation waste management are the lynchpins of Alappuzha's solid waste management system. The success of Alappuzha's solid waste management system was recognised and these two aspects were picked up by many municipalities across the country.

For source-level segregation, local SHGs should be recruited. This is very important as it allows community members to work within the community. Access to households is much higher for local SHGs as residents trust them. Workers are better motivated to make the project a success as it affects their lives. It is also a step towards poverty eradication as the most vulnerable people in the community can find gainful work in waste management.

Mini-material collection facilities have been adopted by various local self-governmental institutions in Kerala. The aerobic compost unit has also become a model followed throughout Kerala. The state government has made a policy for the implementation of decentralised waste management across Kerala. This can be taken up by other state governments as well.

MADHYA PRADESH

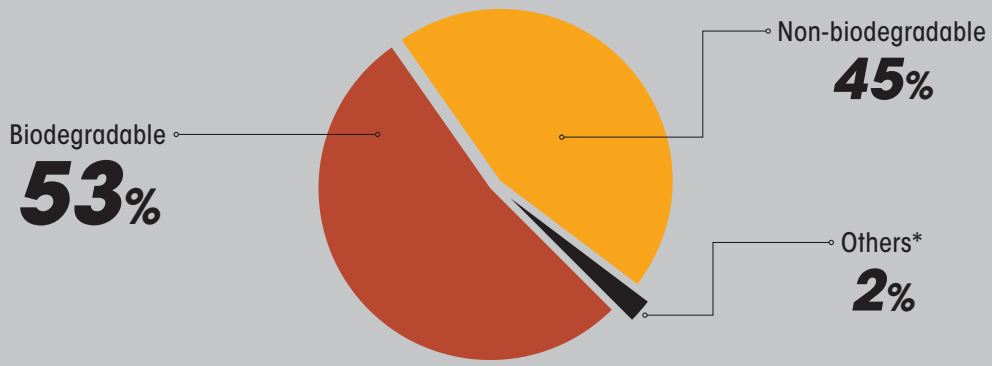
INDORE

Indore has become the cleanest city in India by mastering segregation at source and subsequent steps in the waste management chain

Indore, an education hub and the commercial capital of Madhya Pradesh, is situated on the Malwa Plateau. It generates about 1,029 tonne of waste daily (392.4 g per person per day). The city, which was already famous for its food and bangles, has now earned the 5-star garbage-free city tag. Indore has been ranked the cleanest city of India in Swacch Survekshan surveys since 2017. The city is not only Open Defecation Free but has also earned the first Water Plus Certification in the country.

Waste composition in Indore

Total waste **1,029 TPD**



* Others includes domestic hazardous waste, sanitary waste, C&D waste and inerts.

Source: Indore Municipal Corporation

Population (in million, as per 2011 Census)
1.9

Estimated current population (in million)
2.6

Estimated floating population (in million, daily)
0.26

Area (sq km)
276

Number of households (in million, 2021)
0.49

Number of wards
85

Number of zones
19

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
1,029

Number of sanitation workers
2,854

Number of community bins
0*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
829

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
100

Percentage of waste processed
100

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Indore Municipal Corporation

THE TRANSFORMATION

Indore's waste managament system used to be nothing special. There were over a thousand garbage-vulnerable points in the city. Segregation of waste at source was almost nil. Mixed waste was dumped in the Devguradiya trenching ground and even in open areas and public land, leading to many health and environmental problems. Domestic hazardous waste dumped together with other household waste posed a threat to waste pickers and animals. The river Kahn, which flows through Indore, had become a sewer. Roads were littered with garbage which smelled and attracted stray dogs, cattle and insects. Although Indore Municipal Corporation (IMC) had hired a concessionaire for transportation, processing, and disposal of garbage, the waste management system was extremely inefficient due to a lack of funds, dearth of monitoring and unavailability of institutional capacity to bring change.

Finally, in 2015, things started to change as the mayor expressed her concern about the lack of cleanliness in the city. IMC terminated its contract with the concessionaire after having communicated its apprehensions many times. In December 2015, IMC started door-to-door collection as a pilot project in Wards 42 and 71. IMC also undertook awareness programmes in these wards to motivate residents to segregate their waste into biodegradable and non-biodegradable fractions. It was observed that people were ready to do their part as long as they were assured of regular and reliable garbage collection services. IMC ran another pilot in two other wards but with a different objective – to check whether tricycles or auto-tippers are better for door-to-door collection. In one of the wards, tricycles were used for door-to-door collection while auto-tippers were used to transport garbage from the primary collection points. In the other ward, the use of tricycles was eschewed completely and auto-tippers were used directly for door-to-door collection. The cost of door-to-door collection with tricycles came out to be Rs 2,886 per tonne while the cost with auto-tippers came out to Rs 1,662 per tonne. IMC adopted the cheaper auto-tippers city-wide.

In February 2016, door-to-door collection was extended to ten wards and by October 2016, IMC started door-to-door collection of garbage in the entire city, along with a campaign to promote source

segregation. Initially, a two-bin system was used for segregation as per the guidelines of Swacch Bharat Mission – green bins for biodegradable waste and blue bins for non-biodegradable waste. In 2017, Indore adopted the use of separate bins for sanitary and hazardous waste, as per the new Swacch Survekshan toolkit. Most citizens happily embraced this as well due to the frequent knowledge and trust building sessions the municipality was holding with them. The more intractable of the citizens were forced to change their ways as door-to-door collection vehicles stopped accepting unsegregated waste completely. As time went by, the administration felt confident enough to ask citizens to segregate waste into even more categories in order to maximise the value of waste processing. Presently, the city is segregating its waste into six categories: 1. Biodegradable, 2. Non-biodegradable (excluding plastic), 3. Plastic, 4. Sanitary, 5. Domestic hazardous and 6. Electronic. IMC had originally installed two sets of litter bins across the entire city. During the pandemic, it also installed a set of third bins (yellow) in which people could put their masks and gloves.

HOW THE SYSTEM WORKS

IMC collects waste from different sources, including households, commercial areas, and establishments like shopping complexes, hospitals and institutes. Those generating less than 50 kg of garbage daily are covered under door-to-door collection whereas bulk waste generators (BWGs) are served by a separate dedicated mechanism. BWGs have to manage their biodegradable waste on-site or they can hire private concessionaires to manage it on their behalf.

In order to implement 100 per cent door-to-door collection of segregated waste, an identification study was carried out to find the amount of waste generated in each ward and the population of each ward. On the basis of the data collected, a detailed route plan was prepared to cover all wards. Based on the route plan, an extensive vehicle and staff deployment plan was implemented.

Door-to-door collection is done in partitioned vehicles. There are six separate spaces for biodegradable, non-biodegradable, plastic, sanitary, domestic hazardous and electronic waste in each tipper. These tippers carry waste from households to transfer stations. GPS has been installed in all waste collection and transportation vehicles. A special cell monitors the GPS. Penalties are imposed on drivers for route deviations and multiple deviations can result in their termination.

Indore is running a successful material recovery facility where waste is segregated according to its recyclability value. The city segregates non-recyclable fractions according to their calorific value so that only waste with high calorific value gets used as refuse-derived fuel (RDF).

Source segregation and scientific treatment of biodegradable waste through aerobic composting and anaerobic digestion has helped Indore prevent as much as 630 tonne of biodegradable waste from reaching the dumpsite every day, where it would have been responsible for emitting greenhouse gases into the atmosphere. Carbon credits earned through this process have been efficiently used by the city to generate about Rs 52 lakh. This has been possible due to the following projects:

Compartmentalised vehicle for collection of biodegradable, non-biodegradable, domestic hazardous, electronic and sanitary wastes

- Composting, Devguradiya – 600 TPD
- Biomethanation, Choithram Mandi – 20 TPD
- Biomethanation, Kabitkhedi – 15 TPD

The money flow

The total expenditure made by IMC to run the waste management system is about Rs 879 crore per year. The city collects about Rs 27 crore per year as user charges, and the remaining expenses are met with property taxes. Households pay up to Rs 60 and shops pay up to Rs 150 a month for waste collection. Businesses, offices, etc. pay Rs 3 for every kg of waste collected from them.

WHAT HAS WORKED

Bringing behavioural change at a mass level is not an easy task. IMC took multiple steps to spread awareness among people and motivate them to embrace segregation. Vehicles used for door-to-door collection of garbage were utilised to promote the campaign '*Do Bin Har Din*' (two bins everyday). The campaign was carried out in all residential and commercial areas, including public places. Social media was used extensively, along with *nukkad nataks*, wall paintings, radio jingles, etc. Schools were engaged to promote segregation among students through competitions focused on cleanliness, and through oath taking ceremonies in the morning assembly.

The mayor and the ward councillor got actively involved in the campaign. Municipal officials and public representatives conducted joint visits and road shows to convince citizens to segregate waste. Religious and community leaders have a strong hold on the people, so they were convinced to become *swachhagrahis* and brought on a common platform. They talked about the importance of cleanliness as mentioned in religious books and participated in mass road-sweeping exercises to spread awareness.

IMC has engaged more than 800 self-help groups (SHGs), comprising more than 8,000 women, to spread awareness about source segregation in the nooks and crannies of the city. SHGs have also been recruited to provide workers for the material recovery facilities. This has ensured that SHG members are gainfully employed as integral members of the waste management system. This is really useful in making the system sustainable in the long-term.

Zero-waste tags are awarded to those markets and colonies which excel at waste management. These tags can be used as a marketing tool by these markets and colonies to attract customers and charge higher rents. This motivates other markets and colonies to also take steps to earn these tags. Households and other establishments were also given dustbins at subsidised rates to promote segregation.

IMC deploys one resource person with each garbage collection vehicle in order to spread awareness and to ensure that everyone is giving segregated waste. If a resource person fails to convince any household, then they can bring in the assistant health officer and ward *daroga* to penalise the offender. This is cost intensive but IMC knows that it is necessary to ensure 100 per cent segregation of waste and so it is willing to bear the cost.

It is one thing to have good laws and another thing altogether to implement them. In India, this is an especially big problem. To deal with this issue, IMC levies penalties and fines for people who litter in public spaces and do not segregate at home. Officials at the ward level have been given yellow enforcement vehicles and walkie-talkies to connect to other officials. All officials, including the municipal commissioner, are connected with the walkie-talkies. This gives a sense of confidence to officials, and promotes responsible behaviour among them as the municipal commissioner might be listening to their communications with each other.

LESSONS LEARNT

Participation of all, development for all: Without the participation of all citizens and governing bodies, it is impossible to build and sustainably operate the kind of efficient and reliable waste management system for which Indore has become known. Development of any sort is not a top-down exercise but a participatory exercise. Indore has shown us the wonders that can be achieved when we all come together with a single goal.

Segregate, segregate, segregate: It cannot be stressed enough that Indore's model has only been so successful because Indore focused on achieving 100 per cent segregation at source before it proceeded to the other aspects of waste management. Without segregation, all subsequent steps in the waste management chain fall apart. No matter how good a waste processing centre a city has, or how good its composting plan is, without segregation none of it can work at its full potential.

Impacts

- Indore has been named the cleanest city of India in every Swachh Survekshan survey since 2017.
- Indore has earned the 5-star garbage-free city tag along with five other cities.
- Indore is the first city in the country to earn the Water Plus Certification.
- More than 8,000 women from marginalised communities have been given gainful employment.
- Due to efficient segregation and subsequent processing of waste, almost no waste ends up being dumped in the landfill.
- Illegal collection and dumping activities have been reduced almost to nil.
- Indore has become Open Defecation Free.

REPLICABILITY

The process outlined below was followed by Indore and can inform other such efforts as well:

Steps taken by IMC to reform its waste management system

Considering the fact that Indore was rated 25th in the first Swachh Survekshan survey of 2016 and turned itself around to achieve first rank the very next year, it should be clear that cleaning up is within the reach of every city. The success of Indore's waste management derives first and foremost from its success in achieving 100 per cent segregation of waste at source into six categories. Door-to-door collection of segregated waste is possible in every city, town and village of India as long as the local governing bodies are committed to it. It has to be noted that Indore has been successful because the municipal authority showed the willingness to earn the trust of citizens and make them active participants in cleaning up of their city. Community engagement is absolutely necessary to replicate this model.

GOA

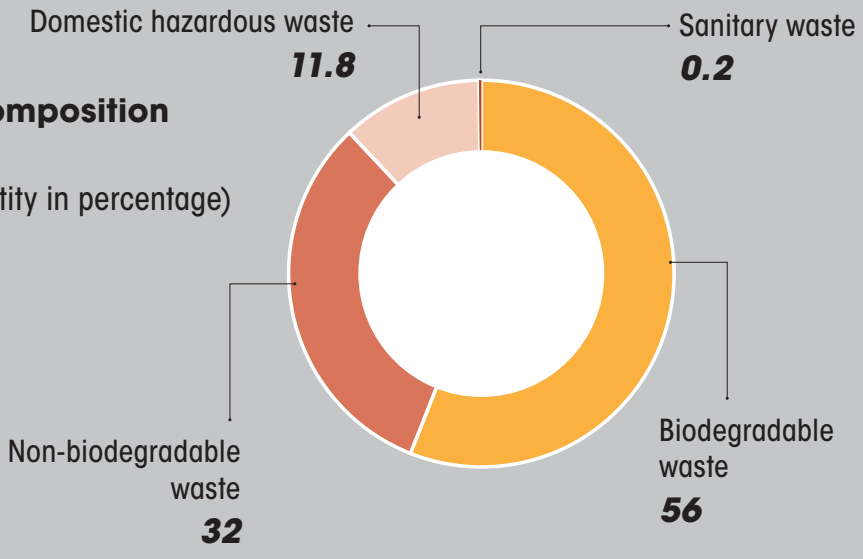
PANAJI

Panaji turns its trash into cash by adopting source segregation

Panaji is a popular tourist destination, blessed with beaches and heritage buildings. Its waste is managed by the Corporation of the City of Panaji (CCP). By extensive information, education and communication (IEC) as well as continuous monitoring, the city has achieved 99 per cent source segregation and changed the way solid waste management was tackled.

Waste composition in Panaji

(Daily quantity in percentage)



Source: CCP

Population (as per 2011 Census)
40,017

Estimated current population
45,800

Estimated floating population (daily)
16,700

Area (sq. km)
8.12

Number of households (2021)
16,000

Number of wards
30

Number of zones
7

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
50

Number of sanitation workers
474

Number of community bins
0*

Number of garbage-vulnerable points
7*

Waste management vehicle fleet size
35

Percentage of households covered under door-to-door waste collection
99

Percentage of households segregating waste
99

Percentage of waste processed
80

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: CCP

THE TRANSFORMATION

In 2001, around 1,200–1,500 garbage bins were placed across the city. But these community bins became points of disposal for every kind of unsegregated waste. Eventually, the waste generated from the bins formed a hill. Subsequently, the heap mounted in a nearby village, Curca, and resulted in the formation of leachates, followed by a landslide.

Improper and unorganised disposal in open areas and landfills resulted in the spread of communicable and non-communicable diseases, and affected the welfare, livelihood and economic productivity of the local population. It also diminished the value of the surrounding real estate. Further, the leachates contaminated the soil, polluting the groundwater. With no options, the Corporation of the City of Panaji (CCP) tried for more scientific and innovative alternatives.

Panaji city's solid waste management programme – managing segregation, sorting and recycling of the city's waste – has been successful because CCP worked consistently over the last 15 years at improving methods and involving citizens in its endeavours.

Of the waste CCP collects, 99 per cent is segregated at source (four-way or two-way). Eighty per cent of the waste is processed, 90 per cent of the roads are swept efficiently and 99 per cent of stand-alone houses have door-to-door collection. Aerobic composting in masonry units and the crate system set up at decentralised facilities have an existing capacity of 20 TPD. Waste going to the landfill is 23 TPD, comprising 5 tonne of street sweepings, 10 tonne construction debris and 8 tonne horticultural waste such as tree branches.

There is currently no sanitary landfill. Waste is disposed of at temporary waste sites identified on a need basis.

CCP recognises the fact that waste collected should be treated locally. But it faces opposition from local sources. It is the same story with making clusters to treat waste – no one wants them in their area.

Women workers segregating waste manually

HOW THE SYSTEM WORKS

The Corporation of the City of Panaji (CCP) developed door-to-door collection of waste indigenously, initially approaching 100 houses to segregate their waste into two separate bins. Panaji was envisioned as the first landfill- and bin-free city in Goa. This was accomplished by 2020.

Way back in 1995, the city had introduced a project called Solid Waste and Resource Management (SWARM). The government of Goa was responsible for technical assistance. The project was undertaken by the Regional Water and Sanitation Group, South Asia (RWSG-SA) at the Ministry of Urban Development, Government of India. Subsequently, in 2000, the Ministry of Environment and Forests (MoEF) set new rules for managing and handling municipal solid waste.

In 2003, the Panaji Municipal Corporation (PMC) was upgraded to the Corporation of City of Panaji (CCP). In 2004–05, CCP targeted training schoolchildren and designed a Panjim Chakachak movement, which led to the TRASH (Thinking Reflecting and Acting for a Sustainable Habitat) festivals, campaigns, and awareness sessions with media. It highlighted why segregation of biodegradable and non-biodegradable waste was important.

In 2010–11, after implementing four-way segregation, an improvement over the earlier two-way segregation, CCP created collection points and recycling stations for

non-biodegradable waste at different junctures in the city. By means of adequate information, resources and efficient management practices, they changed the way solid waste was tackled. They trained volunteers, mostly students, who visited individual households to demonstrate waste segregation. Hotels, hospitals and nursing homes were provided with leaflets and pamphlets with segregation information at the source as well as garbage-lifting schedules.

The CCP procured 10 compactors, two tractors and 16 tipper trucks after successfully encouraging waste generators to recycle their waste. The newly acquired tipping trucks consisted of four bin bags. Each bin was emptied into separate collection bags and sent to the sorting centre. Green and black bins specially designed by CCP were sold at subsidised rates. The bins came with a locking system, which eliminated the chances of waste tipping.

In 2020–21 CCP implemented segregation of waste into 16 fractions. Residential colonies in Panaji were encouraged to collect 16 types of waste in separate bins. CCP made it compulsory for builders and promoters to create a composting pit in each colony so that biodegradable waste was separated at source or their license would be cancelled. Besides, community pits were made near market areas to collect and treat around nine TPD of leaf-waste.

Biomedical waste is stored in and collected from separate bins and sent to Goa Medical College. Hospitals and clinics follow the two-way segregation process. Infectious waste is stored in yellow bins lined with a yellow bag. Sharps (needles and scalpels) are put in blue bins lined with blue bags. To improve sanitary waste management, CCP also procured a vending machines for sanitary napkins and incinerators to dispose of sanitary napkins.

The Corporation treated waste, made Panaji a zero-landfill capital, sent more than 10,000 tonne of refuse-derived fuel (RDF) to Karnataka, and helped the cement industry by limiting its usage of fossil fuels (coal).

Mechanism of waste collection

- **Collection of segregated waste:** Waste that has been segregated into four streams (paper, plastic, metal and non-recyclable materials such as thermocole) is put in a black bin. Each of the four bins has a sticker – in different colours – to identify the stream of waste.

- **Designated days:** CCP has assigned designated days for collection of waste. Biodegradable waste from residential colonies, hotels and restaurants is collected daily and non-biodegradable waste is collected twice a week.

- **Designated routes and vehicles:** CCP has assigned designated vehicles and routes for waste collection. The routes are devised based on traffic and quantum of waste generated. During the Covid pandemic, two trucks were assigned for collection of waste from the homes of Covid patients. They were coloured white and designed so that workers did not come in contact with patients.

Source: CCP

Waste is segregated in 16 separate bins and bags

Non-biodegradable waste from bulk waste generators (BWG) is taken to 14 sorting centres, including mini-centres. Sanitation workers divide the waste here depending on the value of the items. Plastic and paper are sub-segregated into different fractions based on quality, colour, etc. After sorting, bales of non-recyclable waste – separate bales of paper, plastic, tetra packs, and cloth – are made using baling machines. The Corporation earns about Rs 1 lakh per month from the sale of recyclable items. Inert waste is carried to a dumpsite for disposal.

The Corporation initiated the campaign Shop with Your Waste (SWYW) where three designated shops were asked to collect pet bottles, cardboards, milk packets, metals etc. from the consumers and provide them with valuables such as a notebooks, pens or erasers. By adopting this strategy, CCP has collected clean, non-biodegradable waste and helped to increase footfalls in the designated shops.

CCP has also launched the app "I Can Change My City", which helps bridge the gap between communities and the Corporation.

Mural paintings and initiatives such as the campaign Seeti Bajao, City Bachao, in which authorized volunteers blew whistles every time they saw anyone litter, have received a huge response during the International Film Festival (IFFI).

The money flow

According to CCP, over Rs 7 lakh is collected every year as property tax towards sanitation and Rs 9 lakh is generated by selling compost. Operators earn Rs 10 lakh per year by selling recyclables and refuse-derived fuel (RDF). Expenditure on municipal solid waste collection and transportation is over Rs 14 lakh per month, and for processing is Rs 2.5 lakh per month. Total annual revenue generated by CCP is about Rs 27 crore.

WHAT HAS WORKED IN PANAJI

The CCP adopted several new technologies and initiatives for waste management, including:

- **Introduction of mini sorting stations:** There are five mini-sorting stations (KTC, Bhatlem, Caranzalem, Market and EDC Patto) and one large sorting station at St Inez in Panaji city. In case of operational issues at any one station, other facilities can be used so that work is not affected.
- **Aerated pit composting:** By 2006, CCP made it mandatory that every building permit issued for new projects in the city included its composting unit or biodegradable waste processing facility within the premises. The city has implemented aerated static pit composting.
- **Promoting biomethanation:** Bio-digestors of 20, 75, 150, 300, 500 and 1,000 kg are installed for processing biodegradable waste. Further, biogas produced is utilised by local canteens and five-star hotels. The conversion of waste to energy is engineered and used by locals.
- **Segregation through conveyor belts:** The earlier method for segregation of waste was very tedious. The introduction of conveyor belts has brought ease in working, helping sanitation workers in manual segregation.
- **Design of vehicles was consciously customised:** Compartmentalised vehicles were designed for collecting biodegradable and non-biodegradable waste to prevent waste from falling on roads while it is transported. The newly introduced vehicles have leachate tanks that collects leachate from the waste. The vehicles have a hydraulic system that helps to hold two dustbins together and drop the waste inside the vehicle without the need for manual labour. The vehicles are BH-VI compliant, and follow all government norms.
- **Tubelight waste and hazardous waste more efficiently handled:** Hundreds of tube lights are stacked every day, and they get treated by a pollution board-certified agency scientifically. So far, 17,000 tubelights have been treated.

  The agency has a gobbler machine that crushes glass tubelights separating by-products such as mercury and other metals. The drum is sealed and disposed of in a sanitary landfill in Maharashtra.
- **Promotion of eco-friendly products:** Tomato-sauce pumps, steel plates and cloth bags are promoted while use of sauce sachets, plastic straws and polyethylene bags are discouraged.
- **Specially designed street bins were placed across the city, replacing community bins:** Digital litter-bins have been designed by CCP to segregate paper, metal, glass, mobile batteries and plastic for Panjim streets. When the button placed on the bin turns from green to red, the alert

An aerated compost pit near the main Panaji market area

automatically goes to CCP, conveying the message to clear the bin. The bin is also used as an advertisement board, where companies can display digital advertisements across the city.

LESSONS LEARNT

The city has adopted a zero-waste and zero-landfill model by implementing decentralised waste management and treating waste at the source. Space constraints along with large quantum of waste in the city made the municipal city officials look into means such as innovative technologies, continuous information, education and communication (IEC), treating waste at source, waste reduction etc. to manage waste. The city has also looked into alternative mechanisms for channelising non-recyclable waste. Awareness campaigns have helped to promote source segregation of waste in the city.

Despite CCP's initiative, a few places still require continuous monitoring and regulation to ensure longevity of the zero-waste management initiative.

Impacts

Panaji has become a cleaner and more liveable city. Other impacts of implementing new technologies and initiatives for waste reduction include:

- More than 10,000 tonne of waste are diverted from being disposed of in landfills. The use of non-recyclable waste by cement industries directly helps reduce use of natural resources (fossil fuels). Because of 16 streams of segregation, the task of managing non-biodegradable waste at the material recovery facility (MRF) has been reduced.
- There has been an improvement in recovery of recyclables. Nearly Rs 9 lakh is generated every year from it. Recyclable bales are sold to recycling vendors. For instance, bottles made of a certain quality of glass are melted down and are born again as window panes.
- Due to the implementation of newer techniques, CCP was able to create efficient and skilled labour, saving time and money. There has been a reduction of the overall cost, including cost of transportation of waste, cost of acquired land for landfills and labour cost.
- CCP ensures scientific processing of biodegradable and non-biodegradable waste. Additional resources are generated that can be further treated or sold.
- Source segregation ensures different fractions of waste are not contaminated, thus increasing the value and quality of resources derived from biodegradable and non-biodegradable waste.
- Transportation and truck movements are strictly monitored and handled.

REPLICABILITY

Panaji is leading the way for a cleaner Goa. It has shown how solid waste can be effectively managed in densely populated areas where civic sense is lacking. Other cities can replicate Panaji to turn their trash into cash.

The zero-landfill model initiated in Goa presents an easily replicable model for solid waste management. Although the mission started as a pilot project in St Inez, and spread across Panaji, Goa is looking at a state-wide approach. There are 118 small-scale and big-scale composting centres in Panaji.

From sale of recovered goods, the model provides extra revenue and income that ensures the workers' sustained interest in their job and enhanced self-esteem.

2 BIODEGRADABLE WASTE MANAGEMENT

Biodegradable waste comprises more than half of the solid waste that we generate as a country. Technologies and systems for biodegradable waste management at a community level – vermicomposting, windrow composting, biomethanation, organic waste converters and briquetting – can easily be incorporated in any urban centre. By combining home composting with these technologies, all of the biodegradable waste generated can be processed. A participatory approach that combines decentralised and centralised waste management is key to eliminate dumping of biodegradable waste in landfills.

Bobbili: The town produces a substantial quantity of wet waste, and composting, whether it be at the household level or at scale in the form of windrow composting and vermicomposting, has worked well.

Mysuru: Torchbearer in the field of biodegradable waste processing through game-changing zonal zero-waste management plants that receive segregated biodegradable fractions of solid waste.

Vengurla: The city processes 100 per cent of its organic waste through vermicomposting, bio-methanation, organic waste converters and briquetting.

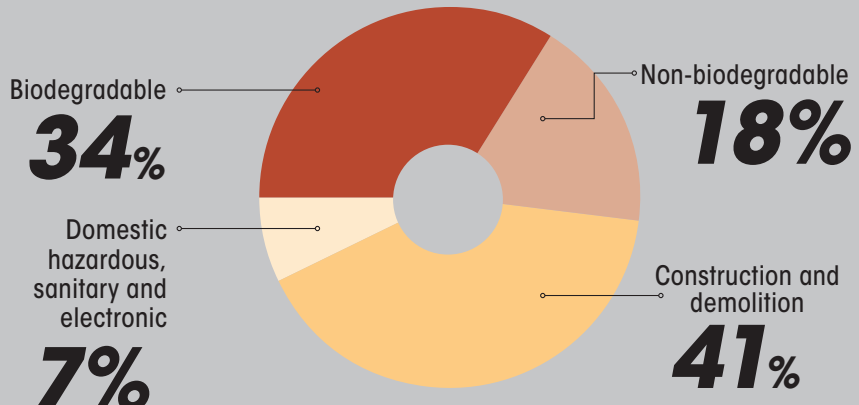
ANDHRA PRADESH

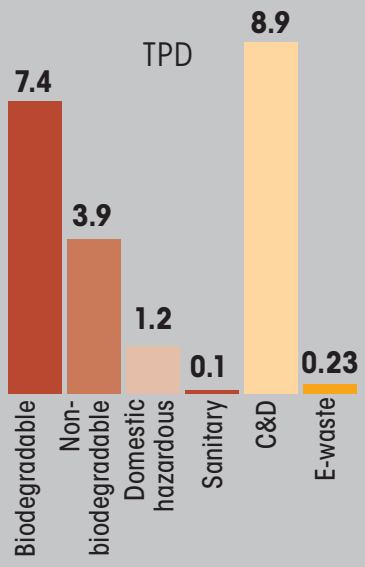
BOBBILI

Synergy between a biogas plant, and home composting, windrow composting and vermicomposting, helps the town process 100 per cent of its biodegradable waste

Bobbili is a historic town in district Vizianagaram, Andhra Pradesh. It generates 21.5 tonne of waste daily (320 g per person per day). It source segregates all of its waste. There has been a ban on plastic bags and pouches in the town for more than 10 years now. But the town's crowning achievement is its biodegradable waste processing. By combining home composting with windrow and vermicomposting, as well as a biogas plant, the town manages to process all of the biodegradable waste it generates.

Waste composition in Bobbili





Source: Bobbili Municipal Corporation

Population (as per 2011 Census)
56,871

Estimated current population
67,500

Estimated floating population (daily)
21,000

Area (sq km)
25.6

Number of households (2021)
16,271

Number of wards
31

Number of zones
4

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
21.5

Number of sanitation workers
167

Number of community bins
0*

Number of garbage vulnerable points
0*

Waste management vehicle fleet size
67

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
100

Percentage of waste processed
100

* According to the Swachh Survekshan ranking (Star Rating for Garbage Free Cities) parameter, zero community bins and zero garbage vulnerable points are strong indicators of an efficient solid waste management system.

Source: Bobbili Municipal Corporation

THE TRANSFORMATION

Before 2010, Bobbili used to be a garbage-littered town and a hub of water- and vector-borne diseases such as gastroenteritis, diarrhoea, malaria and dengue. Government hospitals and clinics always remained full of patients with these ailments. Things became so bad that the municipality started to receive several complaints every day against improper waste disposal.

Today, Bobbili is one of the top 10 municipalities in the country in terms of rate of waste processing. The town has had a ban on plastic bags and water pouches in place for nearly a decade now. It segregates waste into three categories and earns considerable revenue from processing and recycling. How has this change taken place?

Following guidelines issued by the government of Andhra Pradesh, the Visakhapatnam Region conducted a workshop on door-to-door waste collection in March 2010 and directed all urban local bodies in the state to ensure 100 per cent door-to-door collection by May 31, 2010. The municipal commissioner of Bobbili set a challenge to make the town the best in the state in terms of source segregation and door-to-door collection.

An Information, Education and Communication (IEC) programme was recognised to be a key tool to achieve this objective. But before educating the general public, the staff trained themselves about the benefits of source segregation. The public IEC programme consisted of street plays and stage shows organised as per local cultural practices. Pamphlets on the importance of segregation were also distributed.

Within no time, the municipality had a working model to handle various types of waste. The drive received financial aid to procure garbage collection vehicles from the 12th Finance Grants. A route map system was created to cover every house under door-to-door collection of segregated waste. Penalties were imposed on littering and failure to segregate. The town took several steps to eliminate the use of plastic bottles and sachets. Free water is supplied by municipal authorities in cans. Every shop in the town is provided with two bins – for non-biodegradable and biodegradable waste – and it is the responsibility of shop owners to ensure that their customers use the bins appropriately. Only biodegradable cups are

Smart waste management: Garbage collection as per the Real Time Monitoring System

allowed in coffee and tea cafes. Those failing to keep their business premises clean are liable to pay a fine of Rs 100. Garbage collection teams clear garbage during the night after religious processions and public functions.

The town spends Rs 1.53 crore on municipal solid waste management and earns a revenue of Rs 1.57 crore from it.

HOW THE SYSTEM WORKS

Push carts were introduced with bins for biodegradable and bags for non-biodegradable waste to achieve 100 per cent source segregation. The route map system was created by dividing the town geographically into nine routes with 11 vehicles. Each vehicle consists of a route manager, driver, four workers and a 'siren system' to announce the vehicle's arrival.

Within a month of the introduction of the route map system, the staff achieved almost 100 per cent door-to-door waste collection. Efficient collection made it easy for the city to transport garbage to the Krishnapuram dumping yard, about 4.6 km from the city.

By integrating Internet of Things (IoT) and Information and Communication Technology tools, the state government launched a Real Time Monitoring System – an analytical dashboard that has set a benchmark in micro-planning with pinpoint details of source segregation, gate-to-gate collection, collection routes, transfer points and weight of the waste before it is loaded into trucks – in 89 urban local bodies, including Bobbili.

Under the Real Time Monitoring System, every household and apartment,

termed a 'gate', is given a radio frequency identification (RFID) tag. Sanitary workers carry an electronic scanner and share real-time information about household waste with the city-wide monitoring system. Waste collected from each micro-pocket is digitally measured. Garbage trucks are fitted with GPS devices to track their movement. Attendance of sanitary workers is monitored by an Aadhaar-based facial recognition system.

Composting and biogas

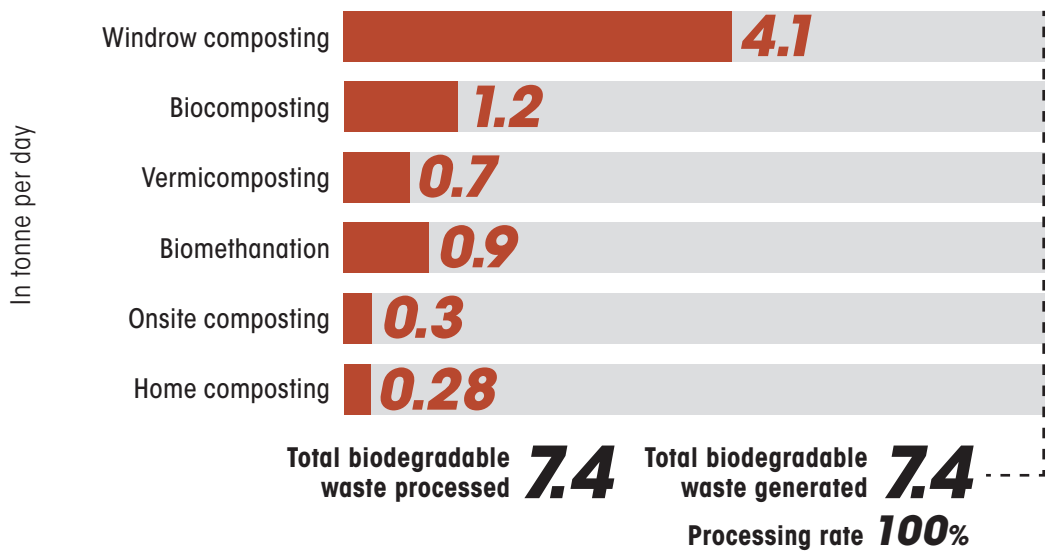
The city generates 7.4 tonne of biodegradable waste daily which is pulverised through shredding and volume reduction before being fed into composting units. Leachate and cow dung are used to produce biogas at the biogas plant.

The municipality encourages home composting and handholds interested households on proper techniques and other information. At present, 345 households are practising home composting and efforts are on to involve more households.

The first windrow composting plant was set up as an immediate solution to the problem of processing biodegradable waste. The unit produces 120 tonne of compost every two months. Initially, the municipality used the compost in roadside plantations, horticulture and green spaces. Slowly, farmers living in the vicinity started to buy the compost. A tractor-full of compost (roughly 1.2 tonne) costs them Rs 2,000. One tonne of compost serves about an acre of land.

Vermicomposting is another effective method of processing biodegradable waste as it brings in sizeable revenue. Therefore, top priority has been given to it in Bobbili. Red earthworm (*Eisenia foetida*) has been found to be the best-suited for vermicomposting. A shed has been built for this purpose because vermicomposting needs to take place in a cool, moist and shady site. About 20 workers have been hired for the job. Compost gets ready in about 45–50 days. The unit produces 60 tonne of compost annually, which is supplied to farmers at Rs 10 per kg. Vermicompost is highly valued by farmers because unlike chemical fertilisers, it enriches the soil and helps in reducing the population of pathogenic microbes.

Bobbili's biodegradable waste processing regime



Source: Bobbili Municipal Corporation

A biogas plant has also been constructed with help from Non-conventional Energy Development Corporation of Andhra Pradesh Limited. It generates 14 m^3 of gas every day. The input material is 350 litre of leachate mixed with equal amounts of cow dung from the town. The gas is utilised in cooking (by the staff at the dumping yard) and for power generation. A small 5 kVA generator is fed a mixture of 30 per cent diesel and 70 per cent gas to produce electricity. It works well even with small quantities of fuel. In fact, it was initiated with only 50 kg fuel as a pilot. A moisture remover is used to remove excess moisture from the gas before connecting it to the generator.

WHAT HAS WORKED IN BOBBILI

More than a decade ago, when Bobbili's municipal administration decided to overhaul the town's solid waste management system, they immediately (and correctly) recognised source segregation as the lynchpin of the whole exercise. Over the years, they have been able to make good use of the IEC programme and Andhra Pradesh government's Real Time Monitoring System to improve source segregation to 100 per cent.

The town produces a substantial quantity of biodegradable waste, and composting — whether it be at the household level or at scale in the form of windrow and vermicomposting — has worked well in Bobbili. In tandem with

Impacts

- Bobbili has adopted three-way source segregation (non-biodegradable, biodegradable and domestic hazardous) for 100 per cent of its waste.
- The town's waste management park, first in the state, is a sort of one-stop-shop for channelisation of recyclable waste to authorised recyclers.
- Almost 350 households are practising home composting. This number is set to increase, given the positive feedback and the municipality's promotion.
- The town's windrow composting unit produces 120 tonne of compost every two months. One tonne of compost is enough to fertilise an acre of land.
- The town also produces 60 tonne of vermicompost annually, sold at Rs 10 per kg, earning the town decent revenue.
- Though Bobbili has sanctioned an 8.4 acre plot for a dumping ground, it is unlikely that the town would need a dumpsite now.
- The biogas plant produces both methane and electricity (from the 5 kVA generator).
- Bobbili has won the Paryavaran Mitra Award from the state government.

Home compost at a residence in Teachers' Colony

the biogas plant, the various means of composting have proved adequate to process all of the town's biodegradable waste.

LESSONS LEARNT

A well-designed IEC programme, sensitive to local cultural practices, can penetrate deep into the collective psyche to yield rapid and transformative change in attitudes. Bobbili's example also shows that fines and application of polluter pays principle (as the town made shop owners responsible for littering by their customers) can help to achieve that crucial last percentage point under any waste management vertical – source segregation, segregated transportation, etc.

Centralised processing – like the windrow, vermicomposting and biogas production that Bobbili has adopted – can be combined with **decentralised processing** – like home composting (as is done in the town) – to good effect. Note that the town manages to process all of its biodegradable waste.

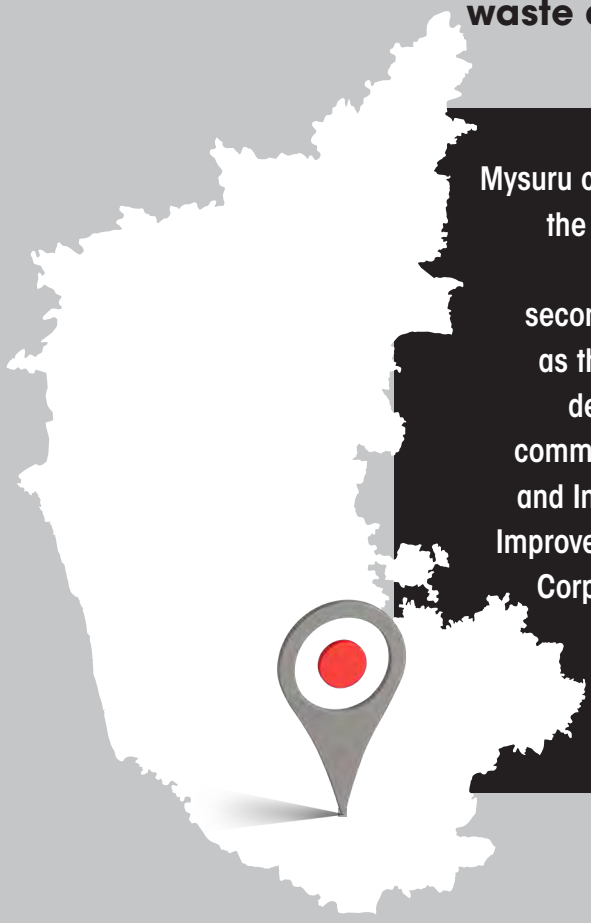
REPLICABILITY

The IEC programme implemented in Bobbili is easily replicable. The town's combination of decentralised and centralised processing of biodegradable waste is also immensely replicable, although local conditions, physical, social and economic, need to be factored in the adoption of the model.

KARNATAKA

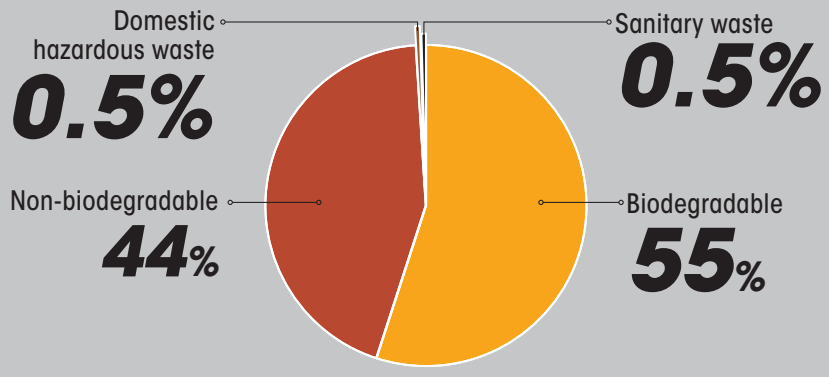
MYSURU

Change was brought about by adopting decentralised management of biodegradable waste and the cradle-to-grave model



Mysuru city is situated 770 m above sea level in the Chamundi Hills. Spread over an area of 155 sq. km, it is, after Bangalore, the second-largest city in Karnataka. Also known as the City of Palaces, it is a popular tourist destination. Mysuru got its first municipal committee in 1862, sanitary division in 1885, and India's first urban planning body, the City Improvement Trust Board, in 1903. Mysuru City Corporation has implemented decentralised waste management to manage biodegradable waste, the major fraction of municipal solid waste.

Waste composition in Mysuru



Source: Mysuru City Corporation

Population (in million, as per 2011 Census)
0.89

Estimated current population (in million)
0.98

Estimated floating population (daily)
49,300

Area (sq. km)
128.42

Number of households (in million, 2021)
0.23

Number of wards
65

Number of zones
9

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
450

Number of sanitation workers
870

Number of community bins
0*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
510

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
80

Percentage of waste processed
70

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Mysuru City Corporation

THE TRANSFORMATION

Due to its cultural history and pleasant climate, Mysuru city sees large numbers of tourists throughout the year, contributing to waste generated. Before 2014, the scenario of waste was not different from that of other cities. Typically, municipal solid waste comprises approximately 40–60 per cent biodegradable waste. The most challenging part is management of biodegradable waste. Unsegregated biodegradable waste cannot decompose and emits a foul odour and leachate, making it impossible for other recycling materials to be recovered from the stinking piles.

Waste was earlier collected from community bins placed at different locations. Garbage was thrown into bins and collected by field staff. Collection from these bins was planned according to the frequency of containers fulfilling and was, for instance, daily, biweekly or weekly. Waste collected was transported to the dumpsite.

The growing height of the dumpsite, its odour and environmental impact alerted officials to seeking a sustainable solution to the Mysuru's waste. They adopted decentralised waste management and the cradle-to-grave model to ensure scientific disposal of biodegradable waste.

In 2009, Mysuru City Corporation initiated the system of decentralised biodegradable waste management, also known by the Corporation as zero-waste management. Zero-waste management plants are constructed at the zonal level.

Mysuru City Corporation is the torchbearer in the field of wet waste processing. Appropriate infrastructure has been developed for proper processing of wet waste.

HOW THE SYSTEM WORKS

With the focus on source segregation and ward-level processing of biodegradable waste, Mysuru Municipal Corporation implemented the strategy in small segments to ensure maximum material recovery, maximum processing and minimum transfer to landfills.

City waste resources

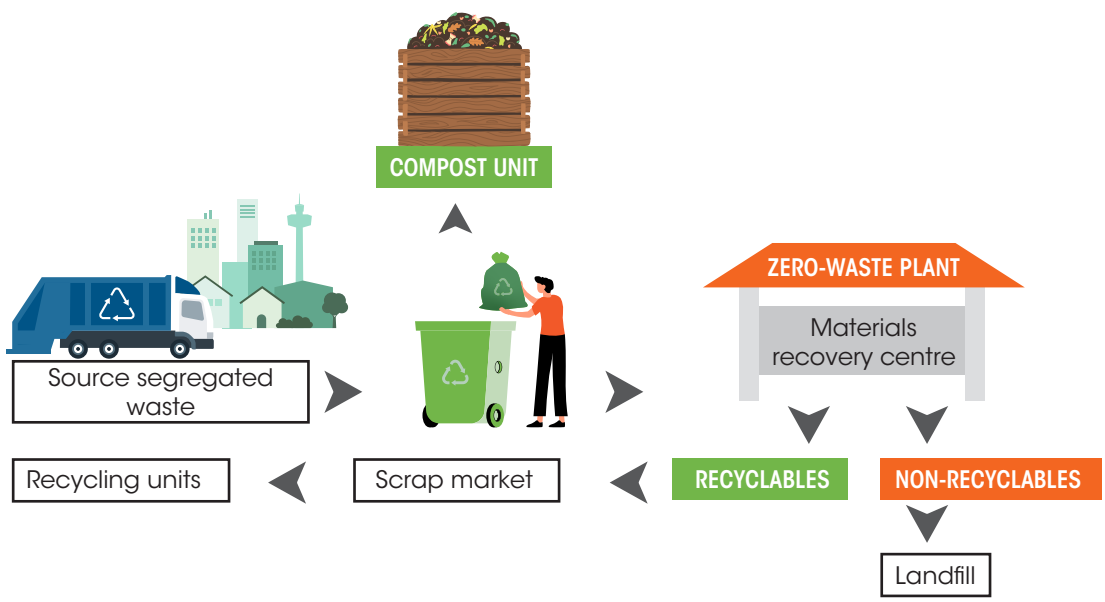
Facility	Capacity (TPD)	Number
Centralised compost plant	200	1
Decentralised waste management plant	35	7
Dry waste collection centre	43	43
Centralised landfill	90	1

Source: Mysuru City Corporation

Source segregation: Source segregation of waste at the household level is in two fractions – biodegradable and non-biodegradable waste.

Collection: Segregated collection of biodegradable waste from households has started in 65 wards. Collection is done daily. Primary collection vehicles collect garbage from households every morning. Trippers are single-chambered and collect biodegradable waste only from households. One pushcart collects waste from 250 households while one auto tripper covers approximately 1,000 households. Biodegradable waste is transported to the centralised compost plant and the zero-waste plants (i.e. decentralised waste management plants).

Cradle-to-grave model of waste management



Source: Mysuru City Corporation

Handling of waste

Mysuru City Corporation is a pioneer in adoption of scientific waste handling and management. After segregated waste is collected, biodegradable waste is directed to the centralised compost unit, with a capacity of 200 tonnes per day (TPD), on the outskirts of the city. Non-biodegradable waste is sent to one of the 43 collection centres in the city.

Centralised biodegradable waste-processing plant

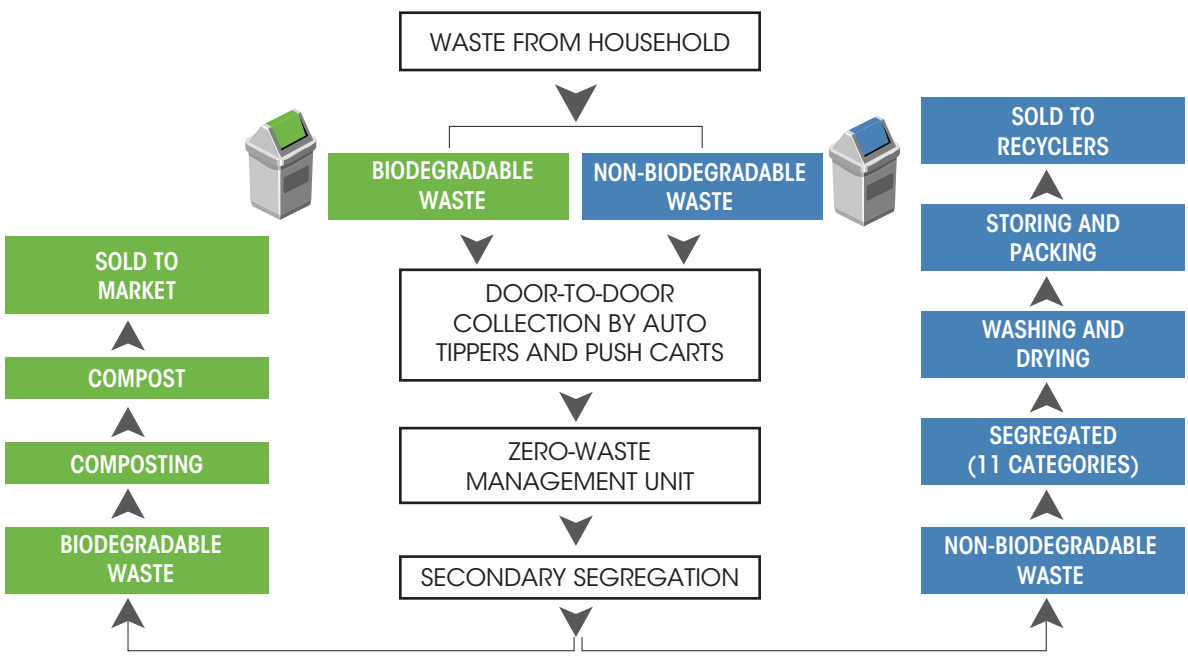
Mysuru City Corporation has one centralised biodegradable waste-processing plant. The city is on the way to achieving 100 per cent segregation, but mixed waste is still generated in some parts. Mixed waste collected is not sent to the decentralised unit but to the centralised unit for processing.

Zero-waste management plant

The central vision is to manage waste at the ward level. The plant is designed to manage biodegradable as well as non-biodegradable waste.

Segregated waste undergoes secondary segregation to ensure there is no mixing of waste during transportation and at the plant. Segregated biodegradable waste is sent for processing, where leachate generated during the process of composting is reused as inoculum.

How MCC manages municipal solid waste



Source: Mysuru City Corporation

Windrow composting in the biodegradable processing plant at Vidyaranyapuram, Mysuru

WHAT HAS WORKED IN MYSURU

Implementation of biodegradable waste management involves four key steps:

1. **Source segregation:** This is the key step in waste management. Segregated biodegradable waste from households is sent to the zero-waste management plant at the zone level. Currently, seven zero-waste management plants and one centralised compost unit are operational.
2. **Processing of biodegradable waste:** At the zero-waste plant, biodegradable waste is processed by aerobic composting. which includes:

- **Centralised biodegradable waste processing unit:** A centralised compost unit produces compost by piling biodegradable waste into long rows (windrows) and aerating it periodically by turning it manually or mechanically.

Infrastructure and workflow in the centralised biodegradable waste processing plant

- Located at Vidyaranyapuram, Nanjangud Road, Mysuru
- Capacity 200 TPD
- Mechanised, aerobic windrow composting
- MCC owns the land, infrastructure and machinery
- O&M by IL&FS Ltd
- Private–public partnership (PPP) model
- No O&M cost is paid to IL&FS by MCC
- IL&FS pays land rent and royalty of Rs 6,00,000 per annum
- 5 per cent of total compost generated is given to MCC

Source: Mysuru City Corporation

A two-stage screening system is adopted to achieve maximum screening efficiency. Screened material coming out of this section is uniform in texture and contains pure organic compost. The organic manure is then packed in 50 kg bags and sold at Rs 1,200 per tonne. The compost is then packaged and sold to nearby farmers and the horticulture department.

- **Decentralised zero-waste management units:** To maximise processing efficiency and minimise load on the centralised compost unit, the concept of a decentralised unit was initiated. Mysuru City Corporation is a pioneer in conceptualising and implementing a decentralised waste unit. Two methods of composting are employed at the zero-waste unit – pit composting and vermicomposting. The city has nine zero-waste management units of which seven are functional. Each plant is responsible for handling waste from five wards. Only segregated biodegradable waste is received at the zero-waste plant. The plant has a composting unit for handing waste from five wards and processing the biodegradable waste at a zonal level to minimise dependency on a single processing plant and the transfer-related issues such as spilling of waste, foul smell and leaking all the way to plant.

Infrastructure and workflow in the decentralised zero-waste management unit

- Also known as decentralized biodegradable waste management unit
- Present on zone level
- Area: 1.5–4 acre (i.e. 0.60–1.61 hectare)
- Shed: Receiving, segregation, processing and storage
- Compost pit: Composting
- Constructed in 2009
- Managed by NGO, SHG or Stree Shakti Sangha
- Infrastructure and vehicle: Mysuru City Corporation
- Financial support from Mysuru City Corporation: Rs 95,000 per month
- Revenue generated: Rs 15,000–30,000 per month
- Capacity: 5 tonne per day

Source: MCC

According to Mysuru City Corporation, the compost is sold to nearby farmers at a minimum cost of Rs 1,200/tonne, with 5 per cent retained by the City Corporation for horticultural purpose.

3. IEC activities: To promote composting and community engagement, campaigns, dramas and seminars are organised at high-footfall areas such as vegetable markets.

After the vegetable market is closed, vegetable vendors and shopkeepers put their vegetable waste into a drum to make compost. The vegetable waste is then covered by coco peat to prevent odour and flies and maintain the carbon-nitrogen ratio.

This system enhances the efficiency of processing and reduces transportation issues

such as spilling of waste, foul smell from the vehicle carrying the waste and seeping of leachate from the vehicle.

LESSONS LEARNT

The cradle-to-grave model of solid waste management gives every segment of waste management equal importance. The model tracks waste from its point of generation – i.e. households – to its processing into compost or recyclables till the disposal of inert to the landfill.

1. **Basic and simple practice of collection:** Despite using advanced technology, the City Corporation has increased the number of porkarmikas (field staff who collect garbage from door to door). Face-to-face interaction has contributed to residents trusting the service and inspired them to segregate their waste.
2. **Zone-wise processing of waste:** Decentralised waste management reduces chances of mixing waste at the secondary centre, making the processing of biodegradable waste more accessible and convenient, and material recovery more reliable and efficient.
3. **Cost-effective treatment options:** The low operation and maintenance due to decreased use of automated mechanised machines and biodegradable waste processing makes the service cost-effective in contrast with the large amounts spent on O&M by larger urban local bodies that use high energy and expensive technologies.

Impacts

- **Environmental:** Environmental and human health have reportedly improved because of decreased pollution levels. Municipal solid waste's biodegradable content made it a potent polluter due to its capacity to generate methane and leachate during decomposition. Managing the biodegradable waste reduces the long-term effects of global warming, climate change and groundwater pollution (due to seepage of leachate into groundwater.)
- **Economic:** Mysuru has become a hub for research in solid waste management. International teams are also attracted by the simple and reliable – and especially the manual – working systems. The system is easy to replicate and doesn't need automated mechanised machinery to work. Smaller O&M costs have made the system run independently. Energy consumption is reduced as less machinery means less power consumption.
- **Employment and empowerment:** Engagement of porkarmikas and/or self-help groups brings a sense of empowerment to women. The manual work engages more women workers, safaimitras and self-help groups and helps them achieve dignified lives by training and authorising them with identity cards.

4. **Infrastructure:** Proper infrastructure to handle segregated waste is a unique feature that made the process sustainable. The decentralised and centralised units for biodegradable waste, zero-waste management plant for secondary segregation and storage, and non-biodegradable waste collection centre for non-biodegradable waste make the process more sustainable.

The USP of the system is the cradle-to-grave model, which reduces the amount of waste reaching landfills. Focus is distributed evenly to check waste at its generation point and make best use of it. Non-biodegradable waste is segregated into the maximum possible categories and organic waste used to boost plant growth nearby. According to Mysuru City Corporation, due to this effort, only 2–4 per cent of inerts, non-recyclables and residues from zero-waste plants go to landfills.

The best way of waste management is ensuring material recovery and maintaining materials in the resource cycle and promoting circular economy.

REPLICABILITY

Mysuru city has adopted various simple and cost-effective processing methods to manage its biodegradable waste and generate additional resources such as compost. The zero-waste plant ensures less operation and maintenance costs and high performance.

Urban local bodies generally focus on recyclables, putting aside biodegradable waste management on the assumption that it will degrade naturally. However, the biodegradable fraction needs to be handled scientifically as this is a major fraction of our municipal solid waste. If not managed properly, it emits a foul odour and produces leachate and harmful gases such as ammonia and hydrogen sulphide, which pollute the environment. Unsegregated waste decreases the value and quality of resources derived from different fractions of waste. If not properly managed, it ends up in landfills or at dumpsites, causing significant environmental and human hazards.

Small urban local bodies have limited funds for waste management services. The cradle-to-grave and decentralised waste management approach with simple and cost-effective treatment options are replicable in urban local bodies. Decentralised biodegradable processing plants do not need high energy or expensive automated treatment options, and are a tested model to replicate, especially in small urban local bodies of Tier 2 and Tier 3 cities, where resource are limited.

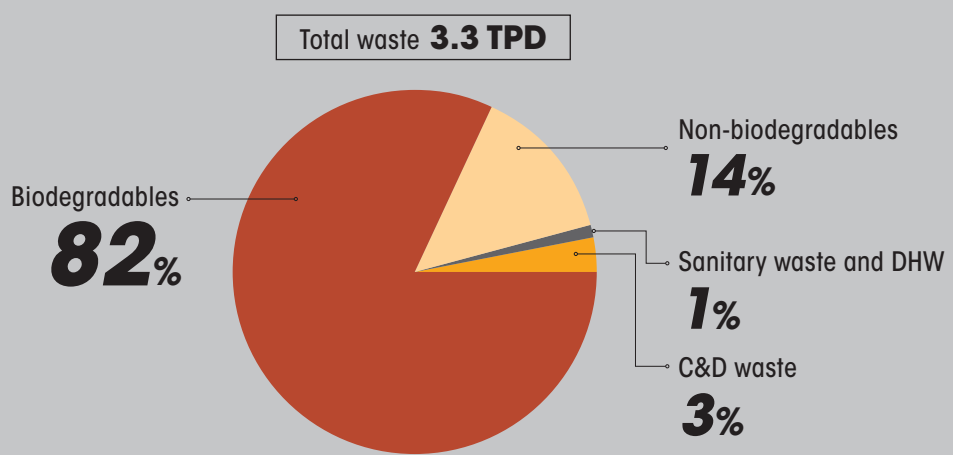
MAHARASHTRA

VENGURLA

Participatory approach has ensured source segregation and processing of all the biodegradable waste the town generates

Vengurla, a town in Sindhudurg district of Maharashtra, has one of the oldest municipal councils in the state. It reportedly generates over 3 tonne of waste per day, of which around 82 per cent is biodegradable. The town claims to be a no-landfill city, as it processes 100 per cent of the biodegradable waste it generates.

Waste composition in Vengurla



Notes: DHW – domestic hazardous waste, C&D – construction and demolition

Source: Vengurla Municipal Council

Population (as per 2011 Census)
12,392

Estimated current population
12,400

Estimated floating population (daily)
20

Area (sq km)
13

Number of households (2021)
4,826

Number of wards
14 administrative **8** electoral

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
3.3

Number of sanitation workers
55

Number of community bins
0*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
11

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
100

Percentage of waste processed
100

*According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Vengurla Municipal Council

THE TRANSFORMATION

Till a few years back, the Vengurla Municipal Council (VMC) used to collect all the mixed waste and throw it in a dumping ground at Parabwada. Besides leading to poor air quality due to emissions and groundwater pollution due to leachate generation, the dumping ground also contributed to marine pollution.

Due to the inefficient waste collection system, littering was a common practice. Multiple garbage dumps around the town hampered handling of the waste and increased the workload of labourers and officials alike. The VMC had to spend extra on cleaning agents like bleaching powder, vehicles and labour. The labourers handling the waste were exposed to occupational hazards. Dry waste generated at the household level used to be burned openly in the backyard, affecting the surrounding air quality.

In 2013, Vengurla initiated a turnaround: a bio-methanisation and vermicomposting plant was approved for the town. The municipal council wanted to change the people's mindset and behaviour towards waste management. It was important to involve citizens in managing the town's waste.

Vengurla devised an interesting format for doing this. It identified and created a cadre of *Swachhata Doots* (People's Ambassadors for a Clean City, literally), who were entrusted with the task of connecting with the residents and troubleshooting problems between them and the VMC with respect to waste management. Additionally, sanitation staff, social workers and politicians were roped in to form a *Swachhata* team.

Each *Swachhata Doot* was assigned one electoral ward. Each ward in the town consists of multiple wadis; and each wadi comprises approximately 25 to 30 houses. As a parallel measure, *Swachhata Sacheevs* (Administrative Representatives) were selected from among the office bearers of the VMC. This team reached out to the people through door-to-door training and monitoring.

Before this, segregation of waste was unheard of in the town – households were initially hesitant to change; instead of handing over their waste to the collection vehicles, they used to burn it. The *Swachhata* team requested citizens to follow the segregation model and give all their waste to the VMC collection vehicles. Citizens who were not willing to change were told that the council would disconnect

their basic amenities and services. The VMC also penalised a few who continued burning dry waste or were found littering.

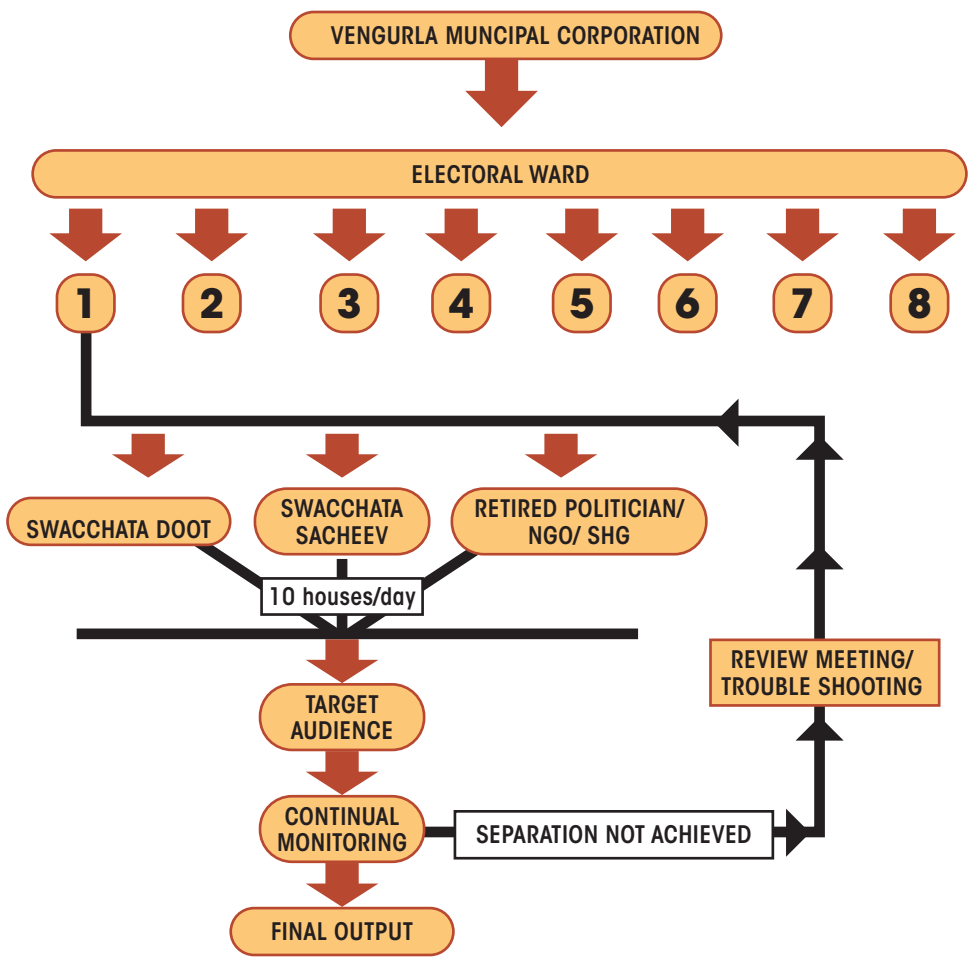
Review meetings were held every fortnight. These meetings helped the team identify, understand and address all the issues.

HOW THE SYSTEM WORKS

Using IEC (information, education, communication)

Building awareness and public acceptance was the first step. Various strategies were adopted to strengthen and reinforce the awareness campaign. Initially, in the absence of adequate numbers of collection vehicles, the council installed common bins at societies/wadis. Monitoring was done using CCTVs. However, a malpractice was soon detected: *Swachhata Doots* and local volunteers observed that defaulters were bypassing the surveillance by switching off the camera and putting mixed waste in the bins. A few defaulters were nabbed, but the VMC

The Vengurla model



Vengurla residents and its Swachchata team on an awareness drive

understood that the process was tedious and not feasible in the long run.

The council then decided to follow the two bins-two bags principle: it distributed differently colored dustbins – green for wet waste and blue for dry waste. Sanitary waste and domestic hazardous wastes (DHW) were collected separately.

Even after all these efforts, there were some who continued to litter and ignore warnings and fines. To deal with them, the *Swachhata Doots* and *Sacheevs* opted for a reverse psychology approach – they themselves took to cleaning the waste that these people littered. Their persistence and determination eventually paid off; the non-compliant population gave in and the town touched the 100 per cent segregation mark.

Collection and transportation of segregated biodegradable waste

The people of Vengurla have been practising source separation since 2016. Having begun with separating three kinds of waste, the town is currently segregating its waste into 27 different categories.

The IEC activity of door-to-door training and monitoring has developed a well-oiled mechanism and understanding between the VMC and the people with the help of the *Swachhata Doots* and the team. Every day, a representative from the team waits for the collection vehicle at the respective ward/s to monitor the collection process; the vehicles coming for collection are accompanied by *Swachhata Sacheevs*.

Good morning Pathak

The *Swachhata* team's innovative training module started every day with a programme called '*Good Morning Pathak*' at 5:30 AM to stop people from defecating in the open: the team physically went around advising people. This was followed – from 9 AM to 12 noon – by an IEC programme called 'Swachhatatun Samruddhi', under which door-to-door training was conducted on waste segregation; the team also monitored progress. This process continued for a period of six months till the town achieved 100 per cent source separation in a majority of households and neighbouring areas.

Vengurla's waste collection fleet

Vehicle details	Units	Activity
Tractor	1	To collect road (swept) waste and biomass waste
Four-wheel mini tipper	8 (each 1-TPD capacity)	Door-to-door collection of waste
Back hoe loader	1	To assist the tractor in loading biomass waste
Tipper	1	To collect C&D waste

Source: Vengurla Municipal Council

With the increase in the number of people segregating waste, the team decided to augment the collection system by increasing the fleet size and the number of *safai karamcharis*. The local MLA's (member of legislative assembly) help was taken to do this, and CSR (corporate social responsibility) money channelised. To tackle the issue of vehicles arriving late or their breakdowns, GPS devices were installed in them and back-up vehicles kept on stand-by. The monitoring of these systems was done by the *Swachhata* team.

The town processes all its organic waste and produces compost that is used internally as well as sold to farmers

Using energy efficiently

- The biogas plant produces its own electricity, and meets the requirements of the briquetting plant and the MLP (multi-layered plastic) shredder – its energy consumption, therefore, is zero.
- The only labour-intensive operation in the vermicomposting plant is loading/unloading – the major part of the remaining work is done by earthworms.
- The 24-hour OWC is an energy consumer, but to balance it, a separate 18-kW solar power unit has been installed in the plant.

The VMC has stipulated two rounds of waste collection. The first of these is from 9 AM to 12 noon. The second, from 2 to 5 PM, is to collect from people/households who or which were missed out in the first round. Each collection vehicle is manned by a driver and two waste collectors. A gender balance has been maintained among the collectors, and attention is paid to ensure safety, specifically around sanitary waste.

Any defaults or malpractices can now be reported directly to the VMC through a toll-free complaint number, and usually, complaints are resolved within a few hours. For better accountability in collection and transportation of the waste, the VMC has started a programme called *Swachhata* NETRA (New Efficient Transport Reconnaissance Application). Under this, every house and commercial establishment is being marked with a radio frequency Identification (RFID); workers in the collection vehicle scan the RFID code and update the collection status on a real-time basis. To fund this, the council has managed to raise Rs 90,000 of CSR money from industries and other organisations.

Identification and use of appropriate technologies

Clearing out the legacy waste of over 300 tonne in the dumpsite was the first step towards movement from this dumping ground to the building of a processing centre. It took three years to clear out the legacy waste. The recyclables were separated and sent for recycling; the non-recyclables were sent to cement kilns; and the residue waste was used to level the dumping site.

Some of the technological solutions that Vengurla opted for at the waste processing centre that was built on the erstwhile dumpsite are:

- Using biogas to generate electricity
- Vermicomposting
- Biomass briquetting unit
- Installation of organic waste convertor (OWC) for converting non-vegetable biodegradable wastes (fish and meat residues) and some reject wastes into compost

The town also adopted decentralised composting techniques to complement its centralised processing systems.

WHAT HAS WORKED

The VMC produces over 2.7 TPD of biodegradable waste – of this, 2.5 TPD is processed at the centralised processing facility; 0.208 TPD is processed in a decentralised form. This dual system has worked for the town.

Decentralised processing

The VMC incentivises households, residential societies and building complexes to process their biodegradable waste. Those who take the help of the council for processing offsite get a 5 per cent rebate on the general property tax; those who process in their backyards get a 10 per cent rebate.

Encouraged by this, 274 households are practising pit composting in their backyards, with a total capacity to generate 69 kg of compost every day. Anandi Arcade Phase II, the first residential society to start pit composting in Vengurla, uses the compost in its own gardens. Most of the decentralised composting plants are either pit composting or in-vessel composting. A deliberate effort has been made to keep the technology simple and affordable, especially in common areas like markets.

Two bulk waste generators have been identified in the town. The VMC has defined a bulk generator as "any organisation/institution/hotel/restaurant/mess producing more than 50 kg of waste a day". The council has forced one of these generators – a restaurant producing 90 kg waste per day – to install a biogas plant within its premises to tackle the biodegradable waste. The plant is an underground system which can produce gas for nearly four and half hours, which is used in the restaurant's kitchen for cooking.

The second bulk generator, a fruit research centre producing 60 kg of waste per day, has installed a vermicomposting system. Most of the compost is utilised inhouse, and the surplus is sold for Rs 12,000 per tonne to local farmers.

Centralised processing

The VMC's centralised processing plant incorporates the following:

Biogas to electricity: This was the first technology identified by the VMC for incorporation at the processing centre. The idea was to make the plant independent of the grid and enable it to produce its own liquid fertiliser. The plant has a capacity of 1.5 tonne per day, and processes around 1.2 tonne of biodegradable waste a day. It generates 100 cubic metre of gas and 50-60 units of electricity every day.

It also produces around 800-1,000 litre of liquid fertiliser. This liquid is first allowed to go to the settling tank where the compost gets settled in the form of solid sludge; the liquid remains on top. It is then extracted and utilised for the garden in the processing centre. Whatever does not get used internally, is sold at the rate of Rs 1 a litre to local farmers.

Vermicomposting: Vengurla's vermicomposting plant, installed in 2015, has a capacity of 500 kg per day. It is primarily fed by the waste from the sweeping of roads, consisting of biomass and green foliage. It is currently processing 200 kg of waste a day.

Organic waste convertor (OWC): There was the challenge of processing non-vegetable biodegradable wastes (fish and meat residues) and some reject fibrous wastes coming from the biogas plant. A one tonne/day capacity 24-hour OWC was installed in 2019 to take care of this waste. The compost produced is used in the VMC's gardens; some of it is also sold to local farmers. The OWC's energy consumption is balanced by the plant's use of solar, but the gases that the convertor emits remain a cause of concern. Therefore, appropriate arrangement for tackling these gases needs to be made.

Biomass briquetting: The VMC is blessed with a large green belt and foliage in and around the town. A one-tonne per day biomass briquetting unit, for processing tree cuttings and garden waste, has also been installed by the council.

The centralised processing facility has 28 workers. Periodic testing of the compost and vermicompost is done at the Fertiliser Control Laboratory in Kolhapur. Latest reports indicate that both the compost and vermicompost hold a healthy percentage of macronutrients (NPK) and micronutrients (Mn, Ca, etc); traces of heavy metals are below the permissible value (as per the Municipal Solid Waste Rules, 2016).

The compost produced has been recognised by Harith Maha City Compost and has been enlisted in its e-commerce portal. Harith Maha City Compost is a brand of compost produced and marketed by cities in Maharashtra, which is the only state in the country to have started this city compost initiative as per the Solid Waste Management Rules of 2016.

One of the town's organic compost-nurtured gardens under preparation

Expenditures and revenues

Parameters	Cost in Rs (monthly)
Expenditure on MSW collection and transportation	2,87,717
Expenditure on MSW processing	4,17,131
Expenditure on MSW disposal	-
Total expenditure on MSW management	**7,04,848**
User fee collected	1,02,085
Revenue generated from selling of compost and biogas	12,726
Revenue generated from selling of recyclables, RDF (refuse-derived fuel)	37,600
Revenue generated from other sources	20,716
Total revenue generated	**1,73,127**

NOTE: It is clear from the table that Vengurla spends much more on its management of municipal solid waste than what it earns. The revenues that it earns are spent on collection and processing of the waste. The shortfall is compensated by funds received from the Zilla Parishad, as well as the money raised from various other sources.

Source: Vengurla Municipal Council

LESSONS LEARNT

Economic benefits: In 2016, efforts of the VMC were acknowledged by the state for the first time – the council received a Rs 2.5-crore incentive from the state government and through CSR funds. The VMC's work since then has garnered it around Rs 12 crore as incentives, grants and awards. The town now has enough resources for managing its waste, and has also invested in developing other

Swachchata Doots at a training workshop

Impacts

- Around 4,826 households and 144 commercial entities sensitised and made aware about the benefits of at-source segregation and waste management
- 12,392 individuals trained about appropriate methods of disposal and recycling
- 1,172 tonne of waste processed every year in the VMC's centralised and decentralised models of organic waste management
- Approximately 54 tonne of compost produced, and 4.7 tonne sold at Rs 10 per kg to farmers – annually

infrastructure (such as a state-of-the-art municipal council office, sports facilities, a museum, a fish market, and digital screens to display weather forecasts etc).

The compost produced by the council has helped it develop five parks/gardens – one of them covering an over 2-hectare area. The council is now exploring the options for making its compost production economically viable and sustainable. It has started selling the slurry coming out of its biogas plant at Rs 1 per litre.

Its biomass to briquette project is a third-party model: DCS Techno Services Pvt Ltd processes all the biomass waste that is collected by the VMC. A public-private partnership initiated by the town – called *Harith* Green – will look after the sale of the compost being produced. The VMC has recently been listed in the Harith Maha City Compost e-commerce platform.

Health benefits: The transformation of what was once Vengurla's dumping ground has had tangible benefits. The site now houses the park covering an over 2-hectare area, which has helped lower the pollution levels at the location. People living in the area are feeling the difference, and so are the town's sanitation staff, who used to handle the waste at enormous risk to themselves.

REPLICABILITY

The VMC model is easily replicable. The council's choice of technologies and systems – from vermi-composting and bio-methanisation for kitchen waste and OWC for fish/meat and fibrous wastes, to briquetting for biomass and green foliage waste – can be easily incorporated in any kind of urban centre, irrespective of the size of the population or the area.

3

MATERIAL PROCESSING

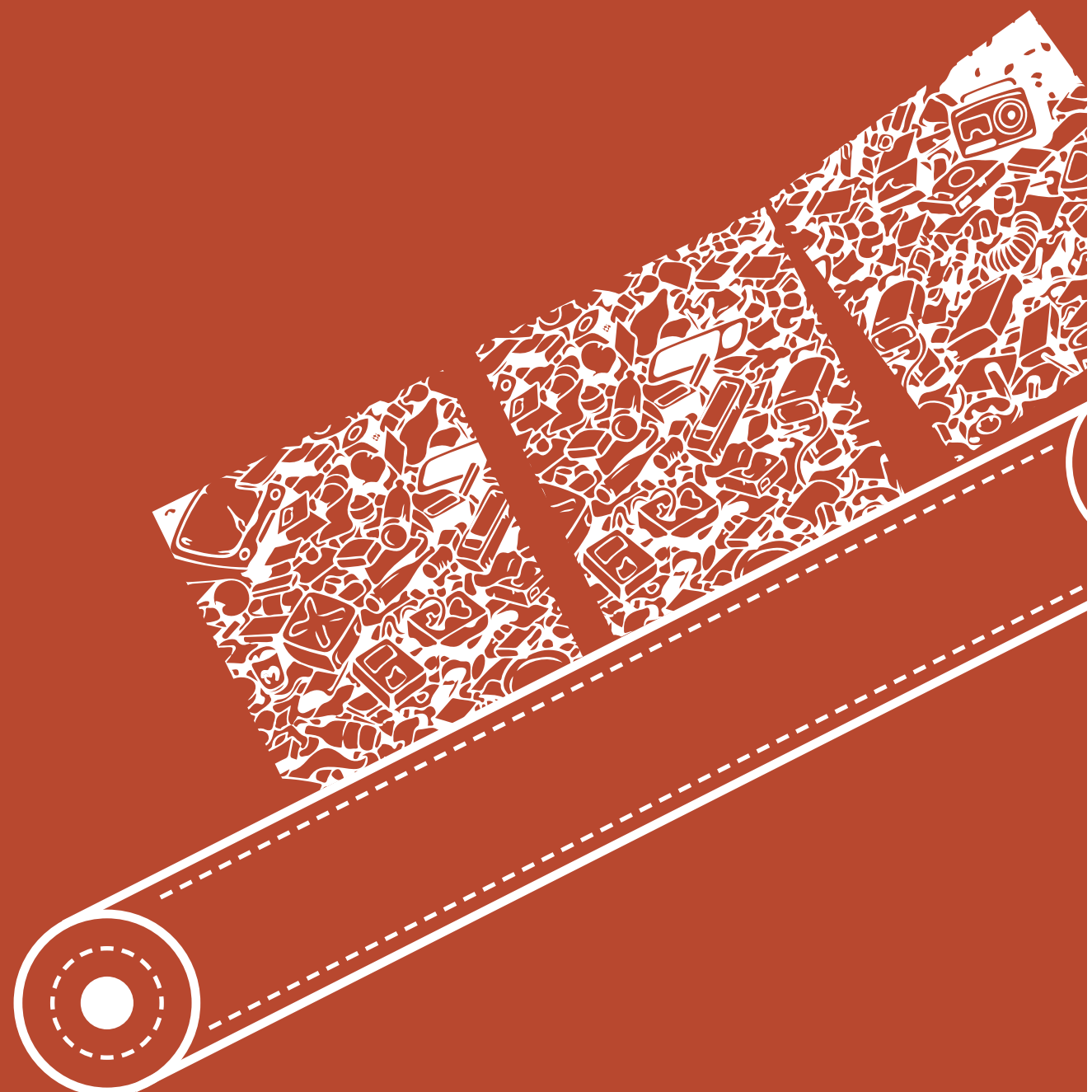
Solid waste, in whichever form it leaves our homes and offices, can be sorted into many different materials in a secondary sorting-cum-material recovery facility. After this sorting, it can be channelised to specific facilities for scientific processing. It is only through this processing that waste transforms into a valuable resource, making waste management economically sustainable.

Bhopal: With enthusiastic participation of citizens, efficient integration of the informal sector and setting up of a robust monitoring system, the city has completely transformed its material processing.

Dhenkanal: By realising the importance of public awareness, involvement of the local community and conversion of waste to resource, and sheer political will, the city has achieved 100 per cent material processing.

Jamshedpur: Has proved to be a model of material recovery by establishing Dry Waste Collection Centres to manage its non-biodegradable waste. Its e-waste recovery is also commendable.

Surat: Adoption of a multipronged approach of achieving 100 per cent source segregation and channelisation of recyclables and refuse-derived fuels to achieve a high material processing efficiency has resulted in substantial reduction of the waste received in the city's landfill.



MADHYA PRADESH

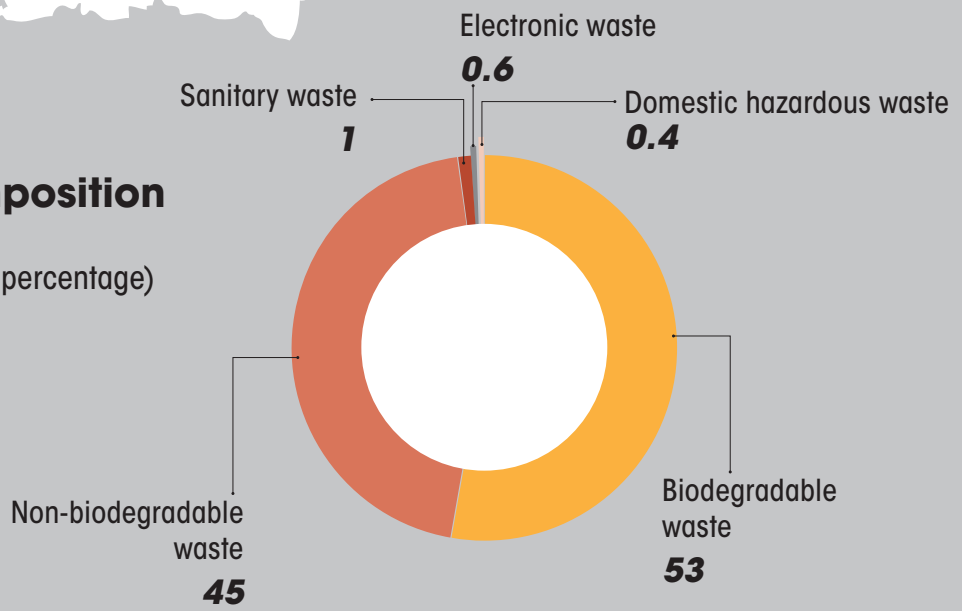
BHOPAL

Bhopal has come a long way from the time when it used to process only biodegradable wastes from bulk generators, to 100 per cent processing today

Bhopal, "the City of Lakes", is said to have been founded by king Bhoj, the famous Parmar ruler of Dhar, in the 11th century. Capital of the state and a rapidly growing city, Bhopal was adjudged an ODF++ (open defecation free) city in Swachh Survekshan 2020: this means it is managing all of its faecal waste scientifically and has adequate infrastructure to handle its black water. For two consecutive years (2017-18), Bhopal was at the second spot in the national rankings of cleanest cities; in 2019, it was ranked seventh, and dipped further down to 14th position in the following year.

Waste composition in Bhopal

(Daily quantity in percentage)



Source: Bhopal Municipal Corporation

Population (in million, as per 2011 Census)
1.8

Estimated current population (in million)
2.1

Estimated floating population (in million, daily)
1

Area (sq km)
413

Number of households (in million, 2021)
0.42

Number of wards
85

Number of zones
19

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
873

Number of sanitation workers
7,839

Number of community bins
0*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
882

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
100

Percentage of waste processed
100

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Bhopal Municipal Corporation

THE TRANSFORMATION

According to a report in the *International Journal of Engineering Research and Technology* (Vol 2, Issue 11, November 26, 2013), while it was difficult to estimate the exact quantity and characteristics of the waste produced in Bhopal, the Bhopal Municipal Corporation (BMC) reported that 550 tonne per day (TPD) of solid waste was generated in the city's urban area before the city began its march towards sustainable management of waste. Most of the waste used to be dumped in the open or community bins.

Door-to-door garbage collection services were started in 2013. BMC had a 2,000-plus strong workforce to do this but they were not monitored and covered only a few colonies, and hence, had no positive impact on the city's waste management practices.

Waste was transported in open trucks to the Bhanpur dumpsite; spilling of garbage and foul odour along the route of the trucks were common problems. According to the 2018 Annual Report of the Bhopal Municipal Corporation, Bhopal had 272 vehicles in its waste collection fleet. Each vehicle (with one driver and five to seven collection labourers) made two to four trips a day. Most of these vehicles were more than eight-10 years old and were in a deplorable condition.

With minimum or no source segregation, processing of the city's waste was an impossible task. Only the biodegradable waste collected from bulk sources (such as vegetable markets) found its way into processing. Recyclable components such as plastics, paper and metals were largely managed by the informal sector; and much of the recyclables were kept intact within the supply chain.

The city's Bhanpur dumpyard, popularly known as Bhanpur Khanti, pointed to the lack of proper solid waste management in the city. For travelers coming to Bhopal, the foul smell from Bhanpur was the indication that they had arrived in the city. The persistent fires in the dumpsite would hinder not only road traffic, but railway traffic as well; the smoke from the fires reached colonies located even a few kilometres away.

The BMC reportedly dumped over 800 tonne of waste in Bhanpur every day. The total quantum

Impacts on the city and its people

- Unclean city, with garbage lying around in the open
- The Bhanpur dumpsite was 16 km away from the city – in rainy season, the access roads to the site used to be badly affected. As a result, most of the vehicles used to dump their garbage outside the site.
- Garbage choked the stormwater drains, causing water logging, especially during monsoons.
- Burning of waste was a common practice at collection points and the dumpsite, resulting in significant air pollution.
- Open community bins accelerated the generation of leachate and foul smell
- Contaminated groundwater around the dumpyard due to leachate formation
- People living in areas close to the dumpyard, moved away. There was a dip in occupancy in residential societies located close by.

of the waste that had accumulated in the 48-year-old dumpyard was estimated to be around 5 million tonne. The dumpsite's sole weighbridge was non-functional, and a 100-TPD composting plant was also not in a good condition. The haul roads to the dumpsite were not well maintained and almost impassable at several locations. During rains, the leachate that formed presented a significant threat to humans and the environment, contaminating the land and the aquifer as well as emitting landfill gases like methane and carbon dioxide which contributed to global warming.

The informal sector was an integral part of the non-biodegradable waste management system, but rag-pickers did not have any social security, or even rights on the garbage they survived on. Completely unprotected, they operated in highly dangerous and unhealthy conditions.

The flagship Swachh Bharat Mission motivated and helped the BMC in adopting sustainable waste management for Bhopal city; the toolkit of Swachhta Survekshan made the decision-making process simpler. Remediation of Kolkata's Dhapa dumpsite offered the necessary technical expertise and experience for the remediation of Bhanpur Khanti.

Bio-capping of the Bhanpur dumpsite has helped the city government earn a lot of confidence from the citizens as this 48-year-old dumpsite was nothing less than a nightmare for the locals. The preamble to the changed waste management ecosystem started with very heavy focus on source segregation. As an important strategy, the city converted the six transfer stations to material recover facilities to eliminate the secondary transportation for the non-biodegradable waste out of the equation. The city also started utilising informal waste pickers, who had developed their skills by working in far worse situations.

Aided by 100 per cent segregation of waste at source, the city has managed to get the fruits by setting up facilities for treatment of biodegradable waste, non-biodegradable waste and other fractions. The city's non-biodegradable facilities are cumulatively processing 565 TPD; about 412 TPD of biodegradable waste is processed at the waste-to-compost facility; another 105 TPD is processed at the waste-to-biomethanation plant.

A collaborative effort

Bhopal's transformation required the full cooperation of its citizens. Their old habit of keeping the house clean at the cost of public spaces was no longer to be tolerated and had to be changed. To do that, the BMC launched many awareness campaigns with a partnership approach; it also conducted a wide variety of consultations with citizen's groups, Resident Welfare Associations (RWAs) and traders' bodies. The Corporation also undertook a mammoth publicity campaign, generously aided by the media. To further convey its seriousness about compliance, the municipality placed special emphasis on fining offenders. Facilities for eco-friendly immersion of idols during festivals and plastic-only collection drives have also been launched.

The impact of these activities has been positive. Citizens have hailed these efforts, the compliance of residential and commercial establishments with the expected norms is increasing, the crackdowns on sales of unauthorised polythene are going up and overall public hygiene has taken a turn for the better.

Initiatives launched by the BMC

Initiative	Aim and outcome
Gobar se Gamle	Sustainable sanitation
E-waste clinic	Waste management
Bartan Bank	Behaviour change
Carry Your Own Bottle/Bag (CYOB)	Sustainable sanitation
"Kitaab Ghar" Activity	Behaviour change, sustainable sanitation
Gau Kasht	Behaviour change, sustainable sanitation
Golden Leaf	Waste management, behaviour change, sustainablesanitation
Kachra Rakshas	Waste management, behaviour change
Fresh Rooms	Behaviour change
Community Composting	Waste management, behaviour change
Sanjiwani Box	Waste management, behaviour change

Source: BMC

HOW THE SYSTEM WORKS

Door-to-door collection is the key

The BMC realised that door-to-door garbage collection with source segregation is a must for sustainable material processing – the initiative kicked off with the city being divided into 19 zones for operational purposes (each zone has four to six wards). Waste is segregated into four categories – biodegradable, non-biodegradable, sanitary, and DHW (domestic hazardous waste). The BMC deploys 469 auto tipper vehicles with partition for source segregation.

Management of recyclables

Managed at source by citizens/ households/ commercial establish-ments
Sold to individual scrap buyers who visited the colonies/estab-lishments

Managed by BMC collection staff
Collected from households by the staff and sold to scrap buyers

Picked from community bins
Collected by ragpickers and sold to scrap vendors

Managed at the transfer station
Non-biodegrad-able waste left behind after screening picked up by ragpickers as well as munic-ipal staff and sold to scrap dealers

Managed at the dumpyard
Collected by ragpickers and sold to scrap buyers.

Bhopal Municipal Corporation

On an average, five vehicles are deployed in each ward, and these vehicles move according to a pre-determined route plan, which makes their monitoring easier. Monitoring is supervised at the zonal level by assistant health officers with the help of ward-level inspectors/*darogas* and sanitary supervisors.

Monitoring makes things perfect

To streamline monitoring of individual workers, the BMC introduced a facial recognition attendance system which ensured that workers appeared in person to mark their attendance. As the system has no manual inputs, it cannot be manipulated. Adoption of this system has helped the BMC in ensuring punctuality among the workers, as well as checking malpractices like absenteeism.

For monitoring the collection vehicles as well, the Corporation opted for a technological solution, as deploying supervisors with every vehicle is an expensive proposition. The BMC uses a state-of-the-art Vehicle Tracking System (not GPS based), which is connected to its Integrated Control and Command Centre (ICCC) – real-time vehicular movement data gets reflected on the screens of operators at the ICCC. These operators generate daily reports on the collection vehicle movements, attendance etc.

Seamless transportation adds to efficiency

Bhopal today has 11 Material Transfer Stations (MTS) – a big improvement on the earlier six. This has reduced fuel consumption (collection vehicles have to travel less than before to reach the closest MTS) and made the collection system more efficient. RFID-enabled weigh-bridges have been installed at these transfer stations and material processing

facilities. This has reduced manual intervention and hence, any errors in the log book. The RFID reader reads the RFID tag installed in the vehicle and the waste (both biodegradable and non-biodegradable) is weighed. All the data is recorded with time stamp and fed into a database. This has replaced the conventional way of maintaining a log book.

The BMC has installed fuel stations at each transfer station to save on refuelling time; this has also helped the BMC in procuring fuel at reduced prices compared to the market.

The Corporation has recently outsourced the transportation and processing of the garbage, and is paying a tipping fee of Rs 369 per metric tonne for the garbage that is transported.

Material processing with a difference

The disposal site at Bhanpur had a waste processing plant which had become non-functional. The BMC has now built a processing and disposal facility at Adampur. Currently, the BMC has six non-biodegradable waste processing plants (Material Recovery Facilities or MRFs) and five biodegradable waste processing plants, which include three windrow composting and two bio-gas facilities. The six MRFs are located at the transfer stations to avoid extra transportation.

The BMC has actually adopted an interesting model for managing non-biodegradable waste without any operational costs. The Corporation has outsourced its MRFs to three private companies, whose responsibilities include integrating rag-pickers into the system; an effective door-to-door garbage collection mechanism means it is difficult to find any garbage on the streets, which leaves rag-pickers without their source of livelihood. This is the reason the BMC has made it mandatory for the private companies to involve rag-pickers at the MRFs. The companies pay the rag-pickers according to the recyclable waste that they segregate. Mobile applications are used to manage the inventory and calculate the amount to be paid to the rag-pickers.

Biodegradable waste is processed at two centralised windrow composting facilities (capacity 410 TPD) and two bio-gas plants (capacity 105 TPD). Apart from these, the BMC operates one decentralised processing facility at AIIMS. There are 69 bulk waste generators in the city who manage their waste at their own onsite facilities; so do 80 residential welfare associations and 102 public gardens.

Non-biodegradable waste processing in five steps – collection, transportation, sorting, processing and disposal

Collection	Transportation	Sorting	Processing	Disposal
Door to door segregated garbage collection Non-biodegradable waste collected in blue compartments	Transported separately in blue compartment to avoid mixing	Waste further segregated at MRF into more than 10 categories	Recyclables sent to recycling companies according to category	Non-recyclables stored as refuse-derived fuel (RDF)

Transportation of 4-way segregated waste in green, blue, yellow and black container

The Corporation two bio-gas (CNG) plants are located at Sukhi Sewaniya and Bittan Market. The Bittan Market plant caters to the local vegetable market; biodegradable garbage from nearby colonies is also processed here to give good returns in terms of biogas and organic manure. The plants produce bio-gas with a purification of up to 98 per cent. The purified gas is used to generate electricity for Bittan Market.

For managing its sanitary and domestic hazardous waste, the BMC has entered into an agreement with Bhopal Incinerators Ltd, a city-based common bio-medical waste treatment facility. Ramky Infrastructure Limited has been entrusted with the task of disposing of this waste.

Essentially, the Bhopal model has proved to be suitable, efficient, sustainable and cost-effective for the city. Source segregation is the mandatory component for waste processing in this model, with garbage being segregated into four categories. For remediation of the dumpsite, the Corporation has undertaken bio-mining and bio-capping of the inert waste. The Bhanpur dumpsite has been remediated completely and a park is under development at the top of the inert waste.

Among the other initiatives and infrastructure coming up are a 400-TPD torrefied charcoal plant to process non-recyclable non-biodegradable waste, which is being set up by the National Thermal Power Corporation (NTPC) with no cost to BMC; and a 200-TPD bio-CNG plant being set up with a US $1.42 million grant from United Nations International Development Organization (UNIDO). The BMC will get a royalty of Rs 61 lakh per annum for the segregated waste that it will give to the plant.

Today, in Bhopal, all wards are covered under the door-to-door garbage collection with source segregation system. The city's transfer stations are not allowed to accept mixed garbage. Non-biodegradables, 100 per cent of which is collected every day, are sorted into recyclables at the transfer stations by rag-pickers – approximately, 40 per cent of the non-biodegradable waste is made up of recyclables. A total of 40 rag-pickers have been employed at the MRFs.

Non-biodegradable waste processing plants of Bhopal

S No	Ward no.	Plant ID	Plant name	Location	Capacity (tonne per day)
1	2	SBM/BHO/20	MRF Bairagarh Bus Depot	Bairagarh	50
2	50	SBM/BHO/16	MRF Danapani	Danapani	40
3	35	SBM/BHO/11	MRF Yadgare Shahjani Park	Yadgare Shahjani Park	30
4	62	SBM/BHO/19	MRF Transport Nagar	Anand Nagar	20
5	16	SBM/BHO/09	MRF Arif Nagar	Arif Nagar	25
6	62	SBM/BHO/14	MRF Aadampur	Aadampur	400
Total capacity					565

Source: BMC

Biodegradable waste processing plants (windrow) of Bhopal

S. no.	Ward no.	Plant ID	Plant name	Location	Capacity (tonne per day)
1	62	SBM/BHO/13	Aadampur Chhavni Waste To Compost	Raisen Road	400
2	74	SBM/BHO/22	Deewanganj Carcass Center Waste To Compost	Deewanganj Carcass Center	10
3	57	SBM/BHO/23	AIIMS Waste To Compost	AIIMS	2
Total capacity					412

Source: BMC

Biodegradable waste processing plants (bio-gas) of Bhopal

S. no.	Ward no.	Plant ID	Plant name	Location	Capacity (tonne per day)
1	74	SBM/BHO/21	Waste To Energy Sukhi Sewaniya	Sukhi Sewaniya	100
2	45	SBM/BHO/02	Waste To Energy Bittan Market	Bittan Market	5
Total capacity					105

Source: BMC

WHAT HAS WORKED

Bhopal has done a complete overhaul of its solid waste management practices based on a comprehensive strategy directed to source segregation. Aligned with the source segregation strategy through intense citizen's participation, all the wards have been covered under door-to-door collection. The vehicles assigned for a particular ward have been given the responsibility to ensure transportation of segregated waste and report any aberrations. The transfer stations are instructed to accept only segregated waste. The approach has helped to secure 100 per cent of collection of segregated waste. The strategy to merge the material recovery facility along with the transfer station has been pivotal to save a lot of cost for secondary transportation of waste. Private companies have deployed informal workers at the transfer station to collect the recyclables. The dry waste is segregated in more than 10 categories and the segregated garbage is then sent to the recycling agencies. The process rejects were stored as RDF and sent to appropriate sources for energy recovery. Engagement with the informal sector has helped the city authority to achieve remarkable result in terms of recovery and recycling rate in six material recovery facilities. They are paid according to the quantity and type of recyclables processed which is calculated using a mobile app to ensure absolute transparency in the process of payment.

LESSONS LEARNT

Managing municipal solid waste comes with it own set of challenges. Understanding the local situation and making the approach inclusive is critical. Waste management, by no stretch of imagination could be dealt without having it considered as an economic opportunity thereby creating a business model out of it. The key to success is to reduce expenditure on building infrastructure and operations for waste management and augmenting revenue generation by maximum processing. Bhopal has been able to achieve a very high rate of material processing because

IMPACTS

- Awareness campaigns like *Gobar Se Gamle, E-Waste Clinic, Bartan Bank and Carry your own bottle* gave citizens the confidence to become active partners in solid waste management.
- Bulk waste generators like Resident Welfare Associations (RWAs) and traders' associations have become actively involved in waste management.
- Bhopal has achieved 100 per cent source segregation, which made it possible for it process its waste in the most efficient manner.
- The landfill receives little to no waste now. Legacy waste in Bhanpur dumpsite has been bio-capped successfully, thus reducing health and environmental hazards. Remediation of the dumpsite also garnered appreciation from citizens and helped recruit them to the cause of efficient waste management.
- Informal sector has been successfully integrated in formal waste management systems.

One of Bhopal's Material Recovery Facilities

the city continued to adapt to the situation and continued to learn from its previous experience when the city used to be known for all the wrong reasons. The city banked on the skill and contribution of the informal workforce to generate employment, at the same time utilising their services to the best effect to achieve optimum recycling and recovery efficiency.

REPLICABILITY

The Bhopal model of municipal solid waste management could be termed as a hybrid of appropriate strategy, technology and innovation coupled with a level playing field for the informal waste collectors workforce who has been there for decades. In the process of the reform, the city banked on the ability and contribution of the informal waste prickers and ensured that their potential was utilised even by the private companies brought onboard with a basket of technologies to treat various streams of waste according to its merit.

Bhopal adopted a two-pronged strategy to reduce capital and operational cost of managing solid waste while working rigorously to increase its processing efficiency to earn maximum revenue out of it to make the system a business model. It would be too early to conclude that Bhopal has been able to achieve what it has been striving for but it could be acknowledged that the city certainly made some important moves towards sustainability. Bhopal model therefore is very replicable for cities of its size or otherwise that are prepared to learn and adapt.

ODISHA

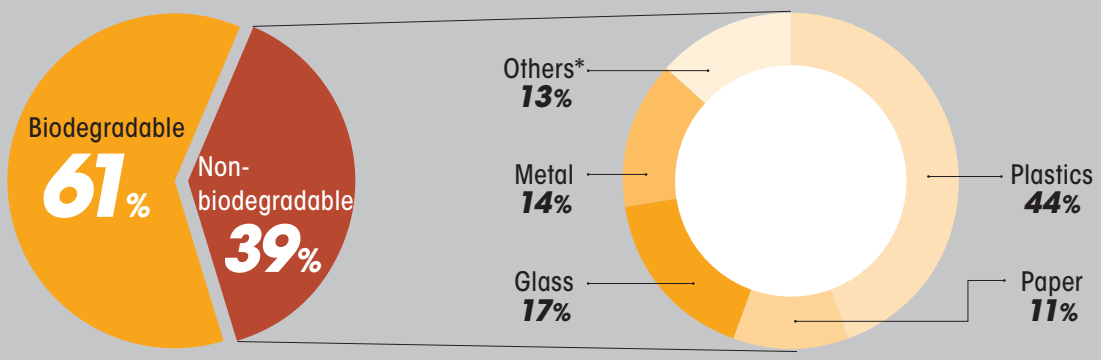
DHENKANAL

With full support from local self-help groups, Dhenkanal Municipal Council has been able to achieve 100 per cent material recovery

Dhenkanal district in Odisha, famous for its fairs and festivals, generates nearly 23 tonne of waste daily (276 g per person per day). Proper management of waste is very important to the district so that it can protect its fragile environment while holding on to its role as a centre for culture and markets. Material recovery has been the answer to a twin set of problems. It has reduced pressure on the dumping ground as smaller quantities of waste is being dumped, while also reducing pressure on the natural resources as most of the waste is being recycled and reused.

Waste composition in Dhenkanal

Total waste **23 TPD**



*Others includes domestic hazarduous waste and sanitary waste

Source: Dhenkanal Municipal Council

Population (as per 2011 Census)
67,414

Estimated current population
83,200

Estimated floating population (daily)
8,000

Area (sq km)
35.5

Number of households (2021)
16,649

Number of wards
23

Number of zones
0

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
23

Number of sanitation workers
225

Number of community bins
0*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
133

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
85

Percentage of waste processed
100

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Dhenkanal Municipal Council

THE TRANSFORMATION

Before Dhenkanal Municipal Council (DMC) took the initiative to streamline solid waste management, things were in a bad shape. Door-to-door collection was carried out in some wards but most areas were serviced only by community bins. Residents did not segregate at source and no guidelines or awareness programmes existed to address that. Even workers involved in solid waste management were not trained to deal with the system. There was a dearth of collection vehicles. Even the limited number of vehicles the council could muster did not collect waste regularly due to lack of monitoring. Consequently, waste would pile up in the streets. Many a time, waste picked up from one part of the town used to be dumped in another. Waste that did manage to reach the dumping site was not dealt with properly. Some of it was burned. Leachate from the dumpsite led to contamination of waterbodies.

In July 2019, Government of Odisha made decentralised waste management mandatory for all 114 urban local bodies in the state. In line with the same principle, the Housing and Urban Development (H&UD) department shared a Standard Operating Procedure (SOP) with all ULBs as a guideline to develop decentralised waste management units.

To start with, DMC arranged a meeting with all local self-help groups (SHGs) and asked them to join the initiative. SHGs which agreed were trained first by DMC officials. Then members of these SHGs, called *Swachh Sathis*, went to each household to explain the benefits of and train residents on source segregation. To effectively transport segregated waste, the municipality procured some battery-operated mechanised partitioned vehicles and also introduced partitions in existing vehicles. These vehicles are driven by trained SHG members. Waste segregation is the first and most important step towards achieving material recovery. Thus, by succeeding in source segregation, DMC could also start focusing on material recovery. Dhenkanal municipality became the first urban local body in Odisha to construct and operate a material recovery facility (MRF).

Waste processing facility at Kathagada

HOW THE SYSTEM WORKS

The entire system is geared towards processing as much waste as possible. DMC does the collection, segregation and recycling. All sanitation workers report to their assigned localities every morning, where biometric attendance is taken. Then, they

Role of *Swachh Sathis*

- *Swachh Sathis* conduct sensitisation programmes for all households in a locality to promote source segregation.
- If residents are not practising source segregation at home, *Swacch Sathis* must demonstrate how to do it while they are collecting garbage.
- *Swachh Sathis* sensitise and give demonstrations to local markets, schools, institutions and parks regarding source segregation.
- *Swacch Sathis* generate awareness regarding various methods of composting, preferably micro-composting, in the locality.
- *Swacch Sathis* assist KMC in undertaking Information, Education and Communication (IEC) activities in the locality.

move in the tagged vehicles for collection of waste. *Swachh Sathis* also move in waste collection vehicles to monitor source segregation.

Segregated waste is then transported to the nearest decentralised facilities. Five micro-compost centres (MCCs) have been constructed by DMC in Alasuahaat, Banamaliprasad, Kathagada, Kunjakant and Mahisapat. Three material recovery facilities have also been set up. Biodegradable waste is transported to MCCs and non-biodegradable waste is transported to MRFs. In MCCs, aerobic composting has been adopted. It is a controlled process involving microbial decomposition of biodegradable waste, converting it into organic manure which is branded as 'Mo Khata'. The purely organic Mo Khata is sold for Rs 20 per kg at outlets throughout the state.

At MRFs, segregated non-biodegradable waste is further segregated into recyclable and non-recyclable fractions manually. The rates for selling various recyclable materials are fixed by the municipality only after assessing the demand in the local market. Non-plastic recyclable materials are generally sold to authorised *kabadiwalas* through formal agreements. Revenue generated from selling these materials is used to manage MRFs and distributed among the members of the SHGs.

Non-recyclable materials are stored inside the facility. DMC has made an agreement with Ecokart Technology Pvt Ltd wherein Ecokart collects 150 tonne of all types of non-recyclable waste on a monthly basis. Ecokart has a formal agreement with Baragarh Cement Plant. It sends the non-recyclable waste there to be used as refuse-derived fuel (RDF).

Non-recyclable plastic waste is also processed to make PVC paver blocks, which are good substitutes for cement concrete paver blocks. In the areas around Dhenkanal, there is a high demand for these blocks to make roads and platforms. These blocks are cost effective and more durable compared to concrete blocks. The facility which makes these paver blocks was constructed by DMC and is operated by Mission Shakti SHG. Paver blocks are sold to local contractors and the revenue generated from selling them is distributed among the SHG members.

Selling price for various recyclable materials

Unit rate (in Rs) per kg

PLASTIC	PAPER	GLASS	METAL	RUBBER	PLASTIC CARRY BAGS
10/-	5/-	3/-	3/-	10/-	6/-

Source: Dhenkanal Municipal Council

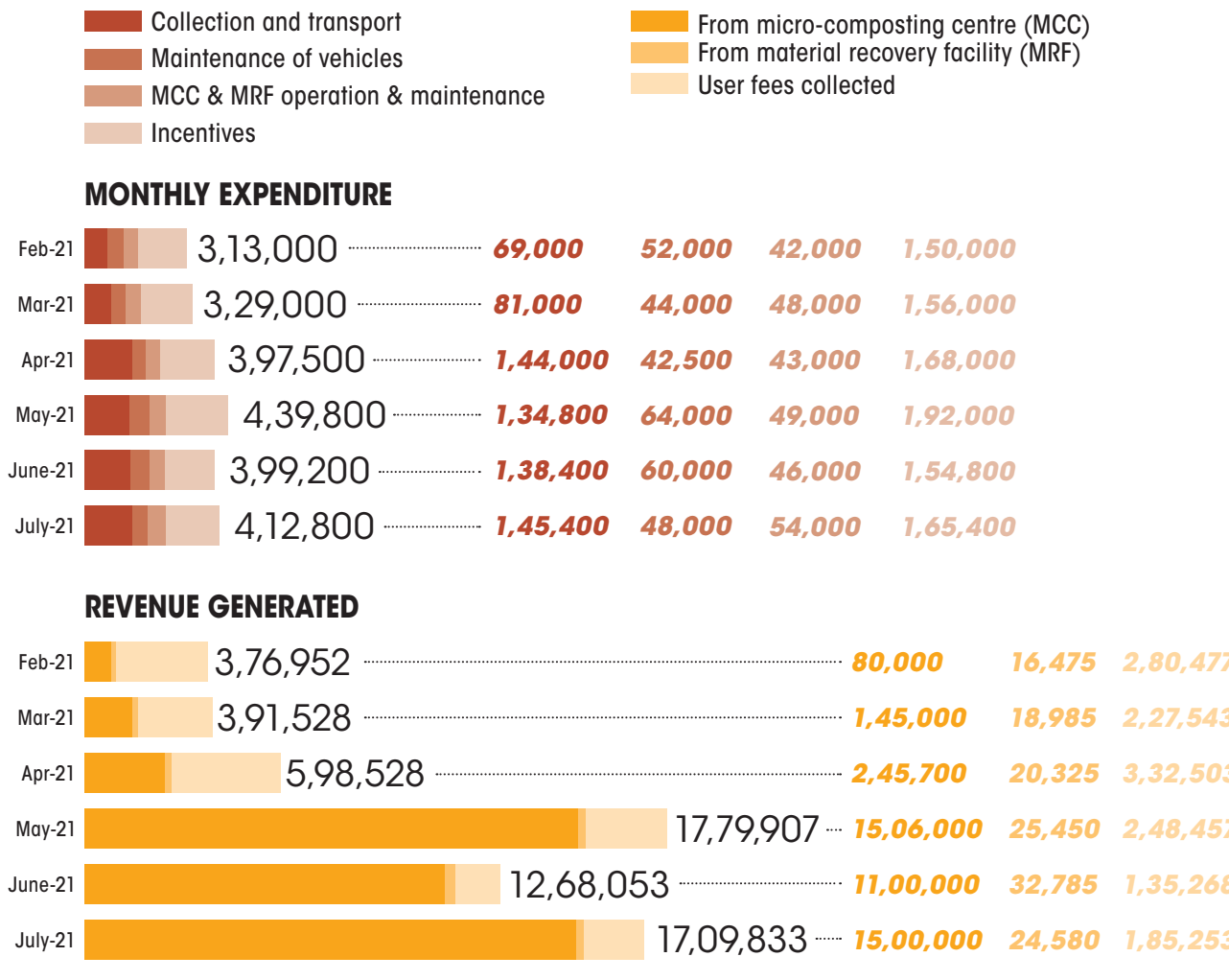
WHAT HAS WORKED

DMC has realised that to change the behaviour of citizens towards source segregation, it is necessary to create awareness among them. Therefore, they have empanelled SHGs to communicate directly with citizens. The involvement of SHGs has been very successful for DMC. Due to a rigorous door-to-door campaign organised by the *Swachh Sathis*, a remarkable change has occurred in the outlook of citizens. Segregation at source has become the norm, which makes the subsequent process that much easier to implement and manage. The overall aesthetic of the city has also improved because littering has almost stopped.

SHG members who were previously earning very low incomes, if they were working at all, are now earning a good amount in the waste management sector.

The money flow sheet

(Figures in Rs)



Source: Dhenkanal Municipal Council

Chambers for secondary segregation of non-biodegradable waste in MRF

Initially, the DMC used to pay these SHG members. Now that the system has become fully functional, revenue generated from MCC and MRF units is sufficient not only to run the units but also to pay all SHG members associated with waste management. Thus, the system has become self-sustaining.

As per instructions received from the H&UD department of the Government of Odisha, female workers must be provided some additional benefits such as safety gears, free health check-ups, education and transportation facilities. Additional incentives have also been provided to those *Swachh Sathis* who work more efficiently than others. Till date, public grievances regarding solid waste management have been reduced by 70 per cent due to the direct involvement of *Swachh Sathis* with the people.

The Banjhakusuma Mahisapat dumpsite, containing approximately 89,000 tonne of legacy waste, has been subject to bio-capping. DMC is paying for the bio-capping. The dumpsite is spread over an area of 2.8 hectare, of which 70 per cent has already been already bio-capped. Once the whole area has been bio-capped, the land shall be utilised for setting up a C&D waste management plant. The municipality has also developed a park named Udyan Kunj on an old dumpsite. The plantation inside the park has been developed using compost produced from the MCCs.

Secondary segregation of non-biodegradable waste

Impacts

- As a result of the decentralised solid waste managment initiative, self-help groups (SHGs) were inducted into the waste management system, which allowed them a chance to be financially independent.
- Due to a rigorous door-to-door awareness campaign, there is huge behavioural change among citizens. Source segregation of waste reached 85 per cent from a mere 10 per cent. The city's aesthetic has drastically changed over time due to littering reducing to almost zero.
- The municipality achieved 100 per cent material processing. All the biodegradable waste generated from the city is treated efficiently in five micro-compost centres while non-biodegradable waste is treated in three material recovery facilities. Since all the waste is processed, no mixed or untreated waste is dumped anywhere.
- The revenue generated from user fees and selling of compost and non-biodegradable waste is higher than the urban local body's expenditure. Not only is the model self-sustaining but profit making as well. The waste processing facilities which were previously known as waste centres are now known as wealth centres.
- The muncipality is bio-capping the existing dumpsite itself, and thus saving a lot of revenue which they might have ended up paying to a concessionaire.

LESSONS LEARNT

Importance of public awareness: The door-to-door awareness campaigns led by SHG members were effective because they were so personal. Residents could clear any doubts they had with members of their own community and understand why such and such a thing was being asked of them. Once they understood the importance of source segregation, they had no problem in following through, as it was being done only to make their environment cleaner and their lives better.

Involvement of the local community: Dhenkanal has been so successful in transforming its waste management practices because it actively involved the local community through SHGs. In the first place, these people already know local conditions very well. Secondly, they are interested in cleaning up their environment over and above any other benefit they might get from the initiative. Thirdly, the money that is made through the programme stays in the community. Lastly, with a sense of ownership over the process and the outcome, sustainability over a long period of time is ensured. Once the model is up and running, no outside interference is required.

Waste as a source of revenue: We have a tendency to see waste as a liability. What models like Dhenkanal show us is that when treated rightly, waste can be a major source of revenue. An entire industry can come up around waste which provides tonnes of green jobs to people from marginalised backgrounds. Further, a successful industry also generates prosperity in the community. Incomes earned through proper management of waste can be used to improve the future of the whole community.

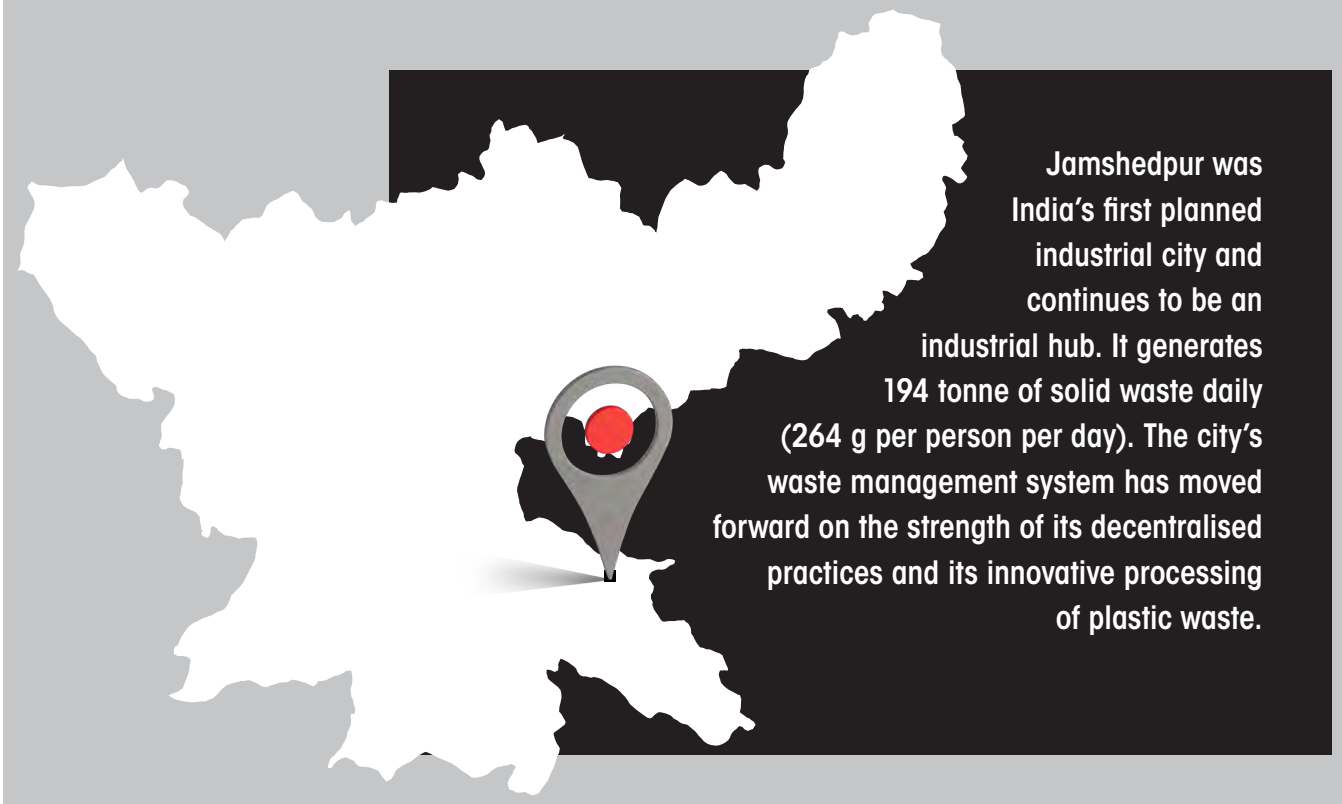
REPLICABILITY

To develop sustainable material processing like Dhenkanal, cities should start with awareness campaigns, source segregation, segregated collection and transportation, decentralised processing, and scientific disposal of inerts and residues. Women and other marginalised sections of society should be involved in the process through SHGs. They are able to manage the solid waste management chain effectively and efficiently because they are locals and thus possess the knowledge and interest to make the project a success. Since they also earn revenue from the process, they have an added incentive to do it in the long run and make the model sustainable. With proper channelisation of the output materials by developing a market, all streams of waste can generate revenue, which means that waste centres throughout the country have the potential to become wealth centres.

JHARKHAND

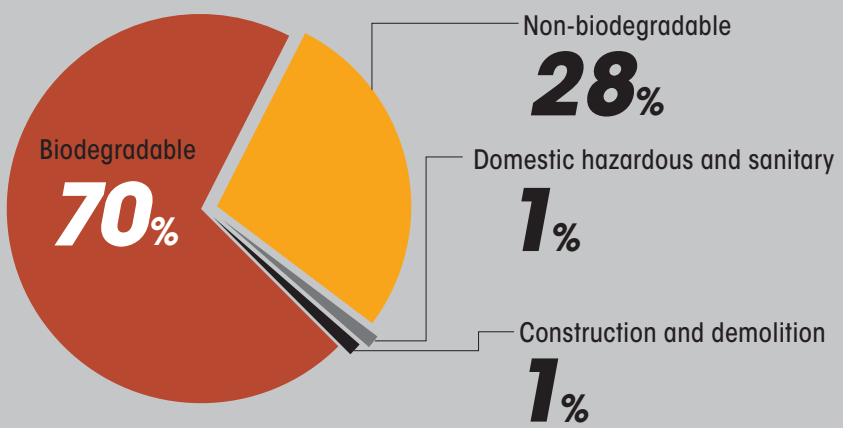
JAMSHEDPUR

Rag pickers and local NGOs power the engine of technology to bring the city's waste management system up to speed



Jamshedpur was India's first planned industrial city and continues to be an industrial hub. It generates 194 tonne of solid waste daily (264 g per person per day). The city's waste management system has moved forward on the strength of its decentralised practices and its innovative processing of plastic waste.

Waste composition in Jamshedpur



Source: Jamshedpur Notified Area Committee

Population (in million, as per 2011 Census)
0.63

Estimated current population (in million)
0.78

Estimated floating population (daily)
10,000

Area (sq km)
64

Number of households (in million, 2021)
0.15

Number of wards
0

Number of zones
17

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
194

Number of sanitation workers
1,400

Number of community bins
0*

Number of garbage vulnerable points
0*

Waste management vehicle fleet size
253

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
95

Percentage of waste processed
100

* According to the Swachh Survekshan ranking (Star Rating for Garbage Free Cities) parameter, zero community bins and zero garbage vulnerable points are strong indicators of an efficient solid waste management system.

Source: Jamshedpur Notified Area Committee

THE TRANSFORMATION

Way back in 1905, Jamsetji Tata envisioned a clean city with "wide streets planted with shady trees, every other of a quick-growing variety" and "plenty of lawns and gardens". But years of massive industrialisation, urbanisation and the ancillary population growth left Jamshedpur's solid waste management system lagging behind.

The city is served by two municipal bodies, Jamshedpur Notified Area Committee (JNAC) and Jamshedpur Utilities and Service Company (JUSCO). It has developed in two ways; one part has been developed in a planned manner by Tata Steel and the government while the other part consists of unauthorised colonies. JUSCO caters to the planned areas and JNAC serves the unplanned and unauthorised colonies.

Before 2016, garbage collection was carried out in around 500 strategically located community bins and *dhalaos*. The authorities deployed more than 15 dumper placers to empty these bins on a regular basis. Bins placed in commercial areas were emptied twice a day, while those placed in residential areas were emptied bi-weekly or thrice a week, depending on the quantity of garbage received. Area supervisors were responsible for coordination with the control and command centre on the need to empty the bins.

Although citizens were supportive of this system, some households would simply throw garbage near the community bins instead of putting it inside them. In order to counter this problem, the city tried using covered bins so that citizens would have to lift their lids when disposing of waste. The city even tried 'Smart Bins' (with infrared sensors), but some people continued to throw unsegregated garbage near the bins. Composting unsegregated waste is next to impossible, so only garbage collected from the vegetable markets was fit to be sent to the city's composting facility.

In 2016, worried about the unsegregated waste being disposed of at the dumping yard, and facing many complaints of fire at the dumpsite, the city began to consider door-to-door collection and source segregation.

Pilot project with Hasiru Dala

In April 2016, Jamshedpur's city administration initiated a pilot project to create a self-sustaining model of door-to-door garbage collection and provide employment to rag pickers, who would be left without a source of income when garbage was not put in community bins. Hasiru Dala, a Bengaluru-based waste management service provider, was engaged to reach out to rag pickers, and convinced them to be part of a pilot project in select areas of Kadma, such as ECC Flats, Farm Area and a portion of the Kadma Market. Around 50 rag pickers were selected and trained on door-to-door collection and ensuring source segregation. They were rebranded as social entrepreneurs and, based on their performance, converted into vendors of waste collection. Seven rag pickers are grouped together as a vendor. Each group is given six *thela* rickshaws and one electric rickshaw and allotted a contract for a particular area.

Rag pickers are paid minimum wages and charged a monthly rent of Rs 550 for each rickshaw. Recyclables are the property of rag pickers. They complete collection by noon, after which they assemble at the Dry Waste Collection Centres. There are four such centres covering the four zones of the city. Non-biodegradable waste is further segregated into plastic, cloth, glass, paper, cardboard, packaging material, metal and rubber. Recyclable portions are sent to recycling agencies through local suppliers and the money earned from their sale is given to the rag pickers.

The pilot project was later extended to other areas and, at present, more than 200 rag pickers have become vendors.

HOW THE SYSTEM WORKS

To ensure segregation at source by households, a two-bins-one-bag system was implemented in Jamshedpur in 2016. Under this system, each household is provided a 10 litre green bin for biodegradable waste, a three–five kg white bag for non-biodegradable waste, and a red bin for domestic hazardous and sanitary waste. At present, all wards in Jamshedpur have daily door-to-door garbage collection with source segregation. The city is served by 120 auto-tippers and 133 *thela* rickshaws. Each *thela* rickshaw is handled by two *safai mitras*. Auto-tippers operate on two models. In some cases, workers collect waste from households, while in other cases, citizens bring garbage to the tippers. These vehicles transport the waste to secondary transfer stations. Three key performance indicators have been identified to evaluate the door-to-door collection system:

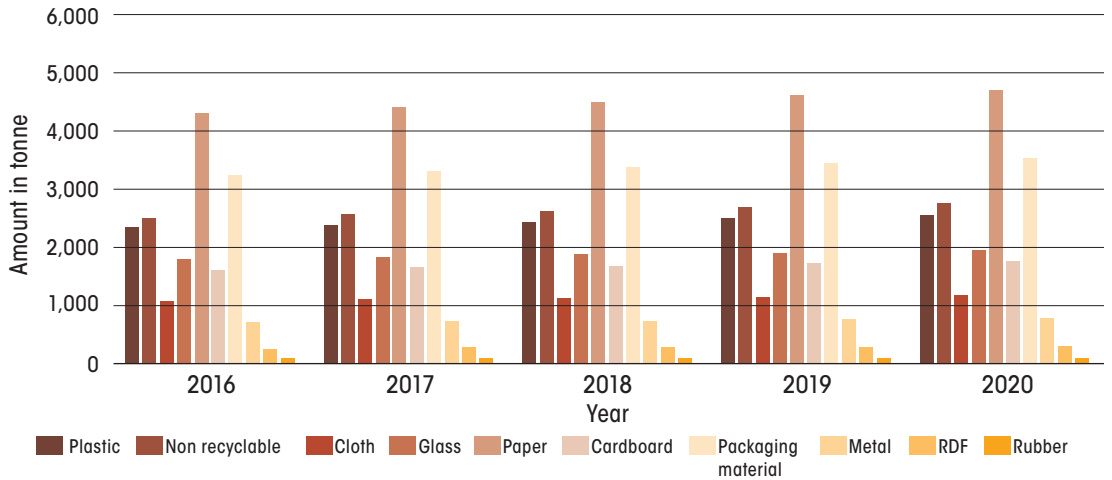
- Removal of garbage vulnerable points.
- Quantum of garbage coming to garbage vulnerable points.
- Biological oxygen demand level of drains (signifying littering).

Jamshedpur has six secondary transfer stations: 1. Uliyan, Kadma. 2. Northern Town, CH Area. 3. WWTP, Bistupur. 4. Tube Club, Nildih. 5. Zone 4, Sastrinagar. 6. Surya Mandir, Sidhgora. Secondary transportation is done in compactors and dumper placers.

The city has three biodegradable waste processing plants to manage its 130 tonne per day of biodegradable waste. Two technologies are used for biodegradable waste processing, windrow composting and vermicomposting. Market and kitchen waste is sent to one of the six decentralised biogas plants, each with a capacity of 100 kg per day.

From the transfer stations, non-biodegradable waste is transported to material recovery facilities, locally known as 'Dry Waste Collection Centres'. There, the waste is further segregated into paper, metal, wood, cloth, non-recyclables and packaging materials.

Composition of non-biodegradable waste sorted at the Dry Waste Collection Centres



Source: Jamshedpur Notified Area Committee

WHAT HAS WORKED IN JAMSHEDPUR

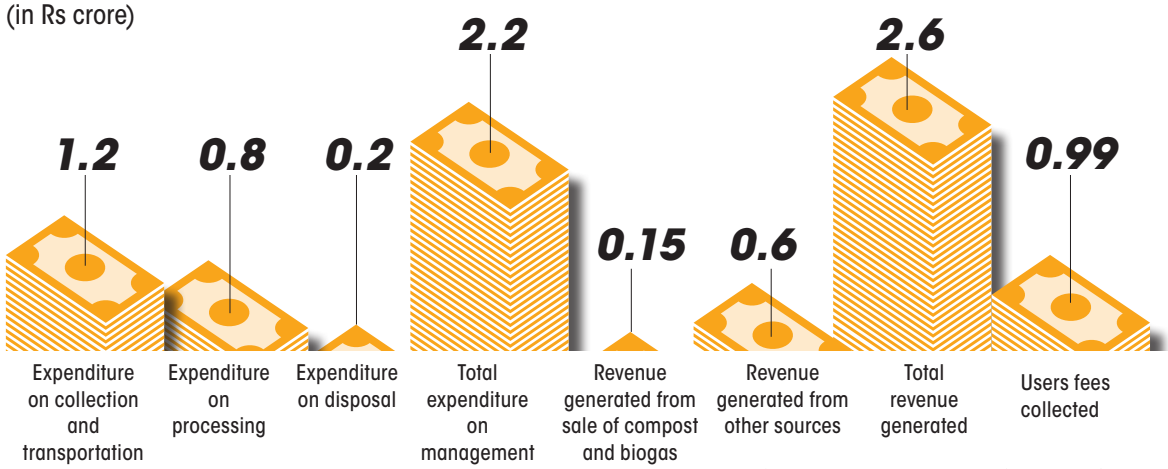
Engagement of rag pickers at the Dry Waste Collection Centres has helped the city manage its non-biodegradable waste optimally, as rag pickers are experts in the field and know exactly which segregates can be sold and which ones can be sent for recycling. The decentralised biodegradable waste processing units complement this system.

IEC activities and a *swachhta* ranking among societies, hotels, offices and schools promote source segregation. Rag pickers are also incentivised to promote source segregation as segregated waste is easier for them to process.

Windrow composting at the city compost plant at Jubilee Park

Jamshedpur's municipal solid waste management budget

(in Rs crore)



Source: Jamshedpur Notified Area Committee

Processing plastic waste: Best practices

Plastic roads: Jamshedpur has constructed more than 20 km of roads using plastic waste. Non-recyclable plastic from the Dry Waste Collection Centres is shredded into 2–4 mm size particles. The shredded plastic is mixed to make a coating for large aggregates used in road construction, providing roads tremendous strength at no extra cost. It is easy to coat road gravel with plastic, and the coated gravel is then mixed with bitumen (tar) to lay roads.

Eco-bricks: The concept of eco-bricks has been popularised in schools and residential societies in Jamshedpur to promote the storage of non-recyclables at the household level. Children are asked to fill polyester bottles with non-recyclable multi-layered plastic (MLP). MLP is tightly packed in the bottles, which have a layer of coloured soil at the bottom. These bricks are used to make attractive walls. This helps promote behavioral changes among children: MLP, that used to be seen as non-valuable garbage, is turned into something of value.

Waste disposer at the crematorium: A waste disposer using plasma technology that requires no additional energy input has been installed at the crematorium. Air is passed through a strong magnetic field and gets ionised. This ionised air burns all the waste. Smoke from the disposer is filtered using bag filters. The bags are cleaned regularly using air pressure controlled by a programmable logic controller. The *shamshaan* ghat has thus become waste-free.

PET bottles filled with multi-layered plastic waste by children, to be converted into eco-bricks

Impacts

- About 1,400 people, including rag pickers, obtain their livelihood from solid waste management in the city.
- The city has been rid of garbage vulnerable points.
- Garbage that used to be destined for the dump yard is now directed to the processing plants.
- The city spends less than other cities in the state on waste management.
- Garbage from the dump yard used to be carried away by the river during floods. This is no longer the case.
- In Swachh Survekshan 2020, Jamshedpur got 7th All-India rank in the 3–10 lakh population category.

Involvement of NGOs like *Swachhta Pukare*, Rotary Club and Lions Club has helped spread the message of better waste management at no extra cost to the city administration. These NGOs also lead initiatives like a river-cleaning drive, using *diyas* (lamps) made from waste on *chhath puja*, and promoting home composting and a no-plastic campaign in marketplaces.

LESSONS LEARNT

Waste management is a dynamic process. What works today might not be enough tomorrow. Urban local bodies need to constantly think on their feet. Over the years, Jamshedpur has tried many innovative techniques, some with more success than others, but the crucial thing is that the city has never stopped innovating.

Integrating the informal sector (rag pickers) in waste management is a win-win situation. It creates employment for these socially and economically marginalised groups, while enriching waste management systems by making use of the valuable knowledge bank of the informal sector.

REPLICABILITY

Engaging rag pickers in door-to-door collection is an idea from which urban local bodies across India can benefit. They have valuable practical knowledge of waste management and cities do not have to spend money on their capacity building and training.

Refuse-derived fuel is not the only solution for low-value plastics. Jamshedpur's example clearly shows that plastic can be put to a wide variety of other uses. The trick is to keep local conditions in mind and not have a panacea-seeking mindset.

Jamshedpur's decentralised waste management and involvement of NGOs in specific programmes and in spreading the good word are also easily adaptable and replicable.

JHARKHAND

JAMSHEDPUR

The city has set a good example of e-waste management

Estimated e-waste generation (in TPD)
0.5

E-waste collected in tonne (in 2019–20 and 2020–21)
200

Centralised e-waste collection centre
1

Decentralised e-waste collection centres
5

Source: Jamshedpur Notified Area Committee

THE TRANSFORMATION

Before 2018, hundreds of local *kabadiwalas* and recyclers in Jamshedpur used to collect e-waste and burn it to obtain valuable metals from it. During the process, they would expose themselves and the environment to toxic fumes and chemicals. As is the case with other cities in India, this was an unsustainable situation.

Fortunately, Jamshedpur is a city amenable to new rules and regulations that improve public amenities. It takes pride in being a trendsetter in this regard. So the city administration decided to take the initiative to deal with e-waste in a better manner. After trying out a number of recyclers, Jamshedpur Utility Service Company (JUSCO) zeroed in on Hulladek Recycling Pvt Ltd, a company dedicated to e-waste management and working as a producer responsibility organisation (PRO). As mandated by the E-waste (Management) Rules, 2016, a PRO is defined as a professional organisation authorised or financed collectively or individually by producers, which can take the responsibility for collection and channelisation of e-waste generated from 'end-of-life' products to ensure environmentally sound management of such e-waste

On June 5, 2019, after getting a go-ahead from the state pollution control board and completing logistical formalities, Hulladek started its full-fledged operation in Jamshedpur at a warehouse allotted by JUSCO.

HOW THE SYSTEM WORKS

Collection and segregation: The staff of the e-waste management centre at Birupa Road collects e-waste in four ways:

1. Monthly door-to-door collection is carried out by two dedicated Hulladek e-rickshaws, each of them accompanied by two staff members for collection and one for raising awareness about safe e-waste practices. Besides, about 80 vehicles

belonging to the city administration also collect e-waste in a segregated form while collecting other wastes. On an average, about 200–250 households are covered daily under door-to-door e-waste collection.

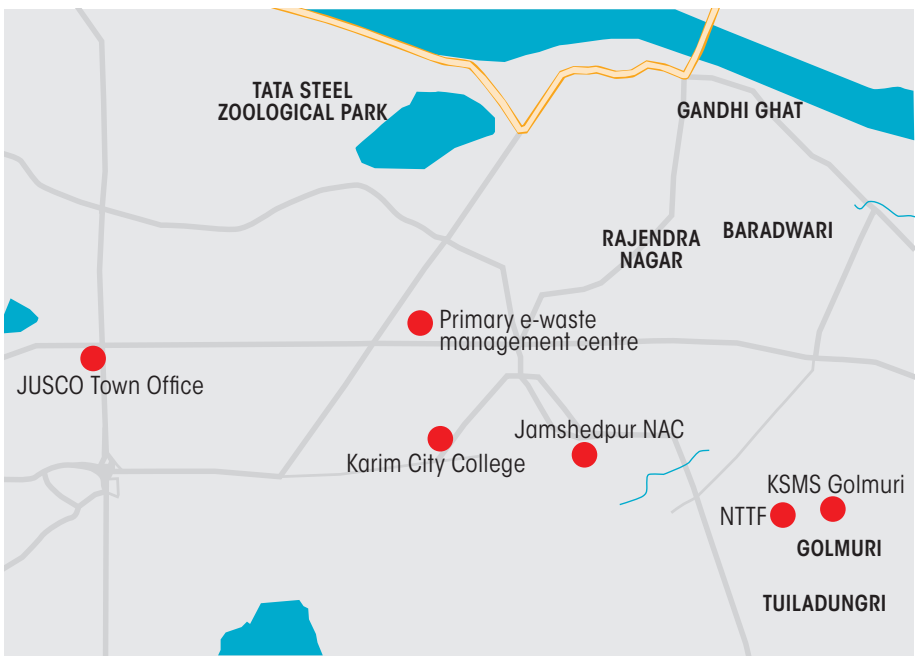
2. During the awareness campaign, many institutes became interested in the cause of managing e-waste better and gave their consent to work as local drop-off points for e-waste, where people associated with the institutes could deposit their e-waste. There are five such e-waste collection centres in Jamshedpur.
3. The largest quantity of e-waste comes from bulk waste generators. About 150 tonne of e-waste has been collected from them.
4. A toll-free number has also been provided, where citizens can reach out to schedule a pick-up of e-waste.

Overall, 230 tonne of e-waste has been collected till date (95.5 tonne in 2021).

Storage and transportation: The e-waste management centre has a capacity of 35 tonne. Once enough waste has accumulated at the centre, it is transported to the Kolkata warehouse of Hulladek, that has a capacity of 160 tonne. In general, the transfer of waste from the Jamshedpur to the Kolkata warehouse takes place once a month. During transportation, adequate precautionary measures are taken to ensure that the e-waste is not damaged.

Processing and disposal: After transportation to the Kolkata warehouse, Hulladek sends the e-waste to six recyclers authorised by the Central Pollution Control Board (CPCB).

The five e-waste drop-off points within institutes in Jamshedpur and the primary e-waste management centre



Source: Jamshedpur notified area committee

Impacts

- Burning of e-waste, which used to release toxic fumes into the atmosphere, has stopped in Jamshedpur.
- Overall, 230 tonne of e-waste has been collected till date (95.5 tonne in 2021).
- More than 20 people have been employed under the initiative.

WHAT HAS WORKED

Although urban local bodies (ULBs) do not have a significant role in management of e-waste, as it is directly monitored by CPCB and state pollution control boards, they come face-to-face with it on a daily basis, as the quantity of e-waste generated in urban areas is higher than that generated in rural areas. The public–private partnership between Jamshedpur Utility Service Company and Hulladek comes at no cost to the ULB, while providing Hulladek a channel to collect e-waste easily. It is a win-win for both of them.

The journey was not an easy one, though. It took a sustained Information, Education and Communication (IEC) programme to raise awareness on e-waste and

Category-wise break up of e-waste collected in Jamshedpur

EEE code	Quantity collected (in tonne)	EEE code	Quantity collected (in tonne)
ITEW1	0	ITEW12	0.1
ITEW2	41.54	ITEW13	0
ITEW3	1.15	ITEW14	0
ITEW4	0	ITEW15 (smart phones)	0.83
ITEW5	0.15	ITEW15 (feature phones)	1.71
ITEW6	0.1	ITEW16	0
ITEW7	35.1	CEEW1	14.58
ITEW8	0	CEEW2	0
ITEW9	0	CEEW3	0.17
ITEW10	0	CEEW4	0
ITEW11	0	CEEW5	0
Total e-waste collected			95.4

Note: For e-waste collected in 2021

Source: JUSCO

E-waste stored at the city e-waste management centre

the dangers of its improper disposal. Easily accessible e-waste drop-off centres also help citizen to dispose of e-waste smoothly.

LESSONS LEARNT

Understanding the target audience: Information, Education and Communication activities are most effective when channelised towards a carefully selected target audience. The campaign of awareness on e-waste in Jamshedpur has focused on institutions like schools, industrial units, chamber of commerce, etc. to good effect.

A thoughtful private-public model can be a harbinger of positive change. Jamshedpur Utility Service Company's tie-up with Hulladek has been beneficial to both the entities and ensures that the city's e-waste is collected and recycled in a smooth and efficient manner.

REPLICABILITY

Involvement of producer responsibility organisations in the management of e-waste is an easily replicable practice as it comes at zero cost to urban local bodies while ensuring adherence to the E-waste (Management) Rules of 2016.

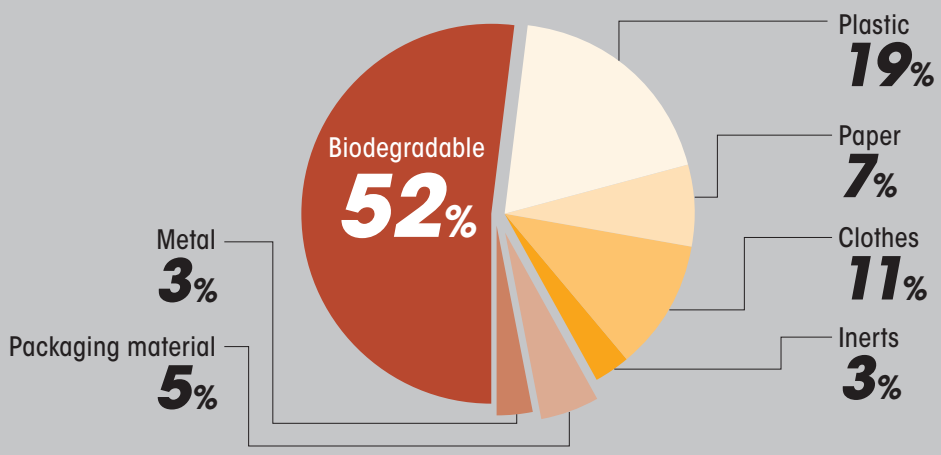
GUJARAT

SURAT

The awareness campaign Surat-Khubsurat spurred the city's citizens to transform Surat into the second-cleanest city in India

Known as the Silk City and the Diamond City, Surat has emerged as the nerve centre of economic activity in Gujarat. It is a hub of both small- and large-scale industrial activities. Surat has one of the oldest municipal governments in the country, established in 1852. In 1964, due to increase in population, Surat Municipality became Surat Municipal Corporation (SMC). It is governed by the Bombay Provincial Municipal Act 1949, which has been amended from time to time.

Composition of waste in Surat



Source: Surat Municipal Corporation

Population (in million, as per 2011 Census)
4.46

Estimated current population (in million)
5.73

Estimated floating population (in million, daily)
0.15

Area (sq. km)
461.60

Number of households (in million, 2021)
1.43

Number of wards
30

Number of zones
8

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
1,838

Number of sanitation workers
10,000

Number of community bins
0*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
683

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
100

Percentage of waste processed
100

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Surat Municipal Corporation

THE TRANSFORMATION

Surat doubled in size between 1981 and 1991. The rapid population growth caused several management problems for Surat Municipal Corporation, which is responsible for provision and maintenance of the entire range of civic infrastructure services in the city (including sanitation and drainage facilities, and solid waste collection and disposal). Waste was disposed of in drains and waterbodies. A 1995 study reported that the efficiency of waste collection in Surat was only 40 per cent.

This lack of basic services and infrastructure led to a plague outbreak in 1994, which claimed several lives. The major cause was considered to be ineffective waste management, which led to the blockage of storm-water drains resulting in flooding of the fringe areas of the city.

The governance of the city changed significantly after the outbreak. Regular sweeping of streets and garbage collection has become a hallmark of Surat Municipal Corporation. A centralised and then a decentralised process of waste collection and disposal were implemented within six months of the outbreak. Public health and hygiene were foremost in the agenda of the political wing and, together with the support of the citizens, excellent results were achieved.

The demolition and cleanliness drives of the Corporation officials are still remembered for their pro-people actions. Separate wards, zones and districts were decided on to make cleaning of all areas efficient and effective.

Surat has achieved 100 per cent door-to-door garbage collection as well as source segregation. In fact, the city also has a mechanism in place for segregating domestic hazardous and plastic waste. All of the city's waste is treated efficiently in decentralised or centralised waste processing plants. Surat was ranked the second cleanest city in India by Swachh Survekshan 2020. It has also received a 5-star garbage-free city tag for its extraordinary management of solid waste. The corporation has been able to successfully remediate 25 lakh tonne of legacy waste at the Khajod dumpsite through bio-capping.

Bio-capped Khajod dumpsite

HOW THE SYSTEM WORKS

The awareness campaign Surat-Khubsurat roused in citizens a sense of belonging to their city. The initiative brought significant behavioural change among the public. They launched several initiatives to promote cleanliness and hygiene in their day-to-day lives.

Solid waste in Surat can be broadly divided into eight major categories on the basis of source of generation: domestic waste, biomedical waste, commercial waste, hotel waste, construction waste, textile waste, dead animal and industrial waste. As part of decentralised solid waste management, Surat is divided into eight zones and 89 sanitary wards.

Primary collection and transportation

Surat is renowned for its food, and a large number of hotels and restaurants operate in the city. Waste generated by these hotels and restaurants is collected from 5 p.m. to 11 p.m. on a daily basis. A large numbers of vendors outside the vegetable and meat markets in the city also dispose of their waste in the underground bins, from where it is taken to the bio-methanation plant. Waste generated from hospitals and private dispensaries are handled separately by a private agency, which runs a biomedical waste treatment and disposal facility on public-private partnership mode.

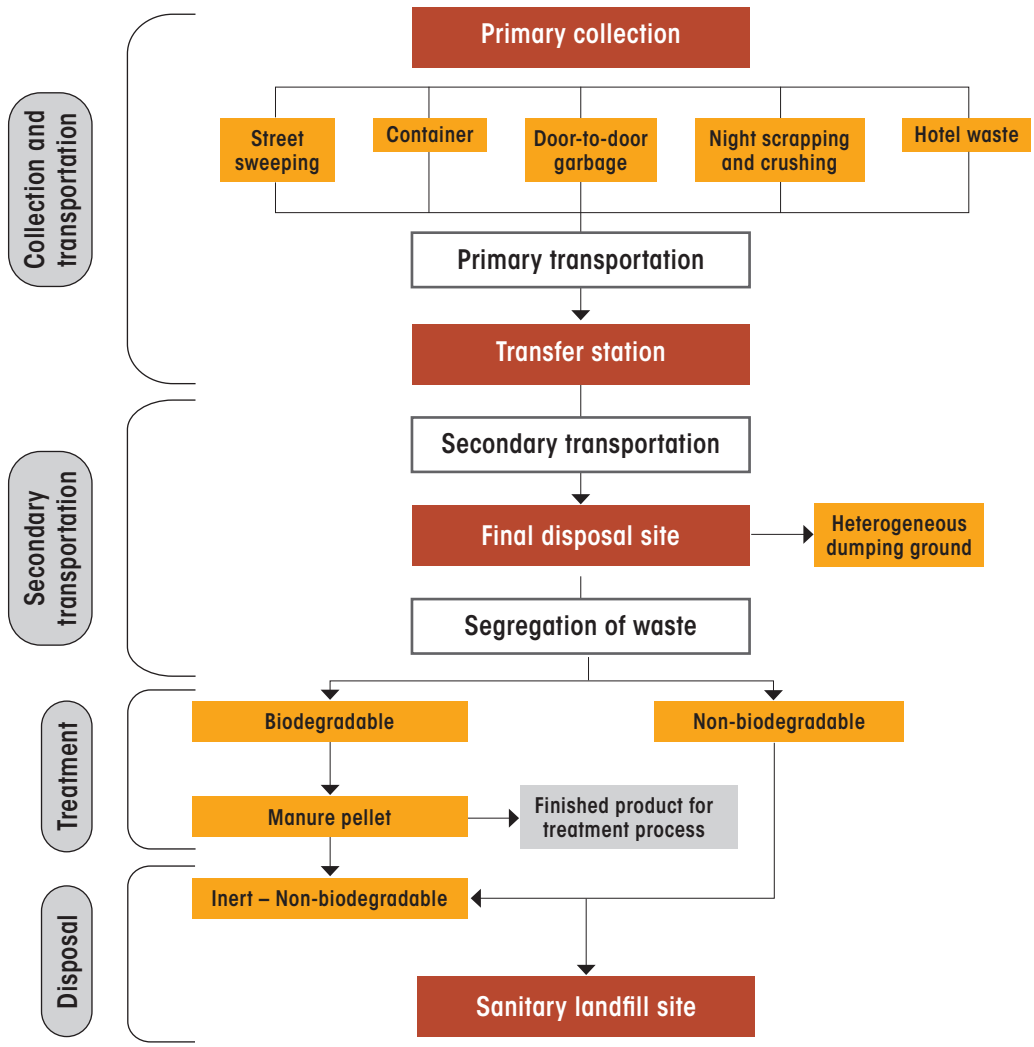
The city is served by 551 vehicles that collect garbage daily. SMC has installed tracking systems in all its vehicles. It has a well-structured administrative line to look after the door-to-door garbage collection service. One vehicle has two *safaimitras* along with one driver. *Safaimitras* ensure that people give segregated garbage. Garbage is collected in three different bins: Green for biodegradable,

blue for non-biodegradable and red for sanitary waste. Special Vehicles are deployed to collect e-waste and valuable plastic waste separately. Segregated valuable plastic waste is collected from households and streets with the help of NGOs and rag-pickers. Non-segregated plastic waste collected by door-to-door vehicles is transported to eight secondary transfer stations for further segregation in a material recovery facility.

Secondary transportation

Municipal solid waste collected through primary collection system is brought to secondary transfer stations. From there, biodegradable waste is transported to a centralised composting plant at Khajod in covered leak-proof containers to prevent any spillage of garbage on roads. Non-biodegradable waste is segregated in mechanised MRF facilities at secondary transfer stations.

The journey of waste in Surat city



Modernisation of refuse transfer station

All eight transfer stations are operational. All the primary collecting vehicles with waste collected from door to door and from sweeping reach the transfer station from where secondary transportation vehicles are loaded to transfer waste to the disposal site. Solid waste received through closed vehicles is dropped off without secondary handling to closed containers. There is no storage of solid waste, permanent or temporary, at the transfer station. As it is directly transferred to containers, without secondary handling, there is no nuisance of flies. Entry of animals is restricted. A separate leachate collecting system is provided.

The money flow

Around Rs 11.295 crore per annum is the expenditure on collection and transportation of municipal solid waste, and Rs 3.29 crore is spent on processing municipal solid waste. Total expenditure on management of municipal solid waste is Rs 14.585 crore. Total user fee collected is Rs 2.18 crore; Rs 2.60 crore is collected through other sources such as spot fines, enforcement activities and corporate social responsibility (CSR) funds.

Revenue and expenditure details of solid waste management in Surat

Parameter	Cost (in Rs lakh)
Expenditure on MSW collection and transportation	1,129.5
Expenditure on MSW processing	329
Expenditure on MSW disposal	–
Total expenditure on MSW management	**1,458.5**
User fee collected	**545.19**
Revenue generated from selling of compost and biogas	218
Revenue generated from selling of recyclables and refuse-derived fuel	6.9
Revenue generated on any other sources from municipal solid waste	260
Total revenue generated	**1,030.09**

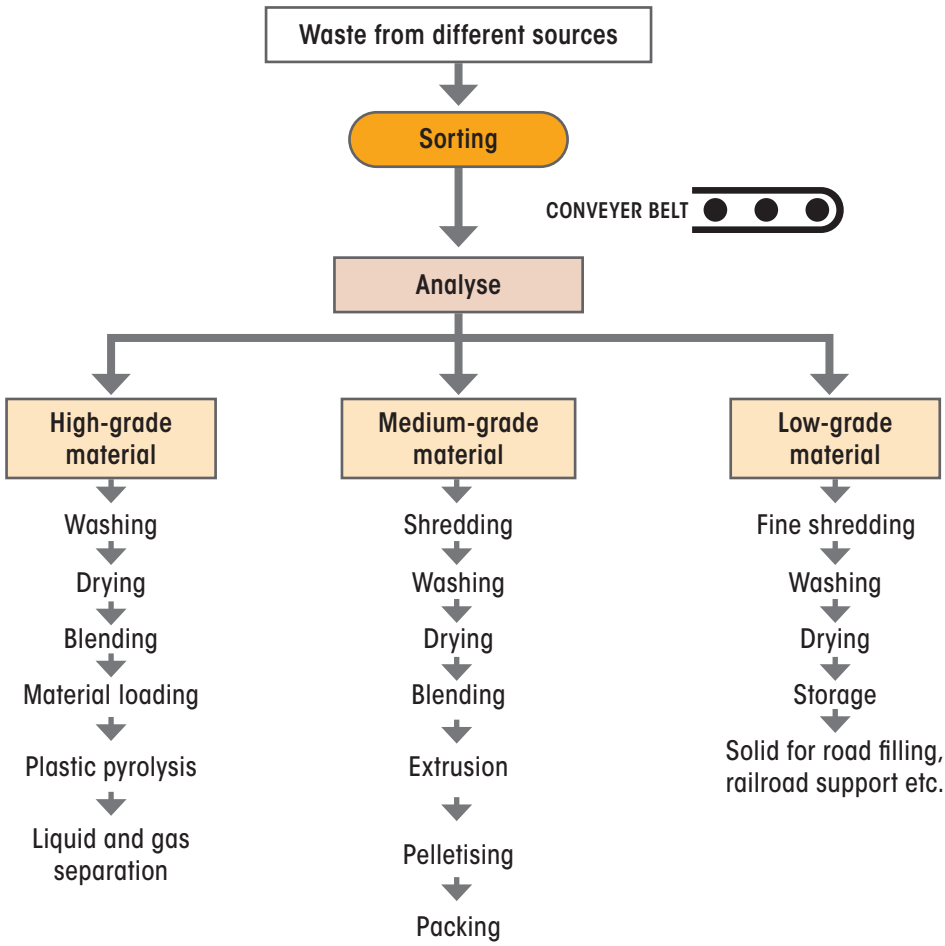
Source: Surat Municipal Corporation

WHAT HAS WORKED

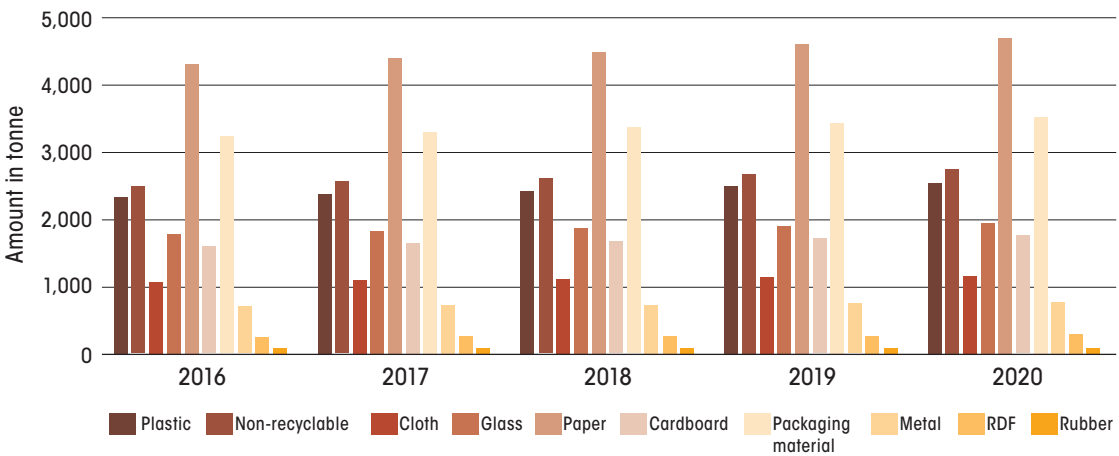
Surat Municipal Corporation has designated eight locations for collection of plastic waste. So far 28,000 tonne of plastic waste have been processed at the facility. The processing plant currently has a processing capacity of 75 TPD and has the scope to increase the capacity up to 200 TPD.

Plastic waste is transported to the plastic waste management facility at Bhatar by 15 dedicated vehicles. Segregated valuable plastic waste is collected from households and streets with the help of NGOs, ragpickers, plastic collection centres etc. Non-segregated plastic waste collected by door-to-door vehicles is transported to eight secondary transfer stations for further segregation in a material recovery facility. Recovered plastic from this facility is send to a centralised plastic-waste-processing

Steps for processing of non-biodegradable waste



Non-biodegradable waste collected and processed (2016–20)



Source: Surat Municipal Corporation

facility at Bhatar. Non-recyclable plastic that is mixed with other waste and is difficult to segregate at the material recovery facility is sent to the final disposal site, where it is converted in to refuse-derived fuel.

A ban on the use of plastic sheets and bags less than permissible thickness is ensured. Until October 31, 2020 penalties worth Rs 3.16 crore were collected and 216.57 tonne of plastic was seized.

Surat Municipal Corporation has started utilising plastic waste for construction of roads. Approximately 21.96 km of road was constructed with plastic waste material in 2020. Twenty tonne of pellets are produced daily

Impacts

Social: Surat residents have become more aware about management and disposal of waste.

Environmental: A huge amount of mixed or plastic waste that could have been hazardous to the land or ocean has now been treated and recycled, and a potential hazard to the environment remediated.

Economic: Waste is treated as an asset that brings economic benefit. A large part of waste goes towards refuse-derived fuel but the part that is recycled is converted to money.

Success was achieved with the vigorous cleanliness drive through regular garbage collection and sweeping of roads and other public areas by the municipal corporation. But this successful turnaround could not have been achieved without the support and cooperation of the people. Surat has thus become a model city and the working of its municipality is an example for other municipal corporations to implement in their respective cities.

A replica of a monster made of plastic picked from Dumas Beach to create awareness about the massive amounts of plastic generated

Anudan Scheme: This scheme prioritised community-level participation in solid waste management. To maintain cleanliness, payments at the rate of 60 paise and 65 paise per sq. m respectively are made to residential and non-residential societies. The minimum amount payable to societies is Rs 1,200 per month. Societies are required to arrange for sweepers and sanitary equipment on their own while the Corporation pays for consumable items such as insecticides. Surat Municipal Corporation makes payments to societies based on production of a completion certificate, duly signed by the president of the society on a monthly basis. Societies are required to make an agreement with Surat Municipal Corporation to provide regular waste management services in their designated areas. More than 600 societies benefit under this scheme.

from waste plastic and used as raw material for various plastic products such as chairs, bench and tiles. Private operators manufacture plastic PET bottles, which are used in the textile industry in the weaving process.

The amount of waste received at the landfill site has reduced since 2017. Reuse of recycled pellets in various materials ensures that the use of virgin plastic reduces.

The business model is based on principles of self-sustainability. Surat Municipal Corporation does not pay a tipping fee to the agency, and the agency does not pay a royalty to SMC. Sumul Dairy has tied up under extended producer responsibility (EPR) for collection of plastic bags used for milk packaging; 1.5 lakh milk bags are collected and processed daily. The agency ties up with ragpickers and NGOs to lift street-level plastic. A total of 89 ward offices of Surat Municipal Corporation have squad teams for monitoring the ban of plastic in their area.

About 15,000 people are indirectly employed from the informal sectors to transform waste material into usable products. This creates the opportunity of regular assured income and sustainable livelihood.

Surat Municipal Corporation disposes of categories of waste apart from plastic – which is recycled in-house – reasonably too. Non-recyclables and cloth (approximately 4,077 tonne per year) are sent to refuse-derived fuel (RDF) stations. Paper and cardboard (approximately 6,727 tonnes per year) are sold to paper mills near Baroda weekly. Glass, metal and rubber (approximately 2,955 tonne per year) are sold to recyclers near Ahmedabad every month.

REPLICABILITY

Surat Municipal Corporation's success story can be replicated by way of effective transfer of knowledge and experience through various tools of communication.

The facility initiated by Surat Municipal Corporation within the framework of the MSW Rules 2016 can serve as a role model for other cities of similar size. It can be adopted with some modifications to make it sustainable.

The biggest advantage of this model is that the local body is not required to make any investment except for payment of the monthly bill raised by the contractor. The contract is awarded for seven years taking into consideration the useful life of vehicles deployed by the agencies.

4 PLASTIC WASTE MANAGEMENT

Over the last few decades, plastics have become an integral part of our lives because they are cheap, lightweight, durable and versatile. Unfortunately, these properties have also turned the wonder substance into a major waste management challenge. Plastic is choking our water systems and landfills and its proper management is essential to protect our environment from irreversible degradation. Reducing the use of plastic through fines, bans and awareness programmes is as important as efficiently recycling the plastic that is used. Plastic that cannot be recycled can be turned into refuse-derived fuel to be used in cement kilns.

Bicholim: Focussed on managing non-biodegradable waste and continuing to act proactively to reduce the impact of plastics on the environment and human health.

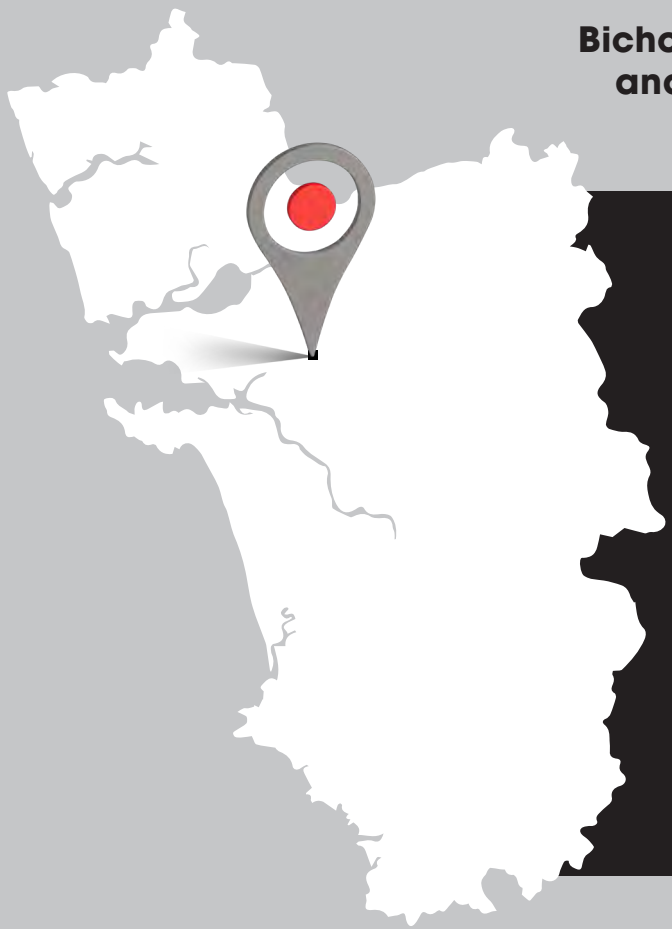
Gangtok: Has adopted a strategy of banning to minimise the environmental and health hazard of plastic waste pollution.

Kumbakonam: Quickly followed a state-wide ban on use of plastics in 2019 by setting up a resource recovery facility where non-recyclable plastic is converted to refuse-derived fuel and channelised to cement factories for co-processing.

GOA

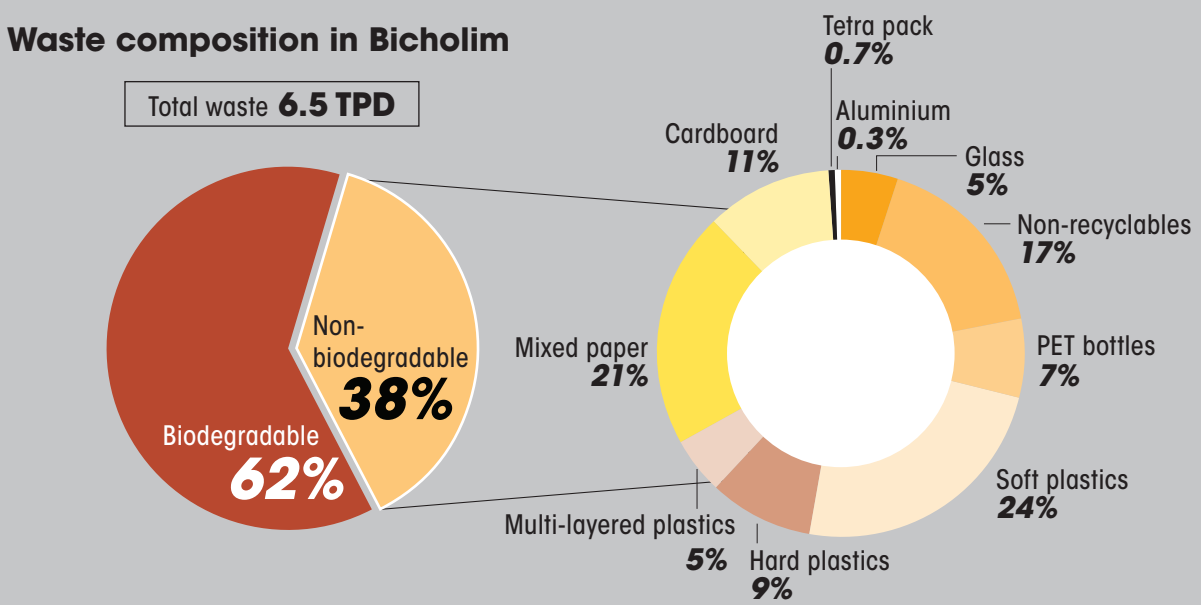
BICHOLIM

Bicholim optimises source segregation and material recovery to manage its plastic waste



Bicholim, also known as Divchal or Dicholi, is a semi-urban town located in the North Goa district, Goa. It generates about 6.5 tonne of waste daily (348 g per person per day). What sets Bicholim apart from other similar towns and cities of the country is the efficiency with which Bicholim Municipal Corporation (BMC) is ensuring material recovery from segregated waste. Bicholim shows us that the the best way to manage plastic waste is to optimise the entire waste management chain.

Waste composition in Bicholim



Source: Goa Waste Management Corporation and Bicholim Municipal Corporation

Population (as per 2011 Census)
16,986

Estimated current population
18,700

Estimated floating population (daily)
1,000

Area (sq km)
14.47

Number of households (2021)
4,376

Number of wards
14

Number of zones
2

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
6.5

Number of sanitation workers
43

Number of community bins
0*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
10

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
95

Percentage of waste processed
100

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Bicholim Municipal Corporation

THE TRANSFORMATION

Bicholim Municipal Corporation (BMC) used to collect unsegregated waste, which was brought to the dumpsite at Lakherem. After maturing, the treated waste would be fed into a mechanical sorting machine to separate inert material from compost. But this method was inefficient, and the non-biodegradable component inevitably contained some biodegradable residue, which meant that it could not be processed and had to be dumped at the site. Due to this practice, Goa Waste Management Corporation (GWMC) dump became over 3,000 m^3 in size.

The first positive steps were taken as early as 2005 when the BMC started door-to-door waste collection. But it was only after the Monitoring cum Working committee (McWc) was formed by the Government of Goa (in 2011) to aid urban local bodies (ULBs) and other local bodies with technical guidance that BMC started paying attention to segregation of waste at source.

In 2015, the non-biodegradable waste components started being baled in machines, to be disposed of at cement factories for co-processing, with assistance of McWc. But not much non-biodegradable waste could be recovered since the BMC had not yet achieved proper waste segregation at the source.

From 2016, when the Solid Waste Management Rules came into force, the BMC started actively addressing this issue by conducting awareness camps about the necessity of segregation. BMC began sorting non-biodegradable waste into various categories to enhance sustainable plastic and other non-biodegradable waste management practices. Finally, in January 2019, the BMC ventured into a Memorandum of Understanding (MoU) with the GWMC for five years to set up a material recovery facility (MRF) at the existing dumpsite. BMC has allotted part of its land free-of-cost for operating this MRF for sorting and managing plastic waste. It is after this final step that Bicholim has been able to recycle or process all of its non-biodegradable waste, including plastic, and achieve 100 per cent material recovery, which means that pressure on the dumpsite has been reduced, resulting in health and environmental benefits to the city.

HOW THE SYSTEM WORKS

Within its jurisdiction, BMC collects non-biodegradable waste in designated collection vehicles, while the GWMC collects non-biodegradable waste from neighbouring panchayats, institutions and bulk waste generators. Both BMC and GWMC bring waste to the MRF for sorting into 13 categories, including four different kinds of plastic.

The MRF is operated by Sampurn(e)arth Environment Solutions and United Nations Development Programme (UNDP), under the supervision and with the support of BMC and GWMC.

Infrastructure and machinery at the MRF

- Sorting platform with a conveyor belt
- Forklift
- Two baling machines

Proposed machinery

- Aglo-mixture lump making machine
- Shredders for plastic and glass
- High air blower machines

Material recovery facility at Bicholim

Waste management process in Bicholim

1. Collection of segregated waste at source

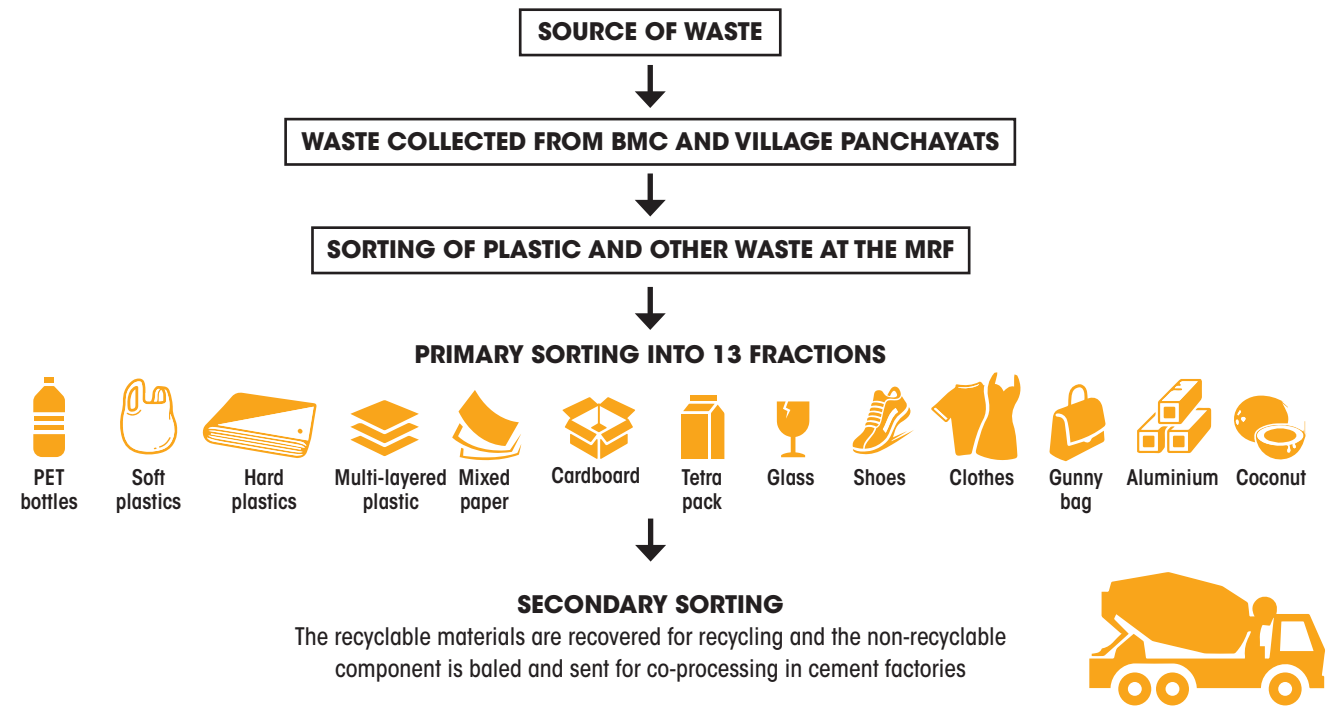
2. Non-biodegradable waste collection vehicle

3. Primary sorting at the conveyor belt

4. Secondary sorting of waste

5. Baling machine at the site

6. Baled waste



Non-biodegradable waste brought to the facility is first segregated on a moving conveyor belt. The waste is further segregated into recyclables and non-recyclables. The recyclable components, including plastic, is sold to vendors registered with the state Pollution Control Board. The non-recyclable component is baled and sent for co-processing as refuse-derived fuel (RDF) to authorised cement factories.

Fines

The BMC has also started imposing fines on users and vendors found using plastic bags of size less than 50 microns. This initiative commenced in September 2020. Fines are collected on a monthly basis. Raids are carried out by the municipal inspector randomly. The inspector issues *challans* to the violators and the fine amount is collected in cash. The revenue collected is used for solid waste management. BMC aims to completely phase out single-use plastics. The city government is also planning to implement new norms to increase the minimum thickness of plastic bags to 120 microns as envisaged in the 2021 plastic waste management rule notification.

WHAT HAS WORKED

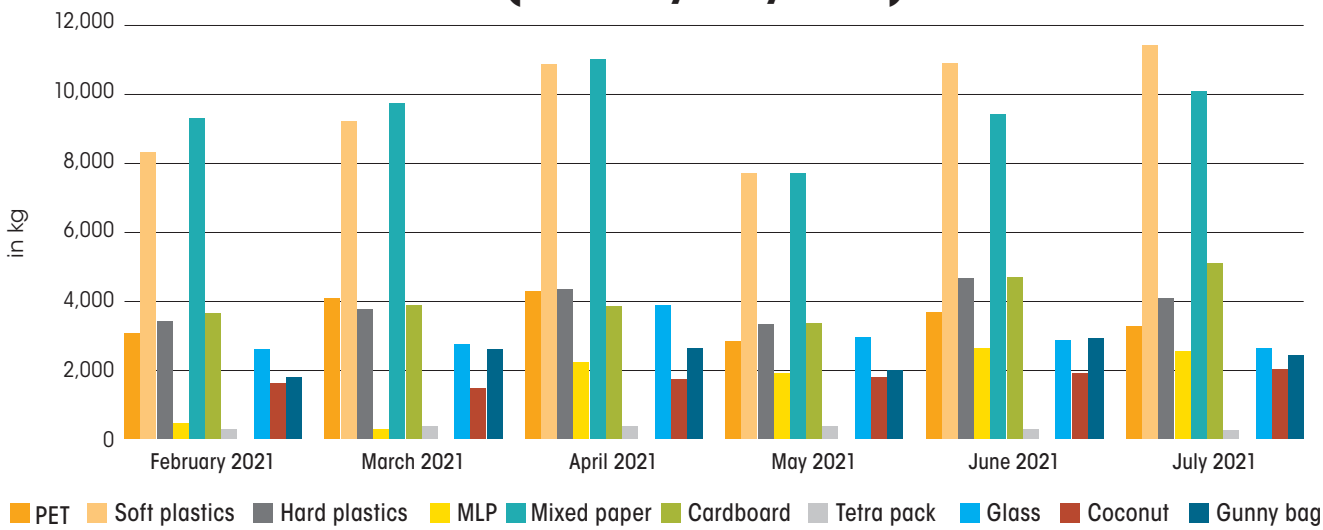
BMC has mainly focused on managing non-biodegradable waste (with an emphasis on segregation at source) and continues to act proactively to reduce the impact of plastics and other non-biodegradable waste on the environment and on human health.

Since the MRF is entirely operated by Sampurn(e)arth Environment Solutions, there are no financial implications for the BMC. Apart from the transportation cost of the non-biodegradable waste to the MRF, BMC does not have any financial liabilities.

Most of the material recovered from the MRF is sent for recycling or scientific disposal. Sampurn(e)arth Environment Solutions generates enough revenue to pay staff salaries (most of the staff is local) and meet other expenses incurred at the facility.

One of the key features of this model is that the BMC, contrary to the concept of 'not in my backyard', accepts non-biodegradable waste from neighbouring local bodies. Due to this, it has effectively treated non-biodegradable waste generated in the entire Bicholim

Quantum of waste sorted (February–July 2021)



Source: GWMC

Impacts

- Bicholim Municipal Corporation is one of the few urban local bodies that has managed 100 per cent material recovery by recycling or processing all of its plastic waste.
- The contamination of recyclable fractions has been reduced.
- The need for a new landfill has been eliminated.
- Negligible amount of non-biodegradable waste is sent to landfills.
- Many women are engaged at the material recovery facility, thereby contributing to the objective of women's empowerment through employment generation.

Taluka. This means that plastic waste is not an environmental threat in Bicholim any longer.

LESSONS LEARNT

- **Waste can create value:** Plastic waste management can be valuable to the community. In Bicholim, Sampurn(e)arth has made the project economically viable by increasing revenue generation with improved collection, segregation and disposal, and by prioritising valuable items when recycling waste. Since the staff is mostly local, their salaries are plied back into the local economy as well.
- **Generation of livelihood:** Many scrap vendors and others in the informal sector get an opportunity to be associated with the urban local body in terms of trading. Many direct job opportunities can also be created by setting up waste management facilities which hire locals.
- **Outsourcing can help:** The MRF is operated by Sampurn(e)arth Environment Solutions and UNDP. Through this outsourcing arrangement, BMC saves both time and money as it does not have to concern itself with processing and recovering waste.
- **Plastic waste management:** The best way to deal with plastic is to optimise segregation of waste. The more fractions plastic is sorted into, the better the results are from a waste management perspective.

REPLICABILITY

Plastic waste is a common problem across India. In this context, Bicholim stands out for the effectiveness with which it has dealt with its plastic waste. Some salient features of Bicholim's waste management system are segregation of waste into multiple fractions and outsourcing of its material recovery facility. The model used by Bicholim is so replicable that GWMC has already successfully adopted it in 191 village panchayats across Goa. It is the need of the hour for other cities, towns and villages to learn from Bicholim in order to improve their own plastic waste management systems.

SIKKIM

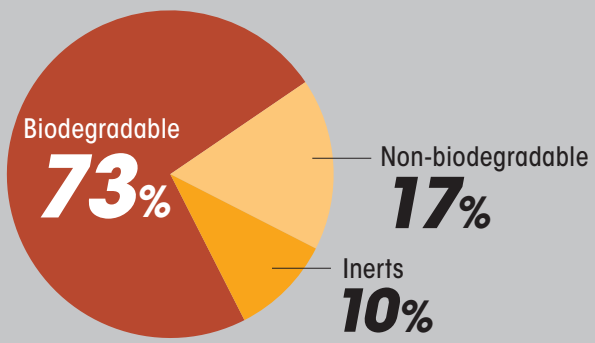
GANGTOK

Gangtok has managed to eliminate the menace of single-use plastic by involving the community through awareness programmes

Gangtok, which means 'top of the hill', is the main centre of Sikkim's tourism industry. The city generates nearly 50 tonne of waste per day (192 g per person per day). Despite being visited by lakhs of tourists every year, Gangtok has managed to become a plastic-free city due to the active role played by the Government of Sikkim and the Gangtok Municipal Corporation (GMC). They have imposed fines on offenders and conducted awareness programmes across all segments of the society to make sure the plastic ban is implemented and that it sticks.

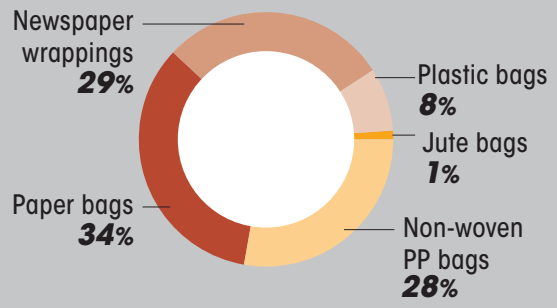
Waste composition in Gangtok

Total waste **50 TPD**



Source: Gangtok Municipal Corporation

Types of carry bags used in Gangtok



Source: Gangtok Municipal Corporation; Study conducted by Toxics links (2014)

Population (in million, as per 2011 Census)
0.10

Estimated current population (in million)
0.26

Estimated floating population (daily)
2,400

Area (sq km)
19.05

Number of households (2021)
22,255

Number of wards
19

Number of zones
0

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
50

Number of sanitation workers
226

Number of community bins
0*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
30

Percentage of households covered under door-to-door waste collection
90

Percentage of households segregating waste
80

Percentage of waste processed
63

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Gangtok Municipal Corporation

THE TRANSFORMATION

Increasing population, urbanisation and tourism led to increased waste generation in Gangtok but this waste was not properly managed. This led to garbage accumulation in water bodies, open drains, open areas and roadsides. The problems were only exacerbated in the early 1980s when the use of plastic bags became popular. By the mid-1980s, plastic bags were used for everything. During the 1990s, blockages in drains due to accumulation of plastic waste caused landslides in the city.

Gangtok is a hilly area with paucity of land for landfills and other waste management facilities. Therefore, an alternate strategy had to be adopted to minimise the environmental and health hazards of plastic waste pollution in the city. Sikkim had already become the first Indian state to ban disposable plastic bags in June 1998. In 2016, Gangtok went a step further and banned the use of packaged drinking water in government offices and at government events, and thermocol plates and cutlery.

The ban was effective because Gangtok Municipal Corporation (GMC) followed it up with awareness and enforcement activities on the ground. Awareness programmes were held in schools and colleges, and with resident welfare associations (RWAs) and market associations. Taxi drivers were trained to make tourists aware of the need to eschew the use of plastic, and bin bags were provided with vehicles to reduce littering. Sanitation staff was trained in dustbin distribution and source segregation by the GMC. Residents were able to understand the negative impact of plastic waste on their city. They readily contributed to curbing the use of plastic.

HOW THE SYSTEM WORKS

Gangtok engages nearly 226 sanitary workers for solid waste management and 30 vehicles for waste collection and transportation. As the city has very narrow internal roads and some houses are not directly connected to streets because of the hilly terrain, door-to-door collection is done by 120 sanitary workers with the help of push carts.

Segregated waste is collected in 15 out of the 19 wards. Waste collected from residential and commercial establishments and street sweeping is accumulated at 38 intermediate collection points. Currently, 80 per

cent of the waste is segregated at source into two fractions – biodegradable and non-biodegradable. Transportation of waste from intermediate collection points is done in 20 dumper placers and three compactors. The city is in the process of redesigning its garbage collection vehicles to optimise the benefits of source segregation. Vehicles will have separate compartments to transport different fractions of waste.

Gangtok has installed a waste processing plant of 50 TPD capacity at Martam, situated about 20 kilometers from Gangtok. Waste is segregated on the tipping floor. Trommels are used for screening of waste, and segregated waste is transported through conveyor belts and stored separately. Nearly 28 TPD of biodegradable waste is converted into compost which is sold to tea gardens at Rs 7-8 per kg. About 3.4 TPD of recyclable waste is recovered manually and sent to recyclers for various gainful applications. Inerts are disposed of in the dumpsite. The city is in the process of installing a material recovery facility to increase its ability to recover more recyclable fractions.

Fines

Around 1,500 offenders have been penalised under the state plastic ban in the last few years. Total fine collected is about Rs 5 lakh.

- Individual households violating the plastic ban are fined Rs 500
- Commercial establishments violating the plastic ban are fined Rs 2,000–5,000

WHAT HAS WORKED

GMC imposed a ban on single-use plastic very early on. It backed up the ban with fines and awareness programmes on the ground which made people understand the importance of participating in pollution reduction programmes in their city. GMC took the lead by banning packaged drinking water and thermocol plates and cutlery in government offices and at government events, thus setting a good example for citizens to follow. The city received adequate support from the government to create necessary waste management infrastructure (even such simple things as providing bin bags to taxis) to reduce pollution.

By selling recyclables and collecting user fees, GMC is generating a revenue of Rs 52.75 lakh per month. Further, the economic and environmental cost of managing the landfill has considerably decreased as significantly lesser waste is ending up in the landfill.

The findings of a survey conducted by an NGO, Toxic Links, in 2014 revealed that non-woven polypropylene (PP) bags have largely replaced traditional plastic carry bags in Gangtok. This material was increasingly used by restaurants, bakeries, clothing and hardware shops, and branded establishments as well as leading apparel brands.

Similarly, brown paper bags and newspapers were being used to a large extent by grocery stores, fruit and vegetable vendors, sweets shops, and chemists. Hotels and restaurants were also using aluminium packaging for take-away dishes, branded shops were using either paper bags and paper cartons or PP bags, and, in some cases, biodegradable bags. Fast food joints and restaurants have been multiplying in the state due to the boom in tourism. These joints and restaurants were found to be using non-biodegradable plates made of thermocol or metallised paper for serving drinks and food. Some used machine-manufactured leaf plates and bowls with an inner plastic lining.

LESSONS LEARNT

Thirty-two states and Union territories in India have some kind of ban on disposable plastic bags in effect, but it is ignored by residents and citizens because enforcement is not up to the mark and needs to be strengthened. The plastic ban worked in Gangtok because of a few reasons:

Active involvement of citizens: GMC took the task of creating awareness on the ground very seriously and engaged citizens through active participation. From workshops in schools to campaigns to enrol taxi drivers, GMC did all that was necessary to make the citizens of Gangtok understand the problem and care about solving it.

Setting an example: The government showed its commitment to tackle the problem by imposing bans on itself. It did not just go preaching to the citizens but went to them as a committed change-maker itself. Seeing the government make sacrifices for the sake of the city, citizens were naturally inspired to do their part.

Clarity and focus: Gangtok focused single-mindedly on reducing single-use plastic in order to deal with the present and clear danger of landslides. The municipality was clear about what it wanted to do and went about doing it instead of getting distracted.

Impacts

- Gangtok has almost rid itself of single-use plastic.
- The city has been able to replace plastic bags with paper or cloth bags and even with leaves.
- Most shoppers come to the vegetable market with cloth bags for their purchases, and shops use paper bags or leaves for packaging.
- These initiatives have resulted in huge savings in processing and disposal cost of waste and also reduced the amount of land needed to dispose of waste.

REPLICABILITY

Numerous environmental and health hazards are associated with plastic pollution. They increase manifold if the region is eco-sensitive. Other hilly states like Uttarakhand, Himachal Pradesh and states in the Brahmaputra basin (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura) may learn from Sikkim and ban single-use plastic to minimise plastic pollution. Sikkim was the first state to ban single-use plastic, but the city authorities made the ban effective by continuous ground-level efforts. By involving students, residents, shopkeepers, taxi drivers, tourist guides, and tourist authorities, the city successfully eliminated single-use plastics.

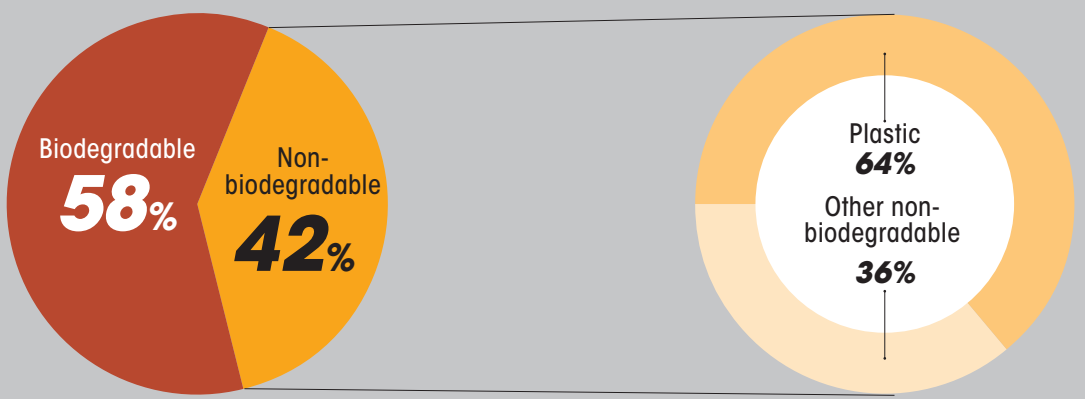
TAMIL NADU

KUMBAKONAM

The temple town converts non-recyclable portion of plastic waste into refuse-derived fuel for cement factories and recycles the rest

Kumbakonam is a special grade municipality situated in the Thanjavur district of Tamil Nadu. The temple town generates 72 tonne of waste every day (511 g per person per day). It has set an example for tier-2 cities of India by effectively managing both its legacy plastic waste (recovered from the Karikulam dumpsite) and new plastic waste, produced mostly by its thriving food industry (that caters to the high influx of tourists).

Waste composition in Kumbakonam



Source: Kumbakonam Municipality

Population (in million,as per 2011 Census)
0.14

Estimated current population (in million)
0.14

Estimated floating population (daily)
25,000

Area (sq km)
12.58

Number of households (2021)
36,105

Number of wards
45

Number of zones
12

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
72

Number of sanitation workers
390

Number of community bins
4*

Number of garbage vulnerable points
17*

Waste management vehicle fleet size
18

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
65-70

Percentage of waste processed
60

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage vulnerable points are strong indicators of an efficient solid waste management system.

Source: Kumbakonam Municipality

THE TRANSFORMATION

Kumbakonam is a tourism hub and host to mega-religious events such as *Magamagam* and *Masimagam*. It receives a daily floating population of 25,000, which has led to the development of a flourishing catering industry in the city. Food waste was a major problem in the town, and the 167 dustbins set up to collect it used to overflow frequently, attracting all manner of pests and scavengers. In plastics, the city's food outlets had found a cheap and convenient packaging material. This created a major problem of non-recyclable plastic waste. Moreover, purchasing temple ware from Kumbakonam is considered auspicious by tourists and is the reason for the city's booming copper and temple architecture industries. Waste copper was a worry too.

Stormwater drains in Kumbakonam used to be blocked by a wide variety of plastic waste – straws, thermocol and covers – and led to inundation during rains. Unsegregated waste at the city's landfill at Karikulam rose twenty feet above the ground, spreading over 7.5 acres of the 10.5 acres of the dumpsite area. Biodegradable and plastic waste from restaurants and metal waste from the copper industry occupied a major part of the landfill, with small quantities of e-waste, garden waste and used clothes also thrown in.

In 2015, when the city administration removed dustbins from the city to promote door-to-door collection, people began to resort to dumping waste on street corners. The biggest problem remained the ever-increasing quantity of plastic waste, mostly of the non-recyclable variety (16 TPD), but also a sizeable quantity of recyclable plastic (2 TPD). Since it was mixed with other wastes, there were no takers for it.

In the same year, inspired by the success story of a zero waste ward in the Coimbatore municipality, a team of Kumbakonam Municipality's health department conceived 'Project Sarvam'. Segregation at source had already been mandated. It was also recognised as the most important step to create a plastic-waste free city. So volunteers from Exnora (a non-governmental environmental service organisation), officials of the Kumbakonam Municipality and the city's waste warriors worked as a team to promote the practice under the project. Eleven animators and two supervisors were hired under the Swachh Bharat Mission to sensitise citizens about the

necessity of source segregation of waste. The interlink between a clean city and flourishing business was reiterated among citizens.

Volunteers would draw *kolams* (floor drawings with cultural and religious significance made from coloured flour) at garbage vulnerable points to stop people from dumping waste. City councillors roped in local sponsors from well-off families to finance the practice of awarding households that segregate waste a gold coin every year. At the neighbourhood level, volunteers play a key role by educating children in government schools, and priests and street vendors outside temples; and communicating regularly with citizens through WhatsApp groups on best waste management practices. About 10,000 women working with self-help groups and children have been taught better waste management. Back-to-back awareness campaigns were also run in six wards. In time, reluctance among citizens to segregate waste faded away.

Simultaneously, Kumbakonam Municipality roped in Zigma Global Environ Solutions Pvt Ltd to reclaim the dumpsite (see Box: *A sorry site no more*). A resource recovery facility was set up on the land recovered at the dumpsite.

COVID-19 has brought these endeavours to a grinding halt, with source segregation stagnating at 65–70 per cent, but the municipality plans to pick up things from where it left them once the situation improves.

A sorry site no more

Zigma Global Environ Solutions Pvt Ltd won the tender to reclaim the Karikulam dumpsite on the strength of their proposal of biomining. A mobile municipal solid waste plant was used to segregate legacy waste into 14 different aggregates. Recovered non-biodegradable waste was sent to cement and agarbatti factories, and recyclers. Zigma Solutions bore the transport charges, even paying the factories Rs 500 per tonne to process the waste. At the cement factories, shredded plastic was converted into refuse-derived fuel.

Zigma Solutions has also trained a local contractor, Madurai Meenakshi Solid Waste Clearing Agency, to continue the journey of responsible waste disposal. The waste clearing agency has teamed up with Kumbakonam Municipality on a contract basis to process and recycle waste.

Waste in the dumpyard
131,250 m^3

Area yet to be restored or still occupied by legacy waste
2.5 acre

Total area of the dumpyard
10.5 acre

Area occupied by unsegregated waste
7.5 acre

Area restored through biomining
5 acre

Waste processed and restored through biomining
100,000 m^3

Source: Kumbakonam Municipality

HOW THE SYSTEM WORKS

Once segregation fell in place, the municipality tapped into the backyard space available with most households to set up micro-composting centres to process biodegradable waste, largely food waste, even bearing the cost of digging the compost pits. Larger onsite composting centres were set up in parks and markets, and at bus stops, etc. The funds for these centres are provided by the state Municipal Administration and Water Supply department.

In order to achieve the goal of garbage-free streets, Kumbakonam Municipality mandated a fine ranging between Rs 10 and Rs 1,000 on littering. However, due to political pressure, the fine was later withdrawn. In its place, the municipality deploys workers at garbage vulnerable points, to educate people on, and dissuade them from, littering.

Architecturally, a space of at least five feet is left between houses in Kumbakonam for ventilation and to accommodate sewage channels. But these spaces had been turned into garbage dumping sites. In order to clean them up, the municipality zeroed in on donors to contribute to the novel initiative of planting saplings. Citizens began to keep these spaces spotless to reap the benefits of fruit- or vegetable-giving plants.

In 2016, a biomethanation plant was set up at the cost of Rs 5 lakh, paid for by bulk waste generators, while the land was provided by the municipality. The plant employs 20 workers and has a capacity to process 10 tonne of food and garden waste daily. The municipality has entrusted the responsibility of food waste collection on hotel associations, who are bulk waste generators. Kumbakonam Municipality processes 40–42 tonne of biodegradable waste per day through five micro-composting centres and 34 onsite composting centres (producing compost) and the biomethanation plant (producing biogas).

Domestic hazardous waste (e.g., tubelights), with no reusable value, is sent to factories to be destroyed. Vehicle tyres and water bottles are sent to traders in Kumbakonam and Chennai for reuse. Garden waste (e.g., coconut shells) is sent to a factory in Erode that uses it to make mosquito repellents.

Kumbakonam waste management initiatives
A timeline

2014 — Door-to-door waste collection

2015 — Segregation at source (two-way segregation)*

Reclamation of dumpsite started

2017 — Year of notification of solid waste management bye-laws

2018 — 65–70 per cent source segregation achieved

2019 — Ban on plastic following the state government's order

Setting up of resource recovery facility

Refuse-derived fuel plastic to cement factories**

2019 — Completion of dumpsite reclamation

* Kumbakonam Municipality has introduced two-way segregation – with green and red bins. Citizens were asked to give medical and sanitary waste separately in plastic bags, but the initiative was short-lived.

** Plastic for this purpose is not segregated at source but at the resource recovery facility.

Source: Kumbakonam Municipality

WHAT HAS WORKED IN KUMBAKONAM

In its endeavour to become a bin-free and garbage-free town, Kumbakonam has not resorted to any shortcuts, focusing on a holistic model of waste management instead.

Decentralised waste management and source segregation have yielded good results for this heritage town. Students, resident welfare associations, self-help groups and other important stakeholders have been made an integral part of the transformation. The town's IEC programme on waste management has also had a positive impact. Drawing *kolams* to educate citizens on better waste management practices is an excellent idea. Rewarding good practitioners with gold coins has been helpful too.

The municipality has integrated authorised waste pickers into the management system, thus addressing the shortfall in the number of sanitary workers. While micro-composting centres have struggled to take root, as they attract flies and mosquitoes, onsite composting centres and the lone biomethanation plant processing the waste of the city's 58 bulk generators (contributing nearly 10–20 per cent of the waste) have been a success.

The biggest triumph of Kumbakonam's waste management system has been its processing of non-recyclable plastic, from the city as well as the dumpsite. Use of plastic as a refuse-derived fuel also reduces the need for pet coke in cement factories.

Managing plastic waste

Kumbakonam Municipality has tried many creative ways to reuse plastic waste. In 2015, the municipality began to sell shredded plastic waste to contractors at the rate of Rs 15 per kg. The aggregate mix and bitumen are heated together to make road material. About 16 km of new roads have been created through this process, adhering to the Union government order of 2015 that plastic be used in making roads.

The municipality was also looking for a solid, long-term solution to manage its plastic waste. Once the land under the dumpsite at Karikulam had been recovered, a resource recovery facility was constructed on it.

Kumbakonam now sends its plastic waste to Dalmia and Ultratech cement factories. The municipality bears the transportation charges as the aim is to get rid of the plastic waste and not make money from it. Non-recyclable plastic waste is used as refuse-derived fuel, replacing some of the pet coke used in these factories. Pet coke and refuse-derived fuel are used in an 80:20 ratio.

Currently, there are no takers for reusable plastics such as thin-sheet covers on water bottles. Earlier, the municipality used to sell them to a recycling company in Erode, providing monetary benefits to sanitary workers as a collection incentive. But for the past one year, recyclable waste is accumulating as the Erode company has paused its business.

A year ago, Kumbakonam Municipality also performed an incineration trial run for plastic waste, but the state Municipal Administration and Water Supply department and the Tamil Nadu Pollution Control Board did not give permission to operate incinerators.

Impacts

- Kumbakonam is one of the few towns in the state utilising non-recyclable plastic in an eco-friendly manner as refuse-derived fuel in cement factories.
- Kumbakonam is also one of the very few towns utilising other non-biodegradable waste materials such as coconut shells and liquor bottles in a productive way.
- Kumbakonam Municipality bagged the third prize in Swachhata Excellence Award, 2019 for including self-help groups in its waste management mission.
- It is the first municipality in Tamil Nadu to have successfully used biomining technology for reclaiming a dumpsite.
- At its peak, segregation in the city stood at 80 per cent — a notch higher than most other municipalities in Tamil Nadu.
- Across the country, 11 projects similar to the Kumbakonam plastic waste processing model have been completed till now.

LESSONS LEARNT

Waste is a resource, not a burden: It would be easy for a small town with limited resources to view a dumpsite that contained biodegradable waste mixed with plastic and other types of waste as a financial and logistic burden to clear. But, by signing agreements with nearby cement factories, the municipality has been able to utilise plastic waste recovered through biomining as fuel. Recyclable fraction is recycled.

Decentralised biodegradable waste management makes a lot of sense: Kumbakonam's decentralised food and garden waste processing is yet to achieve the desired benefits more so in the case of onsite composting centres than in the case of micro-composting centres. Biodegradable waste is generally bulky and its transportation a costly affair. Decentralised processing can generate manure that can be utilised locally. However, the town also has a biomethanation plant, **showcasing the benefits of centralised processing of biodegradable waste.** A combination of the two methods suited to local conditions might be an optimum solution for most urban centres.

REPLICABILITY

Kumbakonam's case proves that processing single-use plastic is a technically feasible solution for a city with proper segregation of waste. However, proximity of co-processing facilities (like cement factories) is an essential factor for end-use of refuse-derived fuel, as the cost of transportation is a factor. According to Central Public Health and Environmental Engineering Organisation guidelines, the transportation cost of refuse-derived fuel should be borne by cement factories using them, but only if they are within a certain distance. Kumbakonam has found a viable market for reuse of recyclable plastic. While the financial returns are not sufficient at present, the municipality considers it a profitable deal in terms of the environmental advantages of recycling or processing plastic.

Kumbakonam's model of biomining its dumpsite has already been adopted by many urban local bodies in Tamil Nadu and nationally, a testament to its replicability.

5 CONSTRUCTION AND DEMOLITION (C&D) WASTE MANAGEMENT

India generates an estimated 150 million tonne of C&D waste every year – a mere 1 per cent of this waste is recycled. C&D waste can be used for new constructions, thereby reducing our dependence on virgin raw material, the production of which is in itself polluting.

Gurugram: Has a processing plant with 1,500 TPD capacity – nearly 12 lakh tonne of C&D waste has been collected so far and nearly 3.5 lakh tonne has been processed.

North Delhi: A C&D processing plant at Burari scientifically processes 2,000 TPD of mixed C&D waste and converts it into useable aggregates.

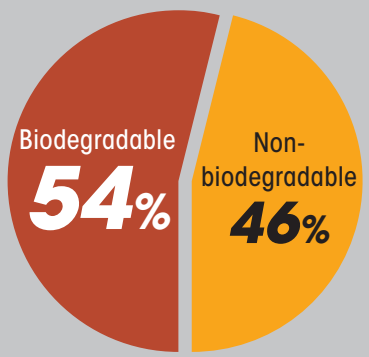
HARYANA

GURUGRAM

The Millennium City has made significant progress in managing its swelling C&D waste

Gurugram, a rapidly expanding urban agglomeration just south of Delhi, has more than doubled its population within the last decade. This has set the city on a rapid path of infrastructure development and redevelopment, creating massive quantities of construction and demolition (C&D) waste. The city has made excellent progress in primary collection, on-call removal, grievance redress and creation of a penal mechanism for non-compliance vis-à-vis C&D waste. After a few hiccups, the processing of C&D waste is also in full flow.

Waste composition in Gurugram



C&D waste statistics

Quantity of C&D waste generated ***1,200*** TPD	Quantity of C&D waste processed ***1,200*** TPD (everyday waste) ***+ 300*** TPD (legacy C&D waste)
Number of vehicles deployed for C&D waste management ***127***	Number of intermediate storage points ***5***
Manpower deployed ***>300***	Percentage of C&D waste getting processed ***100***

Source: Municipal Corporation Gurugram

Population (in million, as per 2011 Census)
0.88

Estimated current population (in million)
1.9

Estimated floating population (in million, daily)
0.1

Area (sq km)
314

Number of households (in million, 2021)
0.42

Number of wards
35

Number of zones
4

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
1,068

Number of sanitation workers
1,310

Number of community bins
0*

Number of garbage vulnerable points
0*

Waste management vehicle fleet size
1,242

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
100

Percentage of waste processed
54

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Municipal Corporation Gurugram

THE TRANSFORMATION

Gurugram is a leading financial and industrial centre situated in the National Capital Region (NCR) of India. The city has experienced exponential growth in the last three decades or so. The pace of its growth can be judged from the fact that between 2011 and 2021, the city's population has risen from 8.8 lakh to 18.9 lakh. Such rapid growth has made the city ravenous for new infrastructure. To feed this voracious appetite, new constructions rise from the city's landscapes like vegetation in an overgrowing forest and old ones are brought down at an alarming frequency. This has created a massive challenge of managing construction and demolition (C&D) waste.

As per a study conducted by Technology Information, Forecasting and Assessment Council (TIFAC), the quantum of waste generated during construction is of the order of 35 kg per m^2 of construction activity, while during demolition the waste generated is about 350 kg per m^2 of demolition activity. It is estimated that the areas governed by the Municipal Corporation Gurugram (MCG) alone generate approximately 1,200 tonne per day (TPD) of C&D waste. In addition, the areas governed by the Haryana Urban Development Authority (HUDA) also generate a substantial quantity of C&D waste.

C&D waste is bulky but inert. Substantial portions of it can be recovered. Typically, demolition activities are undertaken by specialised contractors who bring their own equipment and personnel, and transport the residual waste. The property owners pay a fee to the demolition contractors, based on the recoverable value of recycled materials – steel, wood, glass, pipes, etc. Ideally, the rest of the materials are disposed of scientifically.

In Gurugram, private contractors used to transport C&D waste to privately owned, low-lying land for a price or, more commonly, dump it in an unauthorised manner along roads and other public land, even in isolated areas of the Aravallis (seen Map: *Construction and demolition waste generation and dumping hotspots in Gurugram*).

To streamline and regularise the entire system of management of C&D waste, MCG released a tender for setting up a 300 TPD capacity C&D waste processing facility. The project envisages appropriate collection and transportation mechanism for C&D

Construction and demolition waste generation and dumping hotspots in Gurugram

Source: Municipal Corporation Gurugram

waste, and its processing and disposal at designated sites identified by MCG on agreed terms.

IL&FS Environmental Infrastructure and Services Limited (IEISL), a subsidiary of Infrastructure Leasing and Financial Services (IL&FS), presented a successful bid to develop the project on a build-operate-transfer (BOT) model. In 2016, a 20 year agreement was signed between MCG and IEISL. A four acre plot was allotted to IEISL in 2017, and the plant became functional by December 2019, with a capacity of 300 TPD (and a design capacity of 1,800 TPD). Gradually, the processing capacity has been increased to match the generation and currently stands at 1,200 TPD and can be increased further after careful assessment of generation.

HOW THE SYSTEM WORKS

C&D waste management system in Gurugram is divided into two stages:

1. Primary collection
2. Secondary collection

Primary collection

Primary collection of C&D waste was not a part of the agreement between IEISL and MCG. In February 2019, to strengthen primary collection, MCG appointed a concessionaire, Pragati AL Natural Resources Pvt Ltd (Pragati in short) for collection and transportation to designated collection centres, management of these collection centres, assessment of the waste, maintaining a database, and operating an internet-of-things (IOT)-based customer interface solution.

A compulsory assessment estimating waste generated at a C&D waste site takes place in the presence of a junior engineer of MCG, an agencyperson (of Pragati) and a person appointed by the local councillor. A penalty of Rs 25,000 or 25 per cent of the assessment, whichever is lower, is levied on non-disclosure of generation.

Pragati and MCG have fixed different rates for transporting waste to collection points as follows:

- Rs 360 per tonne for segregated C&D waste
- Rs 720 per tonne for non-segregated C&D waste

MCG was to designate 15 collection points, from where C&D waste was supposed to be collected by IEISL, but thus far only five locations have been assigned. Payments are made to Pragati by MCG only after C&D waste has been disposed of at the secondary collection centres. MCG has provided separate I-cards and uniforms to Pragati employees, along with authorisation letters for collection and enforcement. The concessionaire has deployed 92 separate vehicles and 23 machines for collection of C&D waste. All vehicles are GPS-enabled and colour-coded for easy identification.

In case generators fail to submit a *challan* of C&D waste generation, the site is sealed in the presence of an MCG official. MCG officials also ensure that sites prone to illegal dumping of C&D waste are kept free of the waste through its regular collection. A database of bulk C&D waste generators and hotspots has also been created. A dedicated enforcement team performs night patrolling to identify violators involved in illegal dumping and transportation of C&D waste.

To strengthen the on-call and complaint mechanism, Pragati has provided a dedicated 24 x 7 phone number that is displayed on the MCG website too. Citizens can use it to register complaints and request pick up of C&D waste. Citizens can also raise complaints on the chief minister's online grievance clearance window, social media, Gurugram Metropolitan Development Authority website, Twitter, etc.

Secondary collection

C&D waste stored at designated locations is collected by IEISL using tipper trucks. Waste received at the processing facility undergoes inspection at the entrance to ensure it is not mixed with other solid wastes. A 40 tonne weigh bridge has been installed at the processing facility. It is equipped with a computerised system for recording weights, billing and tracking vehicle movement. After weighing, trucks are brought to the unloading area. Once the waste has been unloaded, a JCB is used to level the incoming material so that segregation becomes convenient. Wood, steel, plastic and bituminous materials are manually segregated and sold to authorised recyclers. The remaining waste is segregated into three parts: (i) Whole bricks that are manually segregated and used internally or sold, (ii) Big concrete pieces, (iii) Mixed C&D waste

Big concrete pieces are fed into a crusher. The output of the crusher is deposited on the main conveyor belt through feeders. The main conveyor discharges C&D waste to a manual

A crusher to process C&D waste at the Basai plant

inspection conveyor placed at an elevated level. On the slow-moving inspection conveyor, all unwanted objects are handpicked at the manual separation station. These are mostly large textile pieces, large twigs and woody pieces, thermocol, and consumer durables; all of which are dropped into separate chutes for collection and dispatch. The output in then fed into the input of the screening section for wet processing. Any remainder pieces of more than 200 mm size are returned to the crusher and the process is repeated.

At present, no wet processing of C&D waste takes place at the plant due to unavailability of water. As per officials of the Basai plant, MCG has committed to arranging the supply of treated water from the HUDA water treatment plant situated in the vicinity of the plant.

Output materials are sold to various bulk buyers, mostly contractors, at a rate fixed by IEISL officials. Bulk buyers can either lift materials from the plant storage area using their own vehicles or get IEISL to transport them for a fee. At present, no secondary materials are made from the output materials, but IEISL officials are planning to manufacture paver blocks, bricks, kerb stones and concrete blocks very soon as these materials have a better market value compared to general output materials.

WHAT HAS WORKED IN GURUGRAM

MCG has hired two concessionaires for performing two key roles in C&D waste management. Pragati performs primary collection and IEISL carries out secondary collection and processing. This model has worked quite well.

Pragati, apart from fulfilling the main responsibility of primary collection, also ensures that C&D waste generators refusing to submit *challans* of waste generated, or dumping C&D waste illegally, are penalised. Pragati's on-call mechanism to clear C&D waste system has also been quite successful.

After a slow start, due to its parent company running into financial trouble, IEISL is now processing 1,500 TPD of C&D waste, of which 1,200 TPD is new waste and 300 TPD is legacy waste.

Impacts

- Approximately 11.75 lakh tonne of C&D waste has been collected and transported through doorstep collection, citizen complaints and enforcement activities, and from unclaimed dumpsites.
- More than Rs 5.67 crore of revenue has been deposited into MCG's account by service providers and through enforcement activities.
- Illegal collection and dumping activities have been reduced by 90 per cent under MCG's jurisdiction.
- To date, approximately 3.5 lakh tonne of C&D waste has been processed.
- Approximately 2.2 lakh tonne of processed C&D waste has been sold.

LESSONS LEARNT

C&D waste is bulky and every step of its management – primary transportation, secondary transportation, processing, and recycling and disposal – presents a mammoth challenge. Gurugram's example shows that **dividing the work between concessionaires ensures none of them is overburdened with the entire process**. As Pragati AL Natural Resources Pvt Ltd is not involved in secondary collection and processing, it can focus on primary collection and enforcement, of which it has done an excellent job.

A nimble penal and grievance system goes a long way towards ensuring that waste is not dumped illegally and violators are brought to book quickly. Gurugram's razor-sharp system of fines for illegal dumping of C&D waste, or failure to report generation, works well in tandem with its lightning fast on-call and grievance redress system.

REPLICABILITY

Indian cities are expanding rapidly and this growth is forever hungry for infrastructure. Real estate industry is expected to grow at an annual average of 6.6 per cent between 2019 and 2028 and is expected to account for 13 per cent of India's GDP by 2025. Construction sector contributes the maximum quantity of C&D waste.

Only 1 per cent C&D waste generated in India is being recovered and recycled. According to Building material and technology promotion council (2017), it is estimated that India generates about 150 million tonne of C&D waste annually (unofficial estimates say the number is three–five times higher). The country's recycling capacity of 6,500 TPD is just 1.3 per cent of the total C&D waste generated. Gurugram's example of C&D waste management can be a beacon for cities looking to manage mounting quantities of C&D waste.

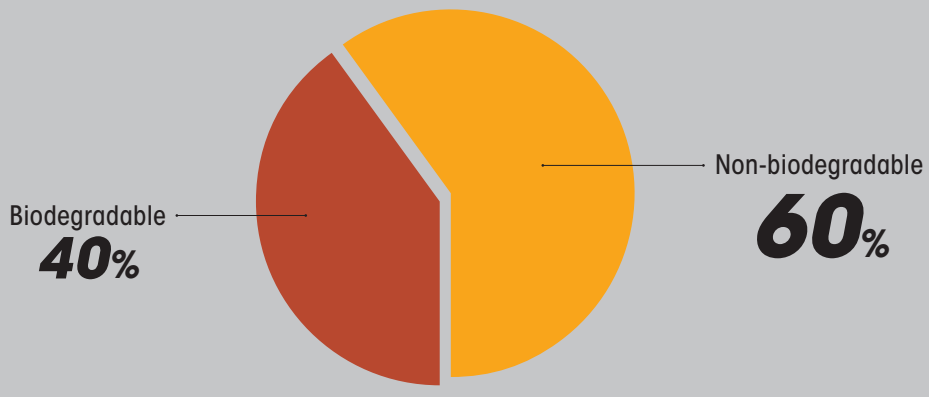
DELHI

NORTH DELHI

India's first construction and demolition (C&D) waste processing plant has efficiently managed the city's legacy waste since the 2010 Commonwealth Games.

The Municipal Corporation of Delhi (MCD) is the second-largest civic body in India. It was divided in 2012 into three parts – North Delhi Municipal Corporation (DMC), South DMC, and East DMC. North DMC currently monitors, upgrades and develops civic amenities for a population of almost 1 crore citizens of Delhi. It has a jurisdiction area of 636 sq. km, which is about 43 per cent of the total area of Delhi. It has 104 wards and is subdivided into six zones (Rohini, Civil Lines, Karol Bagh, City-Sadar Paharganj, Sadar Paharganj and Narela Zone).

Total waste composition



Source: North Delhi Municipal Corporation

Population (in million, as per 2011 Census)
7.67

Estimated current population (in million)
10.89

Estimated floating population (in million, daily)
1

Area (sq. km)
636

Number of households (in million, 2021)
1.47

Number of wards
104

Number of zones
6

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
4,500

Number of sanitation workers
26,324

Number of community bins
38*

Number of garbage-vulnerable points
63*

Waste management vehicle fleet size
558

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
25

Percentage of waste processed
67

*According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: CSE 2021

THE TRANSFORMATION

Delhi produces 5,000 tonne of C&D waste. Its improper disposal used to choke of water drains and pollute the river Yamuna.

Before 2009, around 5,000 tonne of waste was produced by building demolition and land-clearing activities. Because of this around 37,000 m^3 of debris lay around the eastern bank of the Yamuna and 53,000 m^3 of debris lay on the western Yamuna bank (as per NDMC).

During the preparation of the Commonwealth Games, huge quantities of C&D waste were generated. Other construction, renovation and demolition activities – varying from small to large scale – also generated considerable amounts of C&D waste. Due to the lack of availability of any processing unit the waste was eventually disposed of at the Bhalaswa landfill site or dumped on the bank of the Yamuna River. A part of the waste generated was dumped near highways and a small fraction was dumped at the vacant lands inside the wards.

To manage waste generated during the preparation of the Commonwealth Games and to address the illegal dumping of C&D waste in lands and rivers and the blocking of large stretches of land resources from the city jurisdiction, IL&FS Environmental Infrastructure and Services Limited (IEISL) in 2009 set up a project – the first facility of its kind in the country – on the private–public partnership (PPP) model to recycle C&D waste at Burari, Delhi. The Burari facility is under North Delhi Municipal Corporation (NDMC).

HOW THE SYSTEM WORKS

NDMC provided 7 acres (2.83 hectare) of land to IL&FS to set up the plant. Initially, the plant started with a processing capacity of 500 tonne per day (TPD). The cost incurred for setting up the plant was around Rs 22 crore.

From the date of commissioning till 2015, the plant has received approximately 2 million tonne of construction and demolition (C&D) waste. About 0.3 million tonne of this waste is from the NDMC jurisdiction area. In view of the

C&D waste processing plant, Burari

Source: North Delhi Municipal Corporation

gap in waste received as compared to waste processed, NDMC in 2014 ordered the concessionaire to increase plant capacity. In 2015, with an additional expenditure of Rs 2 crore, the plant capacity increased to 2,000 TPD. The construction and demolition facilities in Burari and Shastri Park have collaborated with Norwegian institution SINTEF, one of Europe's largest independent research organisations, under the Indo-Norwegian Bilateral Project C&D WIN. The objective is to sample and test the physical and chemical properties of C&D products manufactured at the IEISL facilities and to develop strategies for market development of the recycled C&D products.

Construction and demolition waste is crushed in a crusher and shredder, reducing the particle size. Finer products are screened and segregated through inclined conveyor belts comprising screens of size >40 mm, 40 mm, 20 mm, 10 mm, 5 mm and up to 3 microns. The plant converts C&D waste into cement bricks, pavement blocks and kerbstones, thereby reducing the consumption of fresh stones and sand, the manufacture of which causes steep rises in pollution. Industrial sewage wastewater is also used in the processing of incoming C&D waste, making the whole recycling process sustainable. This plant follows the principles of waste to value by which not only waste or wastewater is treated but value is also added to the final product or outcome, making the system self-sustainable.

WHAT HAS WORKED

To channelize the C&D waste generated, NDMC categorised collection and transportation in two – direct transportation and indirect transportation

Direct transportation

As per NDMC, an individual or small-scale generator cannot store or dump C&D waste outside their boundary. Those who generate C&D waste can dump the waste at their own cost at the nearest of the 104 designated municipal stores. The generator does not

Department-wise C&D waste received (in tonne)

YEARS	AWARNESS	MCD IEISL	PWD	CPWD	DMRC	NBCC	DSIIDC	DDA	OTHERS
FY 2009-10	20,787	59,442	0	0	0	0	0	0	5
2010-11	52,138	180,502	76,257	269	0	0	0	6	16,867
2011-12	19,560	167,589	4,576	0	0	0	0	0	611
2012-13	7,157	102,034	89,402	0	0	0	35,763	0	481
2013-14	2,371	128,511	133,672	2,525	132,454	9,751	54,497	13,220	1,104
2014-15	16,919	192,312	397,697	34,415	39,740	292	25,972	1,427	3,447
2015-16	5,258	204,262	438,425	44,950	30,786	0	727	200	1,220
2016-17	9,679	200,430	391,934	51,305	17,655	1,502	5,495	0	131
2017-18	1,174	170,770	158,450	27,356	7,733	4,527	2,643	3,543	1,955
2018-19	12,033	164,057	170,116	26,047	18,175	393	4,601	19,063	3,124
2019-20	38,944	167,115	302,905	26,111	6,256	3,210	7,781	76,976	47,366
2020-21	46,376	86,909	434,243	40,784	20,694	11,570	7,963	35,010	26,787
2021-22	3,797	26,464	97,752	405	5,046	65	1,849	3,580	4,027

Source: North Delhi Municipal Corporation

have to pay the municipal store for this. NDMC doesn't charge the small-scale generator as during the approval of building plans the map section charges every applicant a demolition charge that is included in the total fee. Details of the designated municipal stores are given on NDMC's official website.

The municipal stores are spread across all six zones and are owned by NDMC. One maintenance Junior Engineer (JE) is deputed to each MPL store to look after the area. Only a part of an MPL store premise is earmarked for dumping of C&D waste. When the earmarked area is full or about to get full, the maintenance JE informs the IL&FS officials to send their vehicles to pick up the material and transport it to the processing facility.

IL&FS is responsible for lifting and transporting the waste from the MPL stores to its processing facility. It charges NDMC only the cost of transportation at the rate of Rs 251.4 per tonne of C&D waste. As per the contract agreement, IL&FS doesn't charge NDMC any processing fee.

Unclaimed C&D waste dumped inside NDMC's jurisdiction area is collected by its vehicles by NDMC. Unclaimed C&D waste is stored either at the nearest MPL store or on any vacant land. After accumulating a certain volume of the C&D waste, NDMC officials inform IL&FS office to pick up the waste and transport it to the plant for processing.

Indirect transportation

This is restricted to the bulk generators such as Public Works Department (PWD), Central Public Works Department (CPWD), Delhi Metro Rail Corporation (DMRC), National Buildings Construction Corporation Ltd (NBCC), Delhi State Industrial and Infrastructure Development Corporation Ltd (DSIIDC) and Delhi Development Authority (DDA). When NDMC gives a contractor a work order for a large-scale construction or demolition activity, it categorically mentions in the work order that C&D waste generated from the activity is the sole responsibility of the generator, who has to transport the waste directly to the C&D waste processing facility at their own cost. The contractor pays a charge of Rs 205 per tonne as processing fee.

The vehicle carrying the C&D waste is weighed at the weighbridge and a bill is generated. The contractor must pay the amount then and there after which an invoice is given. The invoice is mandatory for the contractor to submit the final bill against the completed work. In the absence of these invoices from the C&D waste plant, the bill is kept on hold. On receiving the invoice, NDMC officials cross-verify it with the plant. Only when the verification is complete is the payment released to the contractor.

Impacts

- The Burari plant is compliant with the Municipal Solid Waste (MSW) Rules, 2016 and scientifically processes 2,000 TPD of C&D waste into aggregates that are converted to ready-mix concrete, cement bricks, hollow bricks, pavement blocks, kerbstones, concrete bricks and manufactured sand, thereby reducing the consumption of fresh stones and sand and mitigating pollution arising in the process. Over 16 lakh recycled concrete blocks from the plant are being used in the new Supreme Court annex building.
- Use of recycled aggregates reduces use of natural resources, enhances conservation, reduces sand mining from riverbanks, and reduces the burden on the landfill sites, saving precious urban land.
- Using specially adapted technology for Indian waste, the plant can recover about 95 per cent of incoming C&D waste and uses recycled sewage water for processing waste. The wet-processing technology minimises dust and noise pollution, making the plant a zero-discharge facility.
- Up to 2016, the project helped save over 45 acre (18.21 hectare) of urban land worth over Rs 400 crore by reducing the burden on landfills. It also provides employment opportunities to locals.
- The plant has processed since its inception in 2009 over 45 lakh tonne of C&D waste that would otherwise have been dumped illegally in river Yamuna or other eco-sensitive areas.
- Construction of New Supreme Court building and MP flats used about 23 lakh tonne M10 grade of recycled materials
- The 4-km Express Bakkarwala Road made by DDA used 2.6 lakh tonne of recycled C&D material.
- The Delhi State Industrial and Infrastructure Development Corporation Ltd (DSIIDC) has already used over 3.2 lakh tonne of screened soil for the development of unauthorized colonies in Delhi.
- Uptake of C&D recycled materials by the government departments during the financial year 2018–19 from three processing facilities in Delhi was over 2 lakh tonne.

LESSONS LEARNT

C&D waste is very high in volume and its proper management is a challenge for most cities. NDMC took the timely decision to set up the processing facility. The mechanism developed by NDMC for dividing the work system into direct and indirect transportation has worked well for them. Small-scale generators would dispose of their wastes in one of the 104 designated places – with one municipal store per ward for free – but bear the transportation cost. Bulk generators, however, had to directly transport the waste to the processing facility and pay the processing charges to the concessionaire.

IL&FS, a concessionaire, has managed India's first processing facility in an organized manner. Though it struggled during the initial years to sell off its process aggregates, the system is now streamlined due to timely intervention of various Central and state government organisations.

REPLICABILITY

Rapid infrastructural development such as highways and airports and growing demand for housing have led to scarcity and a rise in the cost of construction materials. Most of the waste materials generated by demolished structures are disposed of by dumping them into landfills. The dumping of wastes on land is causing a shortage of dumping places in urban areas. It is therefore necessary to start recycling and reusing demolition and concrete waste to save the environment, cost and energy.

The way NDMC has managed the collection and transportation of C&D waste for both small-scale and large generators is worth showcasing to other cities. But processing the waste only will not solve the purpose as processed C&D waste has few buyers due to quality issues. The output materials should be tested in a certified laboratory according to BIS standards so that recycled products find a good market.

6 SANITARY WASTE MANAGEMENT

Of all the streams of solid waste generated at the household level, sanitary waste has been the most ignored. Its handling and channelisation is an occupational hazard and a matter of concern for most cities. To deal with sanitary waste, it is important first of all to run awareness campaigns to break taboos associated with it. Once this waste is segregated at source, urban local bodies must use the best technologies to process it.

Karad: By managing to break the taboo around sanitary waste, the city administration has achieved a 100 per cent sanitary waste collection rate.

Pune: Introduced the 'Red Dot campaign', with a well-planned mechanism of collection, channelisation and disposal, and exploration of state-of-the-art technology to make value-added products from sanitary waste.

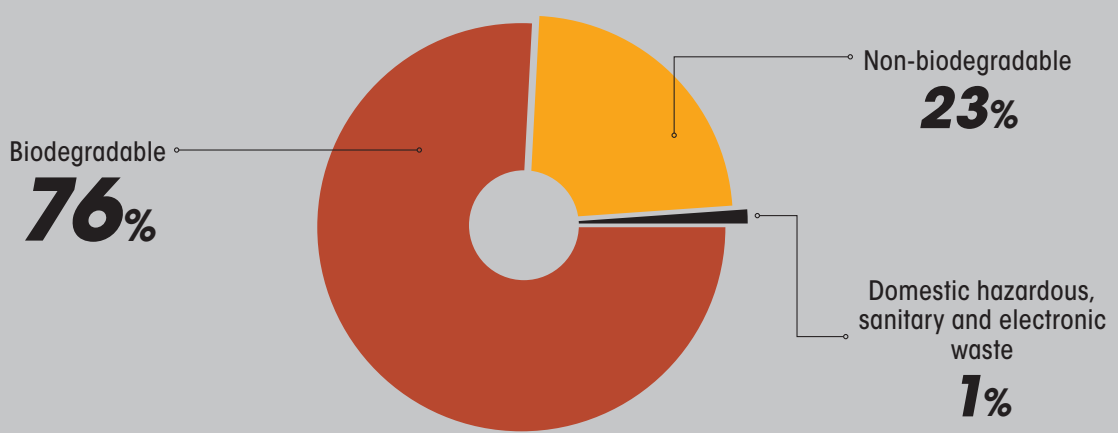
MAHARASHTRA

KARAD

The city has done an excellent job of managing its sanitary waste

Karad is a city in the Satara district of Maharashtra. It produces about 26 tonne of waste per day (around 300 g per person per day). Karad's story is one of cascading adoption of better waste management practices – composting, segregation and remediation of its dumpsite, followed by refined segregation. The city has also ensured that managing sanitary waste comes at no cost to the municipal authority.

Waste composition in Karad



Population (as per 2011 Census)
53,879

Estimated current population
86,000

Estimated floating population (daily)
250

Area (sq km)
1.5

Number of households (2021)
13,900

Number of wards
14

Number of zones
2

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
26

Number of sanitation workers
249

Number of community bins
0*

Number of garbage vulnerable points
0*

Waste management vehicle fleet size
23

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
100

Percentage of waste processed
100

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Karad Municipal Council

THE TRANSFORMATION

Karad Municipal Council (KMC) took up composting as early as the 1970s. But the rise in the percentage of non-biodegradable waste, particularly plastic waste, which could not be composted, ended up transforming the city's processing site into a dumping ground. With time, the dumping ground spread and a section of the city's lower-income group shifted to occupy a part of it. The site attracted stray animals; and there were instances of dogs attacking children in the area around it. Residents living in the vicinity were miserable because of the stench and leachate. During monsoons, mosquitoes and flies became a menace, so much so that people were forced to eat inside mosquito nets.

Although there were sporadic protests against the dumping ground, the turning point came when residents formed a human chain to stop waste disposal at the site. In 2016, city authorities and a self-help group known as Greeny conducted a training programme for 16 foremen and 200 volunteers on segregation of municipal solid waste into three categories – biodegradable, non-biodegradable and domestic hazardous. That was the beginning of a new journey for the city.

HOW THE SYSTEM WORKS

The Information, Education and Communication (IEC) programme was first initiated in areas with a high literacy rate. Door-to-door monitoring helped in the identification of households that were failing to segregate waste properly. Such households would then be trained for the next five days on the practice and importance of segregation. About 70 per cent of household segregation was thus achieved. Complaints registered with a foreman against households that failed to segregate even after the training could attract a penalty in the form of increased water or electricity tariff. Fear of penalty resulted in 100 per cent source segregation in the city by 2018.

Once source segregation had been adopted by the residents, they raised the question of arrangements for processing of waste as they wanted their efforts to be respected. On July 23, 2018, KMC started treating the legacy waste at its dumping ground at the rate of 600 TPD. It reclaimed the plot by

February 26, 2019 by clearing around 59,000 tonne of legacy waste.

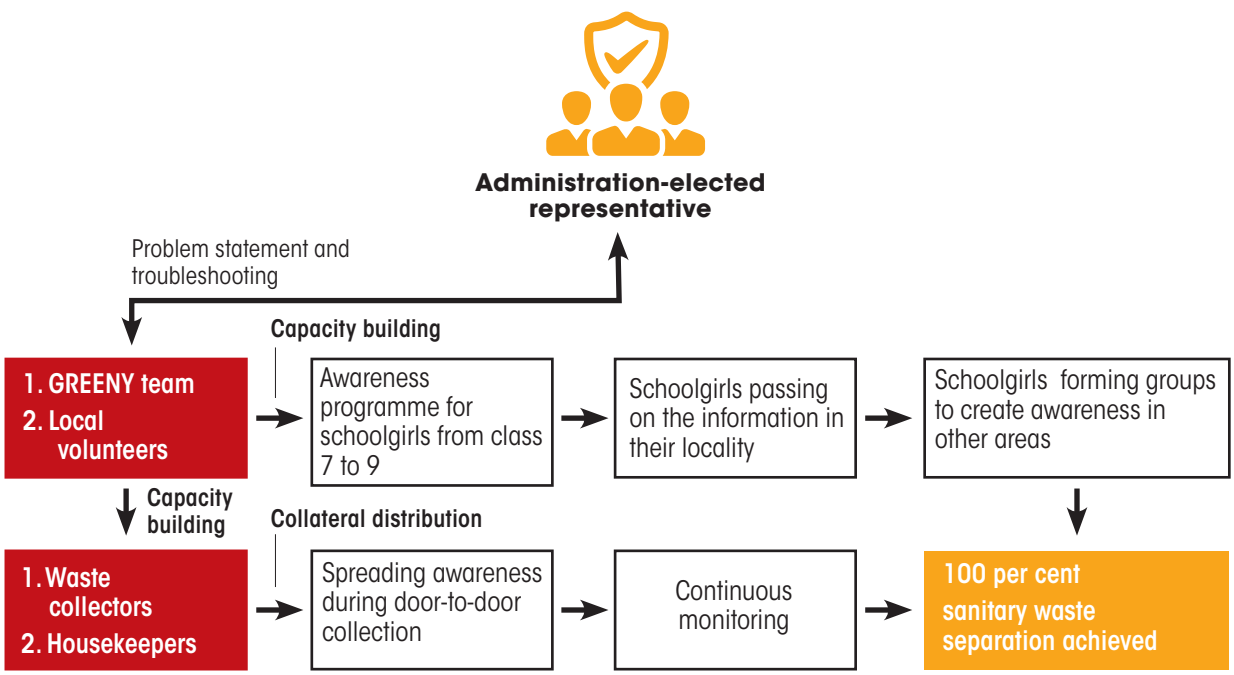
The city had installed two incinerators at its material recovery facility to deal with hazardous waste, including sanitary waste. But the incinerators proved insufficient for all the used sanitary pads and diapers sent in by the city. Some of these items were also only partially incinerated and, because of the taboo associated with sanitary pads, a good percentage of them was not even handed to the waste collectors. Rather, they clogged the city's drains and public places.

The new idea was to segregate waste into six streams: 1) Biodegradable, 2) Plastic, 3) Paper and cardboard, 4) Domestic hazardous, 5) Electronic, and 6) Sanitary. Waste glass, textile, rubber, etc., generated less frequently, were collected in separate bags, reducing the overall burden on the material recovery facility.

In August 2020, the IEC team designed 20 minute sessions for the administrative staff, door-to-door waste collectors, schoolgirls from class 7 to 9, and citizens of Karad. Although the programme was hampered by COVID-19, the IEC team managed to build capacity among 200 schoolgirls to spread awareness and break the taboo around sanitary waste in the society. After a two month-long exercise, 100 per cent of households in Karad started giving sanitary waste separately for collection.

The administration then joined hands with the biomedical waste treatment facility at Kharade colony, which had been running for 18 years (see Box: *Biomedical waste treatment facility, Kharade colony*). The facility was located on the same plot where biodegradable waste was brought in for windrow

Strategy of the IEC campaign



Source: Karad Municipal Council

Breaking the taboo: Distribution of sanitary pads among schoolgirls in Karad as part of the IEC campaign

composting and non-biodegradable waste for recycling at the material recovery facility. The plot also houses the material recovery facility, so integration of the whole system came at no extra transport cost. By spending a small amount of money on IEC and modification of waste collection vehicles, the city administration has been able to achieve the feat of separate collection and scientific processing of sanitary waste.

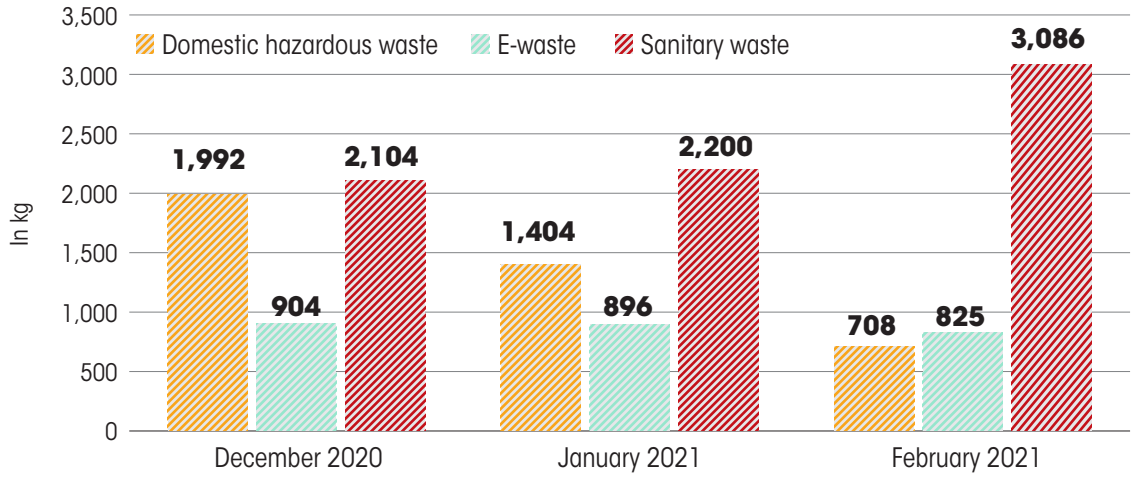
Biomedical waste management facility, Kharade colony

In 2001, the dynamic team of Karad Hospital Association was allotted a one acre plot near the processing centre (at that time a dumping ground) to erect and commission a 600 kg per day capacity biomedical waste treatment plant. A team of 30 doctors governs the association.

Once the plant was set up, training sessions were held for members of the doctors' association, nurses and ward boys. The biggest challenge was capacity building of workers at the processing centre. The initial task was to break the taboo associated with handling biomedical and sanitary waste. An exhaustive training programme to instil a sense of respect for the standard operation procedure, and the importance of personal protective equipment (PPE) kits and good practices was conducted. The workers are remunerated well for the job. Weekly monitoring of the plant is done by a minimum quorum of five doctors. There is an agreement between KMC and Karad Hospital Association which allows sanitary waste collected by KMC to be processed at the biomedical waste plant without a fee.

The results have been excellent. The plant has been functional for more than two decades but there is no record of any accident taking place at it. During COVID-19, staff attrition became a challenge. The new training and continuous monitoring requirements slowed down the process flow at the facility. Usually, it runs for eight hours a day, but it has been running for up to 20 hours daily during the pandemic.

Quantity of sanitary, domestic hazardous and e-waste produced in Karad



Source: Karad Municipal Council

WHAT HAS WORKED IN KARAD

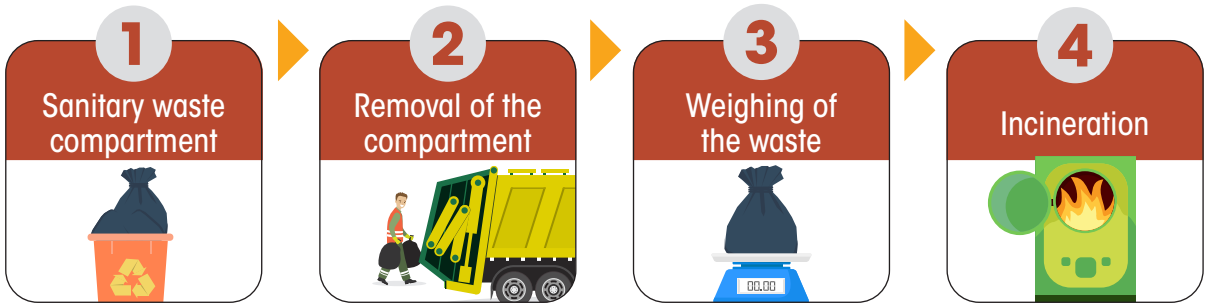
Turnaround in sanitary waste management practices: In the past, the city struggled to manage its sanitary waste because of a number of social and technical issues. By managing to break the taboo around sanitary waste, the city administration has achieved a 100 per cent collection rate for sanitary waste. The administration also ensures that sanitary waste is transported and processed separately.

A biomedical waste treatment facility that pays for itself: The 600 kg per day capacity biomedical waste treatment facility was established at a cost of Rs 20 lakh. No funds were taken from KMC and the facility has never incurred any losses. Operation and maintenance of the plant is paid for from the tipping fees collected from the clinics and hospitals in Karad.

Impacts

- By 2018, the city achieved 100 per source segregation of waste into three streams.
- By 2020, it achieved 100 per cent segregation and collection of sanitary waste. The taboo around sanitary waste has been broken through a sustained IEC campaign.
- The processing of sanitary waste has become a zero-cost affair for the municipal authorities, thanks to its unique arrangement with a hospital association.
- The success of its sanitary waste programme has encouraged the city administration to try a similar initiative to promote sanitary cups and reusable pads.
- The city has remediated its dumping ground, clearing 59,000 tonne of legacy waste in the process and converting the reclaimed land into an integrated waste processing facility.

Sanitary waste process flow, Karad



Source: Karad Municipal Council

LESSONS LEARNT

Waste management is in everyone's interest; therefore, it is everyone's duty: First, the citizens of Karad put pressure on the municipal authorities to stop dumping waste. Then KMC started the IEC campaign and increased tariffs on non-compliance to ensure segregation. Once 100 per cent segregation had been achieved, the citizens turned to the authorities once more, demanding that the dumping site be remediated. This cycle of holding each other responsible has resulted in better waste management to the benefit of everyone in the city.

A thoughtful carrot-and-stick approach can catalyse the adoption of better waste management practices: Through its IEC programme, and by adding a punitive element to non-compliance, the city ensured 100 per source segregation of waste into three streams by 2018.

Transforming a city's waste management system does not necessarily require new infrastructure and equipment: By utilising existing assets or slightly modifying them, the city has made rapid improvements in its solid waste management regime at a minimal cost. Existing waste collection vehicles were modified so that they could collect and transport segregated waste efficiently. The arrangement between KMC and the hospital association ensured that once the city started segregating sanitary waste, it was handled swiftly, professionally and at no additional cost to the municipal authority.

A good system is competent to deal with emergencies: KMC's sanitary waste management has resulted in better handling of waste during the pandemic, which goes to show that once a good system is in place, it is better equipped to deal with emergencies than a system that is not well organised.

REPLICABILITY

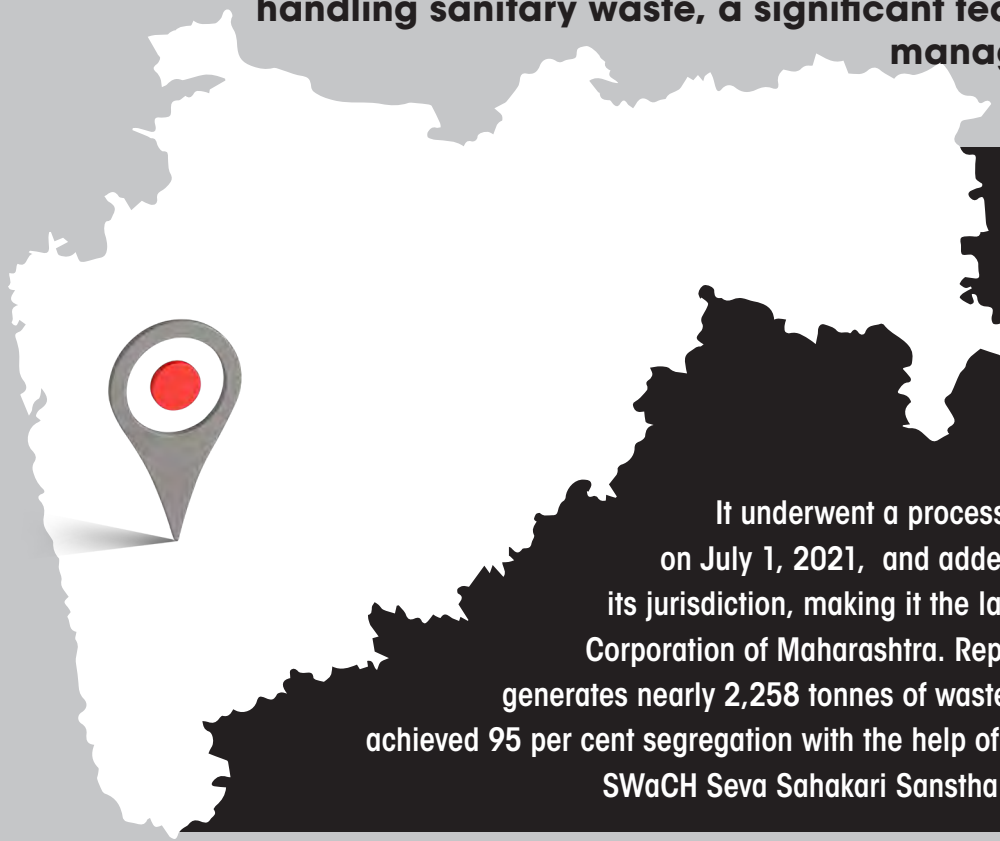
Two major components of Karad's waste management model can easily be replicated in other Indian cities and towns. A common problem is bad waste management practices among citizens due to ignorance, prejudice or some other reason. A solid IEC programme, like the one implemented in Karad, can be an agent of social transformation and bring about behavioural change among residents regarding waste.

Moreover, most cities have some existing infrastructure and human resource that can be leveraged to improve waste management regimes. The key is to think intelligent solutions, not necessarily big-budget solutions.

MAHARASHTRA

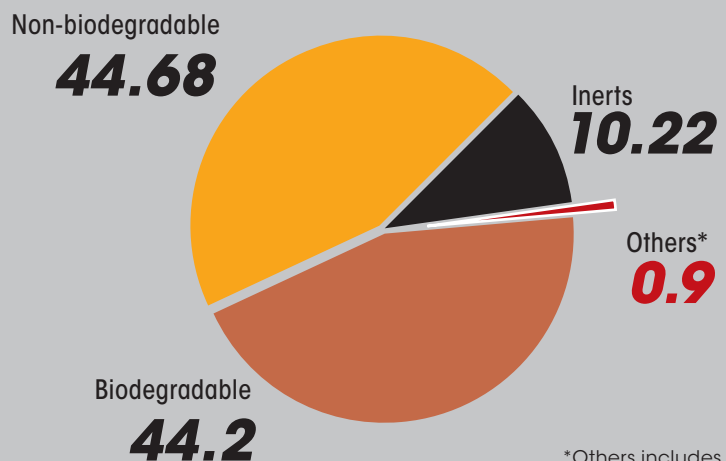
PUNE

The Red Dot Campaign in Pune shows the light in handling sanitary waste, a significant feat in the waste management sector



Pune Municipal Corporation (PMC) is divided into five zones and 42 wards. It underwent a process of delimitation on July 1, 2021, and added 23 villages to its jurisdiction, making it the largest Municipal Corporation of Maharashtra. Reportedly, the city generates nearly 2,258 tonnes of waste per day. It has achieved 95 per cent segregation with the help of self-help group SWaCH Seva Sahakari Sanstha Maryadit, Pune

Composition of waste in Pune



*Others includes domestic hazarduous waste and sanitary waste

Source: Pune Municipal Corporation

Population (in million, as per 2011 Census)
3.12

Estimated current population (in million)
4.29

Estimated floating population (in million, daily)
0.20

Area (sq. km)
516

Number of households (in million, 2021)
0.93

Number of wards
42+23 *villages*

Number of zones
05

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
2,258

Number of sanitation workers
14,087

Number of community bins
0*

Number of garbage-vulnerable points
53*

Waste management vehicle fleet size
745

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
95

Percentage of waste processed
100

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: PMC

THE TRANSFORMATION

In 1993, an organisation called Kagad Kach Patra Kashtakari Panchayat (KPKPK, or Trade Union of Waste-pickers) was formed. The informal sector got a boost – the ragpickers were able to get good-quality non-biodegradable waste due to the practice of source segregation, thereby increasing income and ease of handling waste.

Pune Municipal Corporation has been practising segregation since as early as 2008. Initially waste was segregated in two parts – biodegradable and non-biodegradable waste. Dry waste included both sanitary as well as domestic hazardous waste. Initially, both sanitary and hazardous waste were not quantified but put directly into the landfill.

Before the initiative, citizens were unaware about handling sanitary waste separately. There was a need for capacity development. Workers collecting door-to-door waste faced problems in handling the waste. Both hazardous and sanitary waste were mixed with other non-biodegradable waste, compromising the quality of non-biodegradable waste. As there was no separate technology installed for processing sanitary waste, it went directly to the Uruli landfill.

KKPKP, through its work and approach, established its credibility as a responsible and mature organisation so that more of the informal sector wanted to be part of the organisation.

The vital role of informal sector waste-pickers brought a change in the public perception of waste management. Registered members were endorsed through an identity card issued by the Corporation, thereby gaining recognition in state records. To increase activities in the field of waste management and value-added services, another organisation called SWaCH (2006) was started under the umbrella of KKPKP. SWaCH integrated the registered members of KKPKP with the intention of starting door-to-door collection services under the guidance of the Pune Municipal Corporation. Capacity development of workers was undertaken to mobilise them to segregate recyclable non-biodegradable waste at the source, thus reducing transportation costs as well as the load on landfills.

HOW THE SYSTEM WORKS

Training SWaCH members and PMC field staff was the first step. The training programme was conducted at the PMC main office. The concepts of source segregation and safe handling of sanitary waste were explained. Separate bags were given for collection and transfer of sanitary waste at the feeder points. Norms and standard operating procedures (SOPs) for handling sanitary waste were explained. This gave members and workers the confidence to spread awareness among citizens with regard to the Red Dot Campaign. As per reports of phase I, capacity development of approximately 72 per cent of the waste pickers is completed; the remainder will be covered in phase II. Phase II has been delayed due to the Covid-19 second wave.

Trained waste-pickers conducted awareness programmes for citizens. They went from door to door with Information, Education and Communication (IEC) collaterals and demonstrated how to wrap and mark the sanitary waste before handing it over. Capacity development for workers handling sanitary waste was also done.

While removing recyclable items from non-biodegradable waste, workers would come across sanitary pads, diapers and even needles. This was an occupational hazard that made them vulnerable to infection.

SWaCH workers waiting at the feeder point for the PMC waste collection vehicle

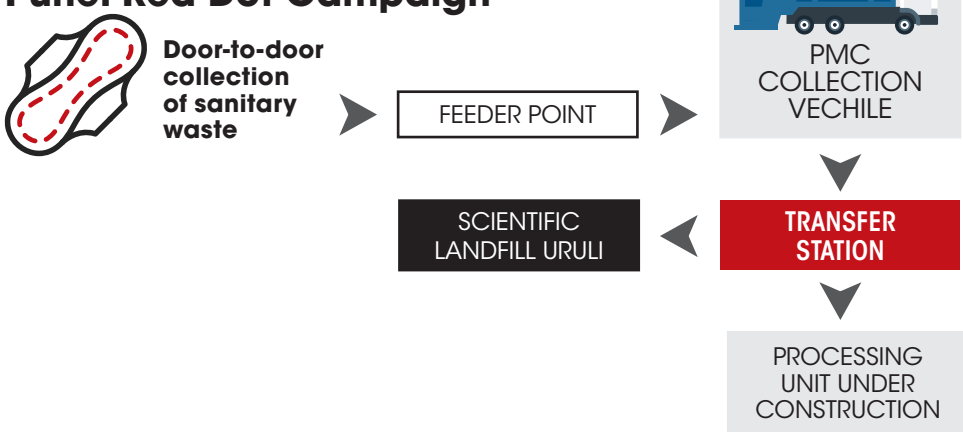
The issue was raised with SWaCH directors, among whom were included on the panel 15 ragpickers. Connecting to problems on the ground was simple and decision-making was swift. In 2016, the directors directly raised this concern with the Pune Municipal Corporation (PMC). But the Manual on Municipal Solid Waste Management (MSW), 2016 had been released, which compelled the Corporation to start clearing around 2.3 million tonnes legacy waste that had accumulated for more than 70 years.

Channelising all the constituents of solid waste became a priority. To solve the problem of sanitary waste, the Red Dot Campaign was born. The idea of managing sanitary waste was driven by both the social need of labour handling waste from door to door and the pressure of adhering to MSW 2016.

Red Dot Campaign

The Red Dot Campaign is well known in the Indian waste management community. It is a one-of-a-kind campaign, where the citizens, labour and administration unanimously accepted their responsibility, making it a lesson for other cities in India.

Sanitary waste management in Pune: Red Dot Campaign



The campaign started in 2016 as part of PMC's and SWaCH's Information, Education and Communication (IEC) programme. The goal was to collect sanitary waste separately, with workers collecting waste from door to door. The interactive nature of the campaign led to better understanding of the issues and approaches of the citizens. In support, PMC notified (Notification no. S.O. 1357 (e) dated April 8, 2016) citizens to give their sanitary waste separately as per the Municipal Solid Waste Management Rules, 2016.

Collection and transportation of sanitary waste

Workers collecting waste from door to door bring their waste to a feeder point. Every feeder point is operated by five to seven workers who offer waste collection services to 100–150 households each. The waste then gets collected by a PMC collection vehicle. The PMC vehicle transports the waste to the transfer station. Sanitary waste is then transferred into a red container, which is then carried to the processing facility.

CURRENT SCENARIO OF TRANSPORTATION AND PROCESSING OF SANITARY WASTE

Feeder point

PMC collection vehicle

Emptying sanitary waste at transfer station

Scientific landfill

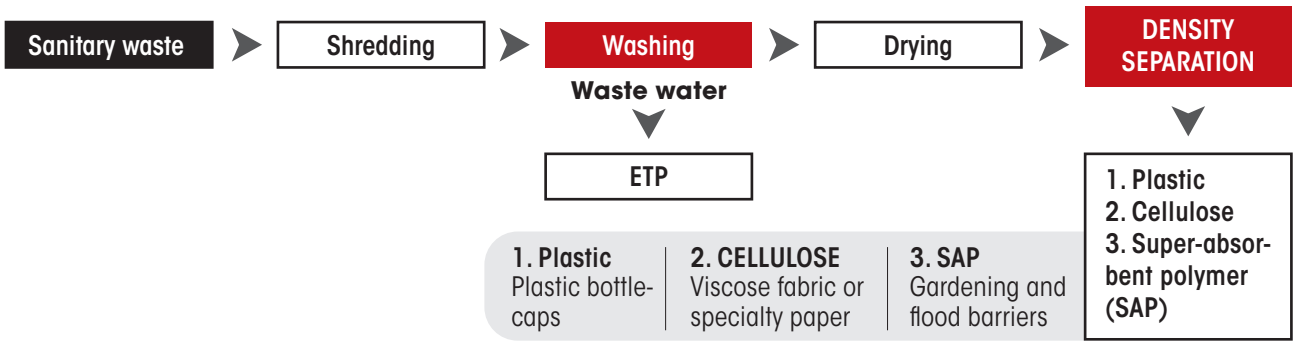
Technology

To develop a sustainable recycling loop in the field of sanitary waste, an Italian company developed a breakthrough recycling technology that can recycle used absorbent hygiene products such as baby diapers, feminine hygiene (fem care) and adult incontinence products to create new products and materials of added value. The technology is installed and operational at an industrial scale at Spresiano, northern Italy. It is able to process 10,000 tonne of used absorbent hygiene products per year. This corresponds to serving around one million people. The plant is unique and the first of its kind in the world.

The technology efficiently breaks down sanitary waste into plastic, cellulose and super-absorbent polymer. These materials can be used for making rigid bottle-caps for non-food applications, gardening barriers and viscose clothing.

The process of installation of the sanitary waste processing plant was initiated in 2019, but due to Covid-19 and a contractual discrepancy of the contractor with PMC, complete installation and commissioning will take another six months. The plant is proposed to have a capacity of 10 tonne per day of sanitary waste.

Treatment of sanitary waste in processing unit



WHAT HAS WORKED

Reaching out to lower-income households was a challenge, and it took time to bring about behavioural change. SWaCH and PMC have a strategic pitch and approach to reach out to its citizens. However, more affluent families were more accepting of the change and have been a part of the system since its inception.

PMC workers were hesitant in handling/collecting sanitary waste from the feeder point (the point where the collected waste gets accumulated). The SWaCH team along with PMC officials intervened, awareness in handling sanitary waste was done, and the PMC workers reciprocated and became part of the campaign.

Due to the Covid-19 pandemic, procurement of the processing machine for sanitary waste was delayed, and this forced PMC to use a scientific landfill in the meantime. As the designated site for installation of the sanitary waste processing machine is under Rochem, Pune, contractual issues between PMC and Rochem is affecting the installation of the plant. PMC has recently decided to break all ties and hand over the model to a new contractor.

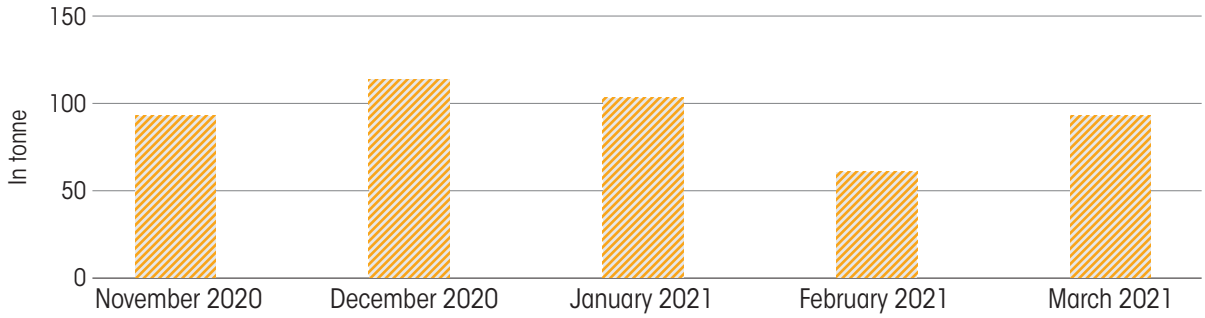
Also, the technology adopted may have a component of social challenge for application of the product obtained from processing sanitary waste. To counter this, the companies involved are planning media campaigns and awareness programmes along with the SWaCH team. (This is still under consideration.)

Current practice of sanitary waste management

- According to data received by Pune Municipal Corporation officials, only 50 per cent of the citizens covered by the Corporation separated sanitary waste from other waste. Around 1.5 TPD of sanitary waste is collected and transported. The SWaCH team and PMC plan to start phase II to reach out to the remaining population.

- SWaCH workers currently collect sanitary waste from citizens either in a paper cover with a red dot or in a separate plastic bag. Collected sanitary waste is then brought to the feeder point and transported into the

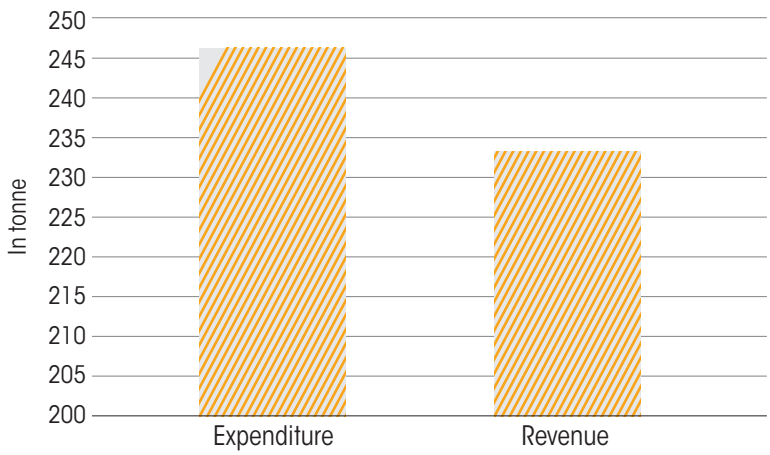
QUANTUM OF SANITARY WASTE COLLECTED AND PROCESSED



designated box in the PMC vehicle. In the case of higher quantities of waste, extra bags are used and hung separately in the collection vehicle. The PMC vehicle empties sanitary waste into a red container at the transfer station. The container is then transported to the scientific landfill.

- All the sanitary waste is collected daily. It is currently processed in the scientific landfill at Uruli, Pune.

REVENUE VERSUS EXPENDITURE (FY 2020–21)



Financial aspect

- A sanitary waste recycling plant is being installed under corporate social responsibility (CSR). No overhead charges have been incurred other than for installing an extra box in the same collection vehicle.

LESSONS LEARNT

The Red Dot Campaign is one of the best IEC programme in India for making people aware about their responsibility with regard to handling sanitary waste. Organisations such as SWaCH can support waste management operations of any Municipal Council or Corporation as they strike the right balance between the

Impacts

- IEC programme: The Red Dot Campaign is one of the most refined ways approaching sanitary waste segregation. Citizens showed willingness to adopt the methodology and recognised its importance in the context of hygiene of Pune city and the dignity of waste pickers.
- During the Covid-19 pandemic, spreading awareness about the Red Dot Campaign in person was difficult. But wherever it was possible, it seemed to be most effective way to reach out to the people. An integrated informal sector becoming the torchbearer for IEC programmes is a laudable achievement of both SWaCH and the PMC team.
- Technology: Recycling sanitary waste and making quality products out of it is a one-of-its-kind approach. It will be the second such plant to be installed in the world.
- Changes: Citizens have developed a sense of responsibility towards handling sanitary waste. The self-respect of the workers handling waste was boosted. The Red Dot Campaign brought positivity to Pune's citizens, and PMC's and SWaCH's efforts as well as media coverage boosted the campaign to a new level. It has acknowledged not just Pune as a city but its citizens as well.
- Betterment: The programme has only completed phase I. As per data received, only 72 per cent of the waste pickers were trained, who in turn were able to develop capacity in 50 per cent of the citizens. Depending upon the Covid-19 situation, phase II will start as early as possible, with the intention of maintaining the current capacity and encouraging more citizens to be part of the sanitary waste management programme.

citizens, waste collector, transportation and processing of not just sanitary waste but all kinds of waste.

One of most credible things is that 15 of the integrated informal ground workers are directors and key decision makers of SWaCH. This gives the ground staff confidence. Their grievances and wellbeing are taken up with utmost priority.

As most of the technologies in waste management are site-specific, PMC may need to plan carefully for challenges specific to India.

REPLICABILITY

The IEC programme of sanitary waste separation is easily replicable. PMC's reaching 2.14 million people (50 per cent population of Pune) is an example for urban local bodies in other cities to follow.

Integrating the informal sector and forming an organisation like SWaCH is the way forward all urban local bodies. It will not only help improve waste management in cities but also uplift the marginalised and underprivileged.

Although processing with the desired technology for sanitary waste has not commenced so far, PMC is processing solid waste by scientific landfill. This integrated model itself can be replicated in all urban local bodies that have scientific landfills and a thriving informal sector workforce.

7

LANDFILL MANAGEMENT

Landfills are not the solution to a city's waste management problems. In almost every city that has them, old landfills have become environmental and health hazards. A zero-landfill model offers a technically appropriate, environmentally and economically sustainable, and socially acceptable solution that is based on resource recovery and principles of circular economy.

Ambikapur: Inspired by the concept of the Garbage Clinic Model, the city has harnessed local women self-help groups to source segregate and process waste, and converted its legacy dumpsite into a waste recycling centre.

Chandrapur: Source segregation and biomining have allowed the city to convert its dumpsite into an integrated waste treatment facility with a sanitary landfill.

Taliparamba: Today, 85 per cent households adhere to the door-to-door collection process, almost 99 per cent of waste is processed in a scientific manner, and the city's dumpsite has been reclaimed, now housing a material recovery facility.

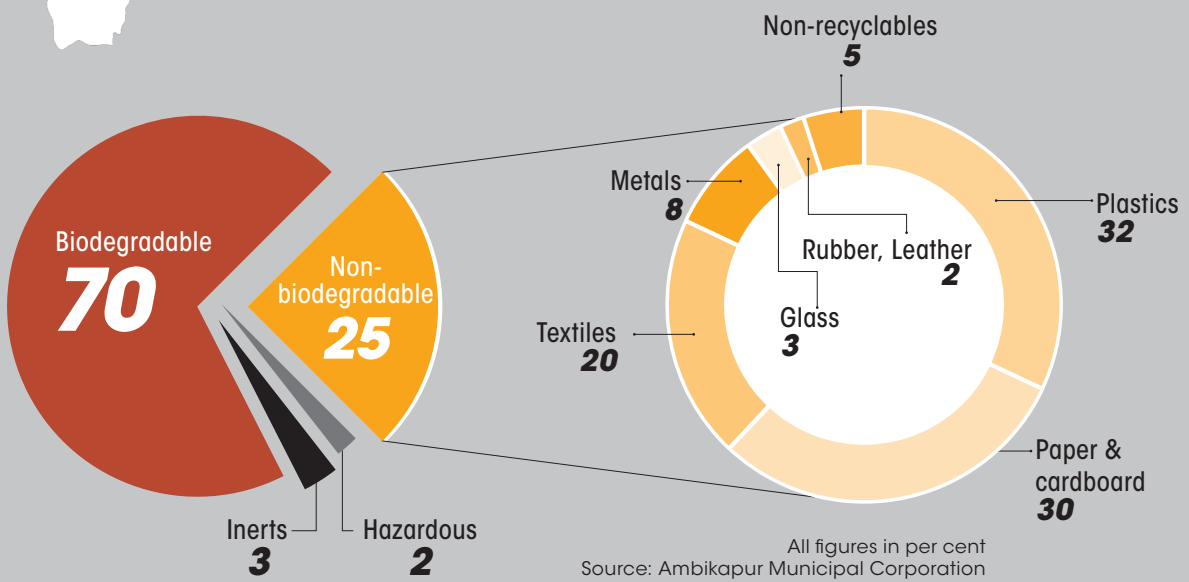
CHHATTISGARH

AMBIKAPUR

'Garbage clinics' drive change and turn Ambikapur into the first landfill-free town in India

Ambikapur, in Surguja district of Chhattisgarh, calls itself a 'zero landfill' town. It generates nearly 48 tonne of waste every day. What sets Ambikapur apart from other similar towns and cities of the country is the transformation that it has effected in its waste management system: the town has notched up an almost 100 per cent performance in source segregation, collection, transportation, treatment and disposal of waste – a result of an initiative involving self-help groups (SHGs).

Waste composition in Ambikapur



All figures in per cent
Source: Ambikapur Municipal Corporation

Population (in million, as per 2011 Census)
0.12

Estimated current population (in million)
0.14

Estimated floating population (daily)
5,000

Area (sq km)
41

Number of households (2021)
27,247

Number of wards
48

Number of zones
17

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
47.91

Number of sanitation workers
470

Number of community bins
0*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
286

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
95

Percentage of waste processed
100

Note: According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Ambikapur Municipal Corporation

THE TRANSFORMATION

It all began in 2015.

Before, Ambikapur used to display the usual manifestations of a town that did not have an effective system of managing its solid waste – overflowing community bins and waste dumped indiscriminately near roads and streets. With no segregation, mixed waste used to be collected from these dumps and off-loaded at a dumping site outside the town. The dumpyard itself was in a poor state, without a liner or leachate and gas collection systems. Open burning of the waste was common, and the resulting emissions of hazardous gases were adversely affecting the communities living nearby.

To improve matters, the town spent considerable amounts of money: 16 of the 48 wards hired private companies to effectively manage their waste, but the results remained below par. Whatever efforts were made, were marred by a lack of public participation and of awareness and interest among the people.

On March 1, 2015, the Sarguja district administration took the first step towards bringing about change: a meeting with all the stakeholders (local body members and officials of the Ambikapur Municipal Corporation or AMC) laid the framework of an action plan to manage the town's waste sustainably. To begin with, about 643 volunteers were trained and 623 of them selected to form Self-Help Groups (SHGs). Sixty-two of these SHGs came together to constitute the 'Swachh Ambikapur Mission Sahakari Samiti Maryadit, Ambikapur' (see Box: *How are the SHGs managed?*). The town has notified by-laws for solid waste management; plastic, C&D and e-waste management; and instituted user charges and a ban on plastics.

How are the SHGs managed?

The federation of self-help groups (SHGs) which is the part of 'Swachh Ambikapur Mission Sahakari Samiti Maryadit, Ambikapur' – includes a chairperson who is elected by the federation members, a centre in-charge, supervisors (who are appointed by the chairperson) and women workers (commonly refereed as didis). The federation has 700-800 workers, of which 470 work on managing solid waste. A worker gets a monthly salary of Rs 6,000, with an additional Rs 1,000 as performance-based incentive.

HOW THE SYSTEM WORKS

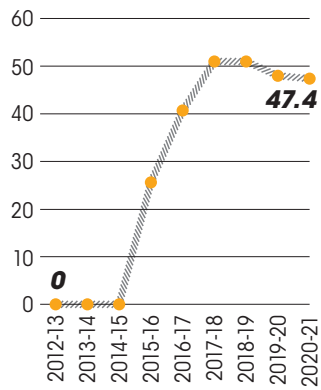
Facilitated by the local administration, the town has launched what is known as the 'Garbage Clinic' model – under it, 17 Solid and Liquid Resource Management (SLRM) centres have been set up, one in each zone. Each centre collects source-segregated waste from two to five wards (600-1,500 households), using a fleet of pedal-rickshaws and e-rickshaws.

The waste is brought to the SLRM centre for secondary segregation into 20 non-biodegradable categories – paper, plastic items, plastic covers, cardboards, glass, metal items, rubber items, leather items, aluminum-coated paper, aluminum-coated plastic, thermocol, cloths, medical waste, tablet covers, electronic items, wooden items, chemical items, x-ray films, expired tablets and inerts. The recyclables are channelised to recycling plants; the non-recyclables are baled, packed and weighed.

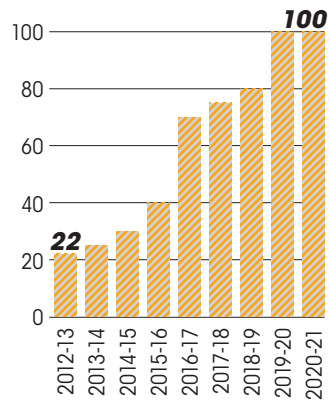
The remaining non-biodegradable waste is transported to a reclaimed land for tertiary segregation, where the waste gets further segregated into 156 categories.

Improvements in Ambikapur – a bird's eye view

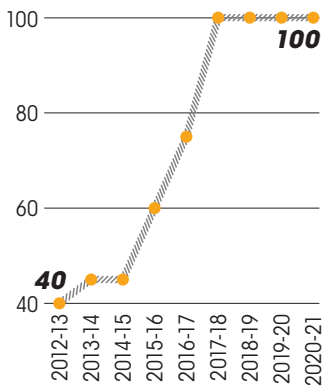
SOURCE SEGREGATION OF WASTE (tonne)



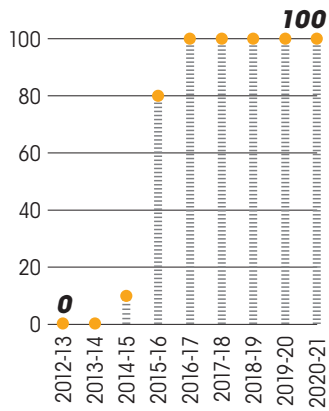
SWM COST RECOVERY (percentage)



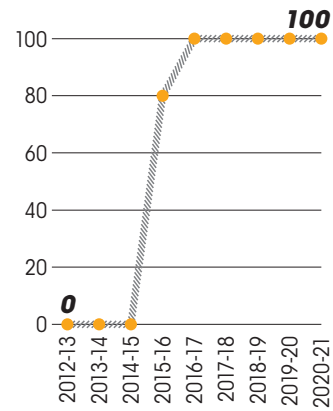
STREET SWEEPING TURNOVER (percentage)



EXTENT OF SEGREGATION OF MSW (percentage)



EXTENT OF MSW RECOVERED (percentage)



Source: Ambikapur Municipal Corporation

Legacy waste treatment: Sprinkling of water and bacterial inoculum – a minimum of 8 litre of water per tonne of mixed waste is required

After the tertiary segregation, the non-recyclables are compressed and converted into cubes, which are then sold to cement plants as a substitute of fuel because of high calorific value.

By 2016-end, the Garbage Clinic model had turned into a success (see Figure: *Improvements in Ambikapur – a bird's eye view*). The *didis* of the SHGs – tasked with spreading awareness and collecting and segregating waste – are the backbones of the system. In 2020, when the COVID pandemic struck, these workers accepted the challenge of helping the town fight the virus: at a time when Ambikapur faced a shortage of masks and sanitizers, these women set up a start-up unit to manufacture these items.

The money flow

Before the current system was put in place, the cost of cleaning the town was met by the AMC. Following the introduction of the Garbage Clinic model, there has been a decline in expenditure and a rise in incomes. To begin with, the reduction

in costs has happened in collection, treatment and transportation of waste: the use of manual rickshaws and e-rickshaws in collection, the complete stop on landfill and leachate treatment, and the reduction in cost of transportation from secondary to tertiary units have helped (most of the paper waste is sold and the wet waste is converted into manure at the secondary unit).

Viability gap funding support has dropped as well in the same period, from Rs 10,50,000 to Rs 3,90,000.

There has been a rise in collection of user charges as the service gets better – from Rs 1,26,000 in 2015-16 to Rs 12,62,000 in 2018-19. Sales of recyclable material and compost (including cowdung which is sold under the brand name of Go-dhan at Rs 2 per kg) have witnessed a five-fold jump, from Rs 92,000 worth of sales in 2015-16 to Rs 5,25,000 in 2018-19.

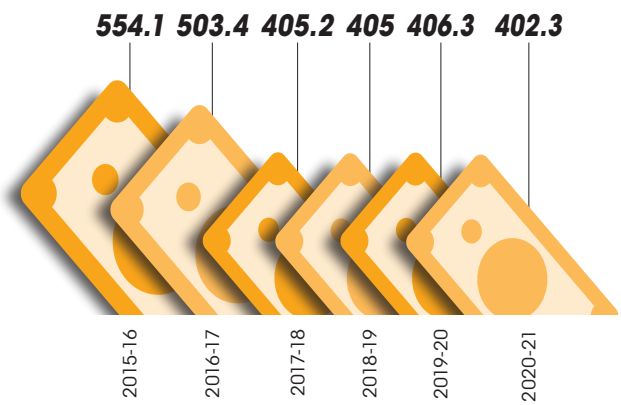
The income is being used for keeping the town clean (see Figure: *Annual expenditure and income*). What has worked in Ambikapur

WHAT HAS WORKED

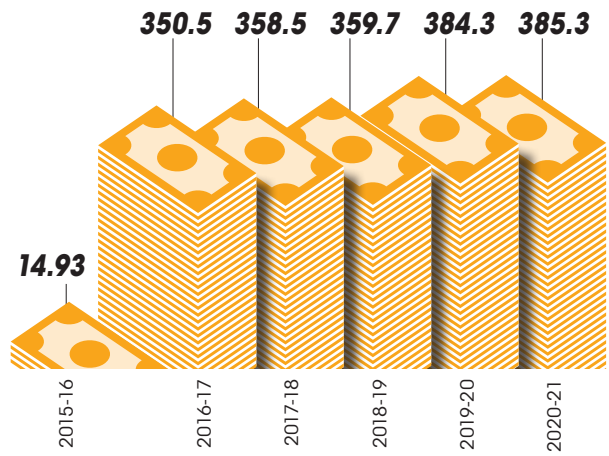
The involvement of women-dominated SHGs and the willingness of the AMC to integrate them into the town's solid waste management system has been a remarkable step. User charges collected from households and the income from sale of waste and manure, which are then used to pay the salaries of

Annual expenditure and income

Expenditure (in Rs lakh)



Income (in Rs lakh)



Source: Ambikapur Municipal Corporation

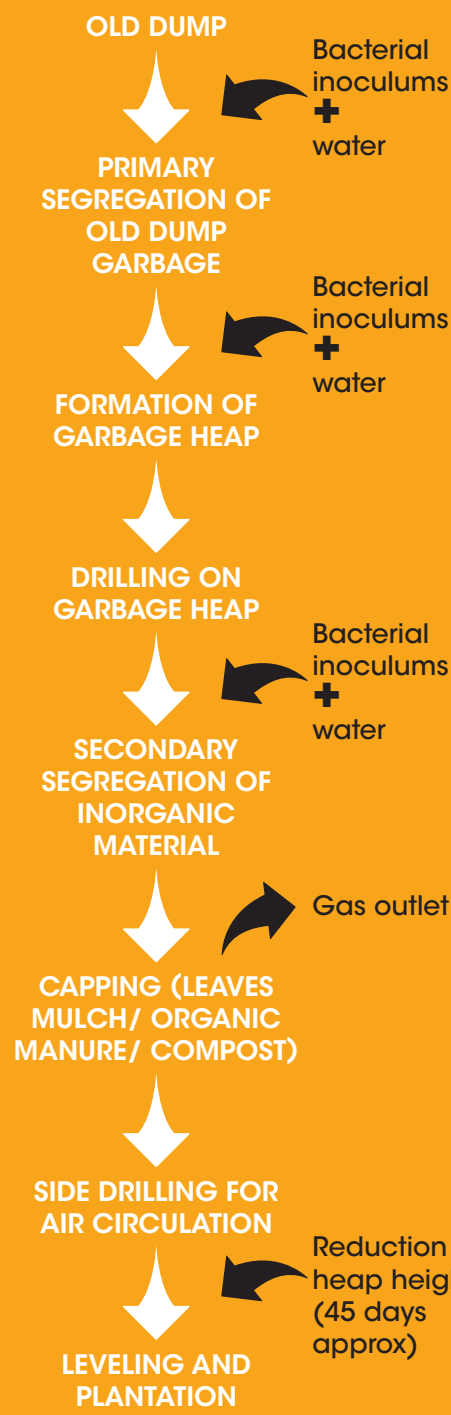
Tertiary segregation and storage area

workers, has made this model sustainable.

At the federation level, the staff have been kept highly motivated and a sense of ownership has been developed. There is continuous monitoring of the SLRM centres through regular interactions with SHG members. Efforts have been made to keep the federation dynamic in its internal decision-making. A continuous outreach programme has been conducted for farmers to promote the use of organic compost.

The AMC has ensured that no waste is dumped in landfills, and that all the waste is treated and used as a resource for generating revenue. Over 6,986 sq m of land has been freed from encroachments and a sanitation park has been built at a cost of Rs 280.54 lakh.

Legacy waste treatment and dumpsite remediation in Ambikapur



Impacts

- Ambikapur has become the first municipal corporation in India to be free of garbage dumping sites; it is also ensuring scientific processing of organic and inorganic waste.
- There has been a positive impact on public health: a dip has been noted in the disease burden of the town. For example, cases of acute diarrhea reduced to 77 in 2020 compared to 156 in 2015.
- The initiative has helped reclaim 16 acres of land valued at Rs 25 crore, and has generated over 500 green jobs.
- It has empowered the women who are members of the SHGs; they have been provided uniforms and safety gear, which gives them and their work a sense of dignity and security.
- The city's waste management system has become financially sustainable – waste collection and transportation costs have gone down, while there have been increases in collection of user charges as the service gets better, and in sales of recyclable material and compost. Viability gap funding support has reduced.
- The town has won recognition for its feat – its model has been recommended by the National Green Tribunal; it has won the Skoch Award in 2015 and was a semi-finalist for the CAPAM International Innovation Awards; and it was shortlisted for Swachh Bharat Mission (Urban) Awards Field Study. It is listed among eight best practices on SWM by the Union Ministry of Urban Development. The Chhattisgarh government has adopted it for replication across the state.

LESSONS LEARNT

Inform, educate, communicate: Ambikapur showcases how IEC (information, education and communication) activities are crucial for spreading awareness and building public opinion and participation. This has been accompanied by regular follow-ups by SHG members and AMC staff, identification of households unwilling to be a part of the initiative and penalising them, and identification of littering spots and deploying corporation staff for imposing fines.

Nurture a sense of ownership: Continuous interactions with SHG members to identify issues and concerns and ensure that efforts are made for their resolution has been critical for the success of this initiative. A modern ICT-based monitoring system (including an android app for attendance, CC cameras, mobile-based vehicle tracking system and MIS for data collection) has also played a role.

Waste is not a liability: The key learning from Ambikapur has been that waste should not be treated as waste or a liability – it has to be reduced, reused or recycled.

Legacy waste treatment: Jute capping, after which the entire waste surface is covered with capping materials like leaf mulch/organic manure/compost for two inches for cultivating local grass/ragi to bind the soil on the surface

A decentralised approach to waste treatment and community participation are the keys to sustainable waste management. Workers employed and monitored directly by the community are more accountable than sanitary workers employed by the government. Community efforts need to merge with the government's efforts in waste management for improved efficiency.

REPLICABILITY

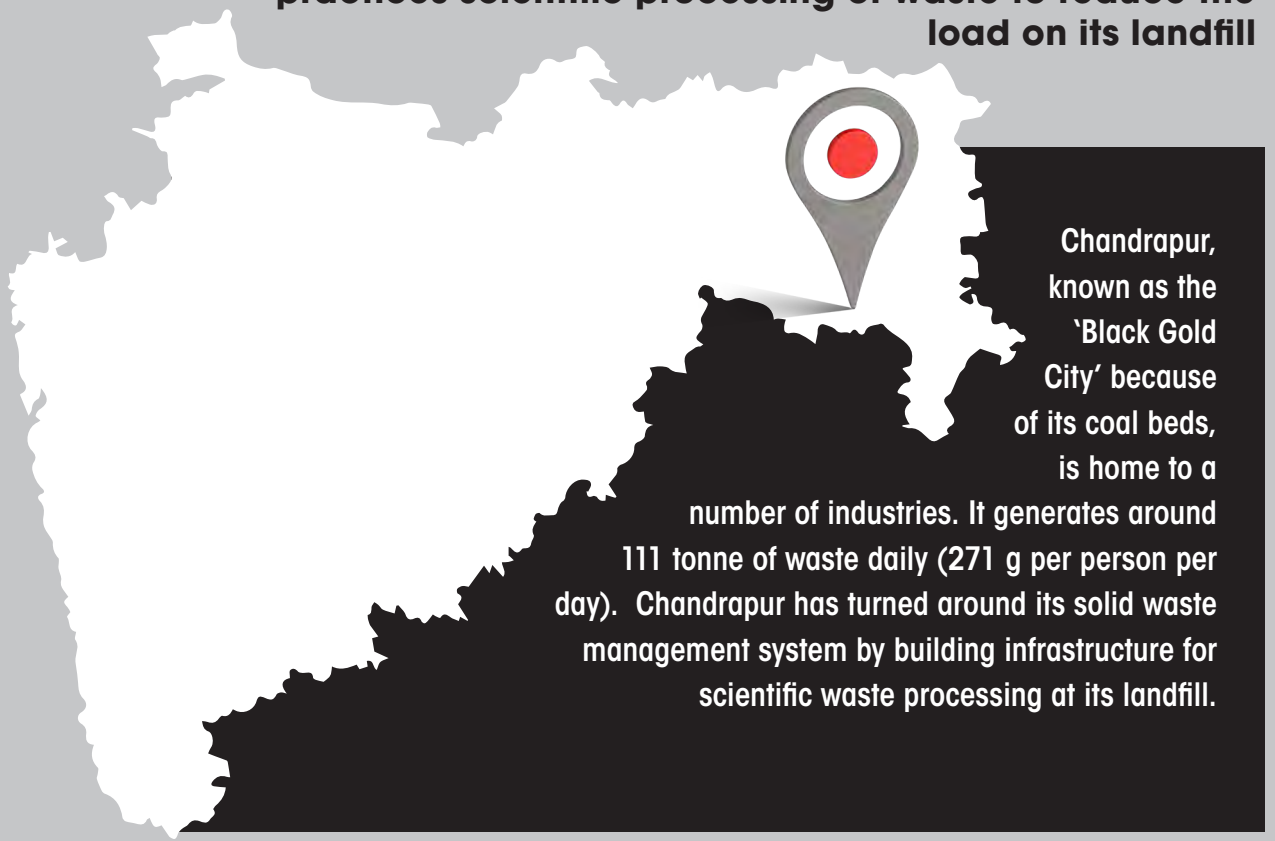
For replicating the Ambikapur model, a municipality needs to concentrate on four areas. – source segregation, decentralised approach to waste treatment, efficient collection and recycling mechanism, and intervention of women or marginalised sections in the waste management chain. The Chhattisgarh government has initiated Mission Clean City, under which the Ambikapur model is being replicated in 166 out of 168 cities and towns of the state. Some states such as Uttar Pradesh, Kerela, Haryana and Andhra Pradesh have expressed an interest in following the Ambikapur model.

Ambikapur's zero-landfill model offers a technically correct, environmentally and economically sustainable, socially significant, alternate and easily replicable model for solid waste management. By involving women from urban poor families, the model creates hundreds of green jobs. By balancing fixed wages and variable returns from sale of recovered goods, it provides for a dual income that in turn ensures sustained interest of the workers in their jobs.

MAHARASHTRA

CHANDRAPUR

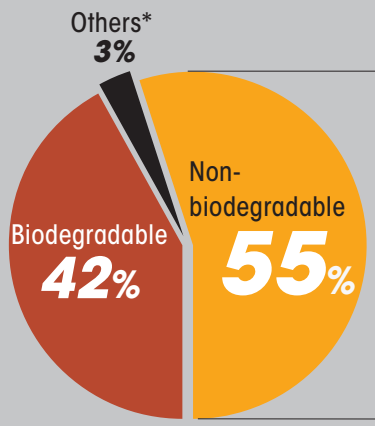
Chandrapur has mandated source segregation and practices scientific processing of waste to reduce the load on its landfill



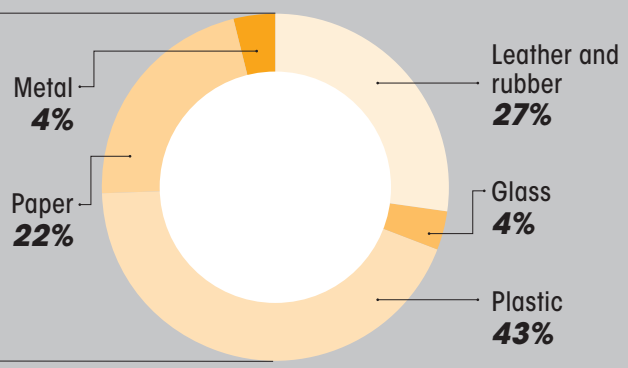
Chandrapur, known as the 'Black Gold City' because of its coal beds, is home to a number of industries. It generates around 111 tonne of waste daily (271 g per person per day). Chandrapur has turned around its solid waste management system by building infrastructure for scientific waste processing at its landfill.

Total waste composition

Total waste **111 TPD**



Non-biodegradable waste composition



* Others include inert, domestic hazardous waste, e-waste, and C&D waste

Source: Chandrapur Municipal Council

Population (in million, as per 2011 Census)
0.32

Estimated current population (in million)
0.41

Estimated floating population (daily)
6,100

Area (sq km)
56.2

Number of households (2021)
79,864

Number of wards
17

Number of zones
4

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
111

Number of sanitation workers
260

Number of community bins
28*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
226

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
85

Percentage of waste processed
95

*According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Chandrapur Municipal Council

THE TRANSFORMATION

Before 2016, Chandrapur Municipal Council (CMC) used to collect mixed waste from households – comprising biodegradable, non-biodegradable and household hazardous fractions – and dump all of it in the landfill in Ballarpur, located on the Nagpur-Chandrapur highway. The mixed waste at the landfill led to a foul stench, land degradation, groundwater pollution, release of a large amount of greenhouse gases, etc., in the vicinity. Due to a lack of awareness about the ill-effects of open burning, it was practised around the dumping ground. There were 800 garbage-vulnerable points and 110 community bins in the city. Littering was common across the city.

Things started to turn around after the Swachh Bharat initiative began in 2016. Now, Chandrapur is segregating nearly 85 per cent of its solid waste into three major categories: biodegradable, non-biodegradable and domestic hazardous. Domestic hazardous waste is further sub-segregated at the secondary sorting facility within the landfill. About 95 per cent of the waste is recycled, processed and recovered, thereby reducing the waste going to the landfill to a bare minimum. Around 800 households have also started practising home composting, diverting some of the organic waste that used to end up in the landfill.

HOW THE SYSTEM WORKS

A proper route map was designed afresh for the collection of waste from households. Residents were asked to segregate into three major categories of waste. Two-bin-one-bag system is followed for collection of segregated waste. Two colour coded bins have been provided to all houses for non-biodegradable and biodegradable waste, while domestic sanitary and household hazardous waste are collected in bags, as they are generated in smaller quantities. For e-waste, common community bins have been set up. C&D waste is collected through an on-call mechanism. A separate compactor has been commissioned to collect C&D waste.

Collection of waste is done daily in tricycles from narrow alleys and in auto tippers for the main

Dealing with legacy waste

In 2016, Chandrapur mandated segregation to improve basic waste management. However, legacy waste in the landfill was a major problem. To deal with it, Chandrapur decided to remediate its landfill through biomining. As per a survey conducted on the dumping site by the city authorities, a total of 68,593 m^3 of waste was dumped on the site spread across 1.6 hectare and with a height of three metre. A private concessionaire was hired to remediate the landfill. By 2019, when their contract expired, they had remediated 85 per cent of the landfill and the remaining 15 per cent is in the process of being remediated. A portion of the remediated landfill was converted into a sprawling garden.

roads and commercial complexes. GPS tracking systems have been installed in all auto tippers to make sure they do not deviate from their set routes.

Over three hundred compartmentalised bins have been installed in public places and an app for collection of waste – 'Recycle-U' – has been created. People are encouraged to practise composting of organic waste at the household level. The municipality has provided home composters to many households. The CMC also announced that they would buy compost at Rs 4/kg from those residents engaged in home composting.

A house-to-house survey was also carried out to ensure that waste segregation and house composting are carried out effectively and efficiently.

CMC has issued a number of notifications to provide impetus to efficient waste management practices. Violations include littering, open burning and non-segregation of waste. Fines are imposed on violators. These fines range from Rs 200–2,000. Notices

Sub-segregated waste at the material recovery facility

displaying violations and the fines asscoiated with them have been prominently displayed at various junctions to grab people's attention.

Awareness programmes were initiated by the CMC in order to encourage residents to practice segregation of waste at source. A Project Management Unit was formulated to manage the entire campaign. Skits and plays were organised. IEC (Information, Education, Communication) played a crucial role. Audio-visual clips were used to screen the message for the entire city through a mobile van.

Many workshops were also organised by CMC for capacity building. One such workshop for students was named 'My role toward cleaner Chandrapur'. In the workshops for *ghanta gadi* workers, every labourer collecting waste was trained. This helped workers understand the concept and objective of the programme and recruited them as active partners. Agencies were also identified to train ULB personnel and orient the elected representatives towards the new programme. A series of sequential trainings was carried out at all the levels from top management to the field workers.

Eleven NGOs have also been empanelled by CMC to conduct awareness and capacity building exercises via corner meetings, door-to-door trainings and *nukkad nataks*. CMC came up with the concept of 'Corner Meetings' that were held fortnightly. In 2017 they started an 'Adarsh Ward Competition' to encourage wards to effectively segregate their waste.

Existing infrastructure for solid waste management at the landfill

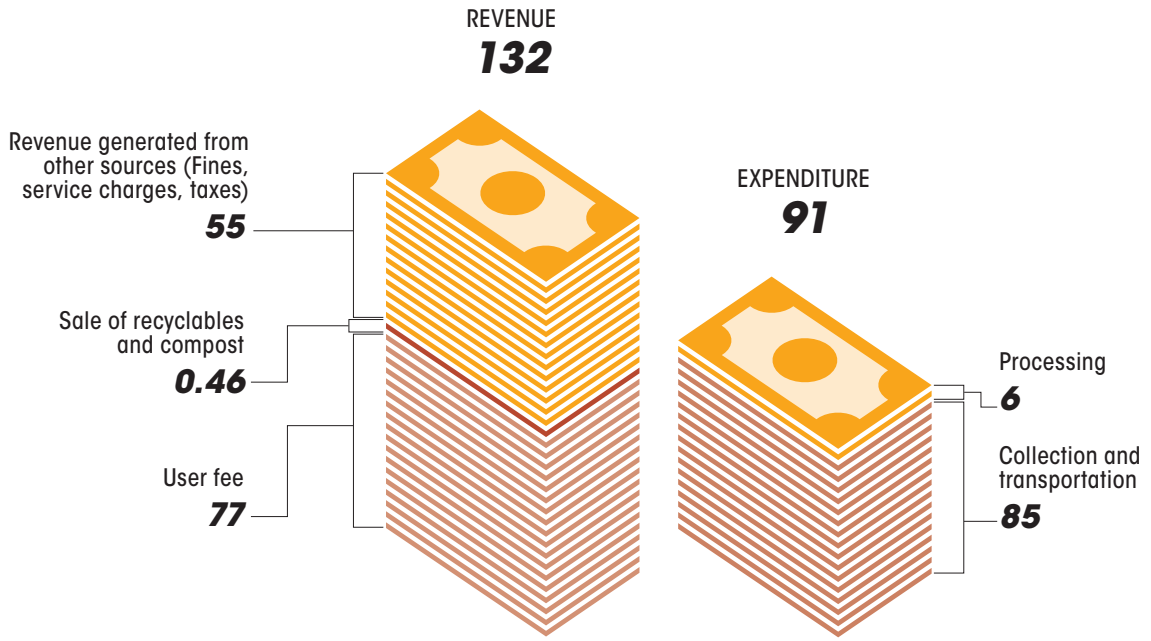
The landfill is an integrated plant with many waste processing units to take care of all types of waste collected by CMC. It has been divided into separate zones to deal with different streams of waste, each with their own set of labourers. Incinerators have also been installed to handle domestic sanitary and hazardous waste.

- Unit 1 (Non-biodegradable waste processing unit): Workers segregate non-biodegradable waste, including plastic, into sub-categories. The waste is then baled with the help of a hydraulic press and collected by recyclers. Non-recyclable material, mostly rubber, leather and thermocol, is sent to the nearest cement kiln to be used as refuse-derived fuel (RDF).
- Unit 2 (Biodegradable waste processing unit): Data on biodegradable waste collected is maintained in a logbook. Biodegradable waste is treated by windrow composting. Compost is used in parks and gardens in the city and sold to farmers for a minimal price. Rejects, if any, are dumped in the sanitary landfill. A vermicomposting unit has also been set up.
- Unit 3 (Hazardous waste storage unit): Data is maintained in a logbook. Hazardous waste is disposed of as per norms through third party vendors.
- Unit 4 (Scientific landfill): Rejects received directly from the city and the other units of the integrated plant are deposited at the scientific landfill. Data is maintained in a logbook.

WHAT HAS WORKED

Chandrapur makes more money from its waste management system than it spends. This not only makes the system self-sustaining in the long run but also makes it a positive source of revenue which can be used to mantain and improve the system.

Monthly finances (in Rs lakh)



Source: Chandrapur Municipal Council

CMC has adopted a holistic approach to waste management by paying equal attention to every step in the chain. It mandated source segregation, along with conducting awareness programmes and imposing fines. It redrew its waste collection plan and achieved 100 per cent door-to-door collection. No resident has to worry about the disposal of waste anymore. CMC's own initiative and efficiency has motivated residents to do their part as well and stop littering in public spaces and dumping mixed waste in community bins. After collection, the waste is taken to a state-of-the-art waste treatment facility where different streams of waste are dealt with in ways most suitable for each of them. Chandrapur's waste management system has become so efficient that barely any waste is left at the end of it which needs to be dumped in the landfill. All waste is treated and used as a resource to earn revenue.

Locals, especially those from marginalised backgrounds and those with a history of working with waste, have been employed at all levels of the new waste management system. They bring traditional knowledge with them which is very useful to take the system over any hurdles that are encountered during the way. Since this provides formal employment to those who have had little taste of it before, the workers are deeply motivated to keep the system running smoothly in the long term.

LESSONS LEARNT

Let waste work for you: CMC provides us with a very good example of what can be achieved when waste is seen as a resource and not as a problem. By adopting optimal practices, CMC has converted waste from a liability to a source of revenue. This revenue can be ploughed back into the waste management system or used to fund other useful initiatives for the city.

Impacts

- Chandrapur's landfill management has made it the second cleanest city after Navi Mumbai in all of Maharashtra.
- From being ranked 76th in Swachh Survekshan 2017, Chandrapur moved to the ninth spot in the Swachh Surveskhan 2020.
- The 8-hectare landfill on the outskirts of the city was improved and updated to handle almost all types of waste.
- A 1.6-hectare garden has been set up on the landfill after remediating that area.
- The initiative has led to huge reductions in the cost of solid waste management. Previously, mixed waste could not be managed and led to various kinds of pollution that costed the corporation socially and economically.
- Hundreds of workers were given employment, including a number of women, be it at the landfill or the waste collection vehicles.
- Garbage-vulnerable points reduced to zero from 800.

Develop infrastructure: The landfill wasn't developed enough to tackle waste generated daily in the city. There was hardly any breathing space left for more waste to be added to the existing heap. CMC developed the landfill and outfitted it with necessary equipment and machines to pre-process all types of waste. Only after the infrastructure was in place did the CMC develop a skilled workforce to handle the new systems.

Integrate existing informal workforce: Most of the former rag pickers were integrated into the system by being given work in waste processing units. This helped not only in giving them stable employment but it is also the most efficient way to run the programme as rag pickers have both traditional knowledge about sorting waste and developed skills due to lived experience. It saves the cost of training new people as well. Every waste worker earns around Rs 7,000–9,000 a month, which allows them to achieve upward social mobility.

REPLICABILITY

A few things are very important to remember for replicating Chandrapur's model. One is to change the psychology of citizens in order to achieve a high level of source segregation. Second is to adopt scientific waste processing techniques to ensure that most of the waste is properly treated.

The involvement of locals and existing rag pickers is also a must. Only when the stakeholders on the ground are fully integrated can the model run sustainably. Not only does this improve waste management, this also improves the economy of the city by providing formal employment to hitherto excluded sections of society.

KERALA

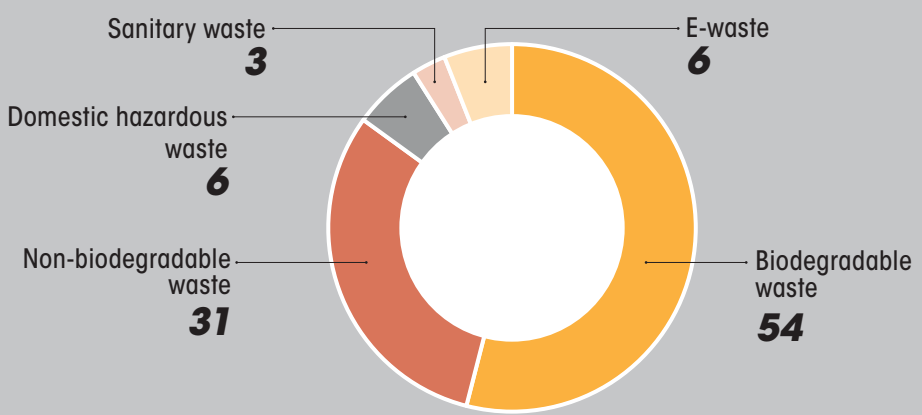
TALIPARAMBA

Decentralised action helps segregate waste and reclaim the landfill

Taliparamba is located in the district of Kannur in Kerala. The town is fortunate to have two rivers flowing through it. Till 2012, the town was sending all its waste to a 2.5-acre (a little over 1 hectare) dumpsite, affecting the local population and environment in the usual manner. Taliparamba reinvented its waste management practices and adapted a decentralised system after 2012, with local women playing a stellar role.

Composition of waste in Taliparamba

Daily quantity in percentage



Source: Taliparamba Municipality

Population (as per 2011 Census)
44,827

Estimated current population
45,600

Estimated floating population (daily)
NA

Area (sq km)
25

Number of households (2021)
11,600

Number of households paying user charges
11,600

Number of wards
34

Number of zones
NA

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
14

Number of sanitation workers
57

Number of community bins
NA

Number of garbage-vulnerable points
NA

Waste management vehicle fleet size
4 auto tippers and **1** tipper

Percentage of households covered under door-to-door waste collection
85

Percentage of households segregating waste
85

Percentage of waste processed
98

Note: According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Taliparamba Municipality

THE TRANSFORMATION

Management of solid waste has always been a bugbear for almost every local government institution in India – Taliparamba was no exception. In 2012, the municipality woke up to the dire need for optimal management of the waste it generated. The dumpsite was recovered within three months at a project cost of Rs 1,969,800.

The town began segregation with active participation of its residents. The slogan of '*My waste my responsibility*' became the call of the hour. The municipality started an intense sensitisation drive. It launched an app called 'Nellikka' to monitor the work. A women's self-help group (SHG) called 'Haritha Karma Sena' was created out of Kudumba Sree, a Kerala state government initiative for poverty eradication and women's empowerment. The members of the SHG were appointed for collecting as well as segregation of waste.

Today, 85 per cent of Taliparamba's households adhere to the door-to-door collection process conducted by SHG members – a majority of these households pay a user fees for collecting the waste from their houses. The municipality has signed a contract with Nirmal Bharath Trust, an agency that manages plastic waste. The agency trains the SHG members to segregate the waste and sell it. For its services, it charges Rs 50 from every household and Rs 100 from every commercial establishment. The money that is collected pays the salaries of the SHG members.

Taliparamba's implementation strategy

The implementation strategy adopted by the Taliparamba municipality is door-to-door collection of waste by the Haritha Karma Sena'. Households are encouraged to compost their biodegradable waste themselves. This approach has served to promote the habit of source-level segregation – the municipality has provided bio-bins for this purpose to the households.

The municipality has two push-carts, four auto tippers and one tipper for transporting the waste. The complete system is managed and overseen by Nirmal Bharath Trust and monitored by the municipality. Egged on by the municipality, about 9,500 households have started practicing home composting and producing fertilisers.

The money flow in Taliparamba

Parameters (monthly)	Amount (in Rs)
Expenditure on collection and transportation	120,000 (cost borne by the agency)
Expenditure on processing of waste	50,000 (cost borne by the agency)
Expenditure on disposal	50,000 (rejects/road waste disposal, cost borne by ULB)
Total expenditure on MSW management	**220,000**
User fee collected	435,000 (collected by the agency)
Revenue generated from selling of compost and biogas	NA (the compost is distributed free of cost to farmers)
Revenue generated from selling of recyclables, RDF	150,000
Total revenue generated	**585,000**

Source: Taliparamba municipality

The town has four decentralised organic waste processing facilities, each with a capacity of one tonne; these use the aerobic composting method. Taliparamba also uses the centralised 'windrow' technology in one facility with a processing capacity of five tonne per day.

The services provided by the SHG members are monitored through the mobile application 'Nellikka', where the registered user can access information on households and institutions from where the waste is collected, the quantity of plastic waste collected, etc. The plastic waste collected is brought to the MCF (Material Collection Facility) and segregated by SHG members with the help of machines; the segregated waste is then sold.

Remediation of the dumpsite

Taliparamba's bane was its 30-year-old dumpsite, located in Karibam. The municipality has reclaimed the dumpsite land over a three-month period. The site now houses the town's Material Recovery Facility, where waste is treated as a source of income for the SHG members. The Facility, built at a cost of Rs 4,691,276 and housing machinery worth Rs 2,967,000, generates a monthly revenue of Rs 5,855,000.

WHAT WORKED IN TALIPARAMBA

- Community participation and action, driven by sensitisation programmes
- Institutionalisation of a wide range of good practices – door-to-door collection through a GIS-based route plan, primary segregation at source, secondary segregation at specialised centres, segregation and recycling of inorganic waste, and treatment of organic waste through composting.
- Participation of women-run SHGs
- Integration of informal scrap dealers – recognising their role in management of the town's waste, the municipality has decided to register them and is providing identity cards to them.
- Development of the monitoring app, which brought all information to the fingertips of those who have registered

Impacts

- The Kerala finance minister mentioned the 'Taliparamba model' of waste management in the 2021 budget presentation in the state assembly.
- Many of the town's women who have joined the SHG can now boast of secure jobs, and feel financially empowered.
- The mobile-based app for accessing information has encouraged the people to participate in this circular economy.
- Around 15 schools of the Taliparamba municipality are now participating in waste management activities through a project named '*Thelima*'

LESSONS LEARNED

Efficient management of waste can bring about significant changes in the condition of the community – health conditions in Taliparamba, for instance, have registered an improvement. Remediation of the dumpsite has led to a reduction in disease incidence, and helped control the mosquito menace. The town also shows that waste can become a source of income for economically weaker sections.

Inclusion of every strata of the society in this enterprise has helped in changing behavioral attitudes towards waste management, and generating awareness about *in-situ* handling of the waste they produce. The use and application of technology has been an asset – it has made monitoring and accessing information far more easy and flexible.

REPLICABILITY

Taliparamba's 'zero-landfill' model has set an example for local governments across the country. Its mention in the Kerala assembly has triggered interest in it. The town has shown that environmental conservation and economic sustainability can go hand in hand. Kerala – as a state – is aiming to introduce a zero-landfill strategy across all its urban centres.

8 TECHNOLOGICAL INNOVATION

In India, technological innovation in waste management is currently in a nascent stage. There is great potential to harness technological advances in other fields and apply them creatively in the waste management ecosystem. Radio frequency identification (RFID) and facial recognition software can be used to take attendance of workers, door-to-door collection can be improved by tracking vehicles using GPS, public grievances can be streamlined and addressed through mobile apps, solar energy can be used to power waste processing facilities, and the entire operation can be coordinated and managed through a central command centre.

Bengaluru: Has employed several ICT solutions, including an RFID-based attendance system, geo-tagging of collection routes and a mobile-based application to monitor garbage-vulnerable points and impose penalties on offenders, achieving 100 per cent door-to-door garbage collection.

Kakinada: The city has introduced advanced Information, Communication, and Technology (ICT) solutions such as RFID to improve door-to-door waste collection efficiency and GPS to track movement of waste collection vehicles.

Keonjhar: Details of fees and fines collected and the finances of micro-composting centers and material recovery facilities are put on a publicly accessible mobile-based app; littering is monitored through CCTV cameras installed at public places; and penalties are imposed; increasing transparency and efficiency.

Leh: Has installed a solar power-based solid waste management plant which is running successfully, reducing dependence on the electricity grid and saving the city administration money.

Vijaywada: Has adopted QR (Quick Reference) Code-enabled RFID tags for monitoring waste collection, Smart Bins, and GPS-enabled collection vehicles for effective route monitoring.

KARNATAKA

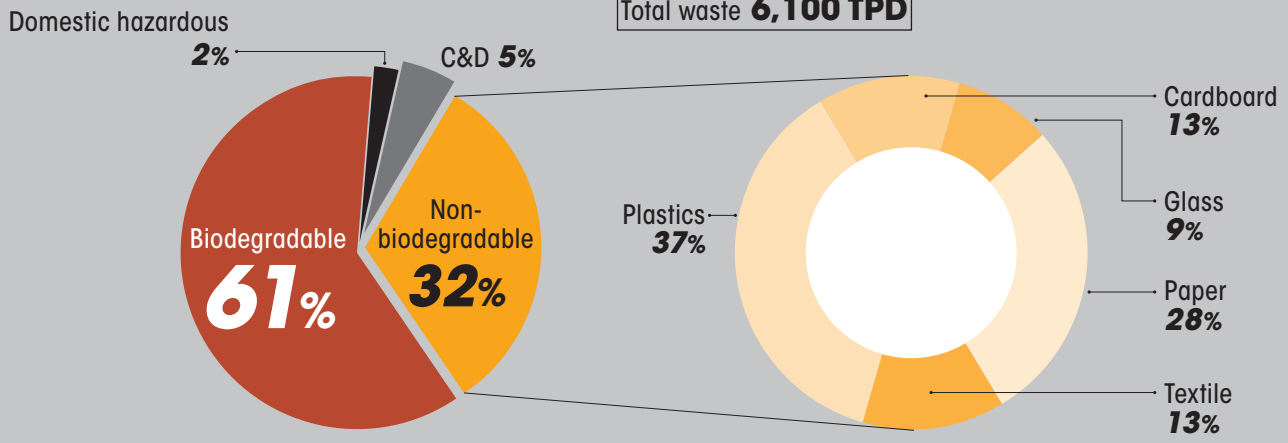
BENGALURU

Bengaluru, the preeminent IT city of India, uses the power of zeroes and ones to solve its myriad waste management woes

Bengaluru is the third most populous city and fifth most populous agglomeration in India. It generates about 6,100 tonne of waste daily (452 g per person per day). Given the importance of the technology sector to the city, the approach that Bengaluru has taken to deal with its mounting waste problem is also tech-based. Technological innovation has transformed the city's waste management system, which has become transparent, reliable and easy to monitor. The problems between civic body officials and contractors that plague large urban local bodies have become a thing of the past in Bengaluru.

Waste composition in Bengaluru

Total waste **6,100 TPD**



Source: Bruhat Bengaluru Mahanagara Palike

Population (in million, as per 2011 Census)
13.09

Estimated current population (in million)
13.48

Estimated floating population (in million, daily)
2

Area (sq km)
713

Number of households (in million, 2021)
3.7

Number of wards
198

Number of zones
8

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
6,100

Number of sanitation workers
18,500

Number of community bins
0*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
4,665

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
33

Percentage of waste processed
53

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Bruhat Bengaluru Mahanagara Palike

THE TRANSFORMATION

In big cities like Bengaluru, it is common to discard waste at the nearest convenient point. This could be at a roadside or next to a drain. Slowly, this informal dumping point grows into a garbage-vulnerable point. Absence of adequate awareness often burdens city governments with cleaning these points with their own resources.

There are three sanitary landfills in Bengaluru: two of these are currently closed and under maintenance; the third is at Mitganahalli, which is operational and is spread over four hectare. According to the Bruhat Bengaluru Mahanagar Palike (BBMP), the total quantity of waste dumped at the site is 2,750 TPD, while the dumpsite already has about seven million tonne of legacy waste. To manage the environmental and health fallouts of this, the municipal corporation has started the process of bio-capping the site, which will take around five years to complete.

To improve the overall waste management operations in the city, BBMP segmented the waste management process into collection, transportation and processing. Each segment has been outsourced to a different concessionaire. While the system was being streamlined, coordination among the concessionaires emerged as an operational challenge, along with ensuring the accountability of each concessionaire. Concessionaires started to complain about timely disbursement of payment while BBMP was unhappy about the quality of services.

In 2020, the BBMP felt that only an efficient system of monitoring waste management systems aided by appropriate technology could improve the scenario on the ground and decided to use a basket of Information, Communication and Technology (ICT) solutions. ICT-based management allowed BBMP to closely monitor the activities of service providers and ensure accountability. Designated routes have been assigned to different concessionaires, and those routes are monitored digitally; each concessionaire is paid only upon completing their share of work satisfactorily. Through the ICT-based technology solutions, BBMP has achieved 100 per cent door-to-door garbage collection. BBMP has also introduced the 'Ezetap' app for imposing penalties on polluters and monitoring garbage-vulnerable points. In about a year's time, BBMP has been able to make the entire

city completely free from garbage-vulnerable points.

The 'technological innovation' enabled BBMP to have real-time data on waste management operations. With automated analysis of this data, BBMP initiated course correction measures, which eventually resulted in substantial improvement in the quality and quantity of services.

HOW THE SYSTEM WORKS

The waste management process is divided into three segments. To update the entire system with new technologies, BBMP adopted decentralised digitisation, i.e. it digitises the waste management chain ward-wise rather than digitising one whole segment before moving to the next. This helps in monitoring the loopholes in the chain.

Door-to-door collection

The first and most important step in managing municipal waste is collecting properly segregated waste from every household. Earlier, the attendance of *safaimitras,* who collect garbage from households, was done manually. This gave rise to many discrepancies.

Radio-frequency identification (RFID) based attendance: To improve monitoring and rationalise payments, BBMP adopted the RFID-based attendance system. A RFID code is provided to every door-to-door garbage collection vehicle and they are instructed to gather between 5:30 a.m. to 7 a.m. at the mustering points. Overall, the city has 587 mustering points where BBMP officials take attendance every morning and assign work. Attendance is taken by scanning the QR code. Anyone who fails to reach on time is marked absent for the day. The code cannot be scanned after 7 a.m.

Safaimitras gathered at a mustering point

Development and execution of web and mobile-based apps: Web and mobile-based applications have been developed to evaluate the performance of all auto tippers and compactors.

Back-end

- Auto-tippers are authenticated through ATR Apk software
- Auto-tippers are assigned individually to zones, divisions and wards

Mobile ATR Apk for auto tippers

- It is mandatory for Health Inspectors (HIs), Senior Health Inspectors (SHIs), and Executive Engineers (EEs) to download ATR Apk on their devices
- One-time verification and approval of each inspector is done through the web admin
- Attendance of auto-tippers is registered through an RFID card allotted to each auto-tipper driver and stored in the cloud server

Fleet management through geo tagging of routes: Each vehicle is equipped with GPS. Junior Health Inspectors (JHIs) allot fixed locations and number of houses to approximately 5,000 auto-tippers which collect garbage daily.

- Every day after attendance, the vehicles collecting segregated waste from households are monitored on a real-time basis for their route coverage. Payment is integrated with the attendance as well as routes covered by auto-tippers.
- A detailed report and alert are generated if:
  - A driver is overspeeding
  - The stoppage is more than five minutes
  - House or lane is not covered or is skipped
  - There is any unusual delay
  - There is a mechanical issue in the vehicle

Black spot removal and penalties: Black spots or garbage-vulnerable points are where city residents dump their household waste resulting in stinking piles. Monitoring and removing black spots was an onerous task for BBMP officials. It has become much easier after the technological intervention. Black spot removal is possible through strict penalties, but only after IEC activities have brought about behavioural change. Ezetap is used for imposing penalties and monitoring black spots. A field marshal is assigned to an area and their role is to monitor and penalise people in order to ensure black spot removal.

Earlier, it was difficult to track black spots manually. With the help of the app, the process of monitoring and removing black spots has become much more streamlined:

- When a black spot is identified, an image with location is uploaded on the app.
- An alert is then sent to the JHI and they must upload the geo-tagged picture of the location after clearing the spot.
- The field marshal monitors the location for 21 days and must upload the geo-tagged picture of any 10 days to close the complaint.
- Point of Sale (PoS) machines were issued to JHIs and field marshals to collect penalties levied on violation of the plastic ban.
- Over 1,100 black spots have been removed till date.
- Over 1,400 penalties have been levied on violators of the plastic ban.
- Over 6,300 penalties have been imposed for littering and open dumping of garbage.

Bengaluru has put in place an RFID-based attendance system for its sanitation staff

Transfer of garbage

Each auto-tipper must unload the garbage at the transfer station into the compactor. The process involves the following steps:

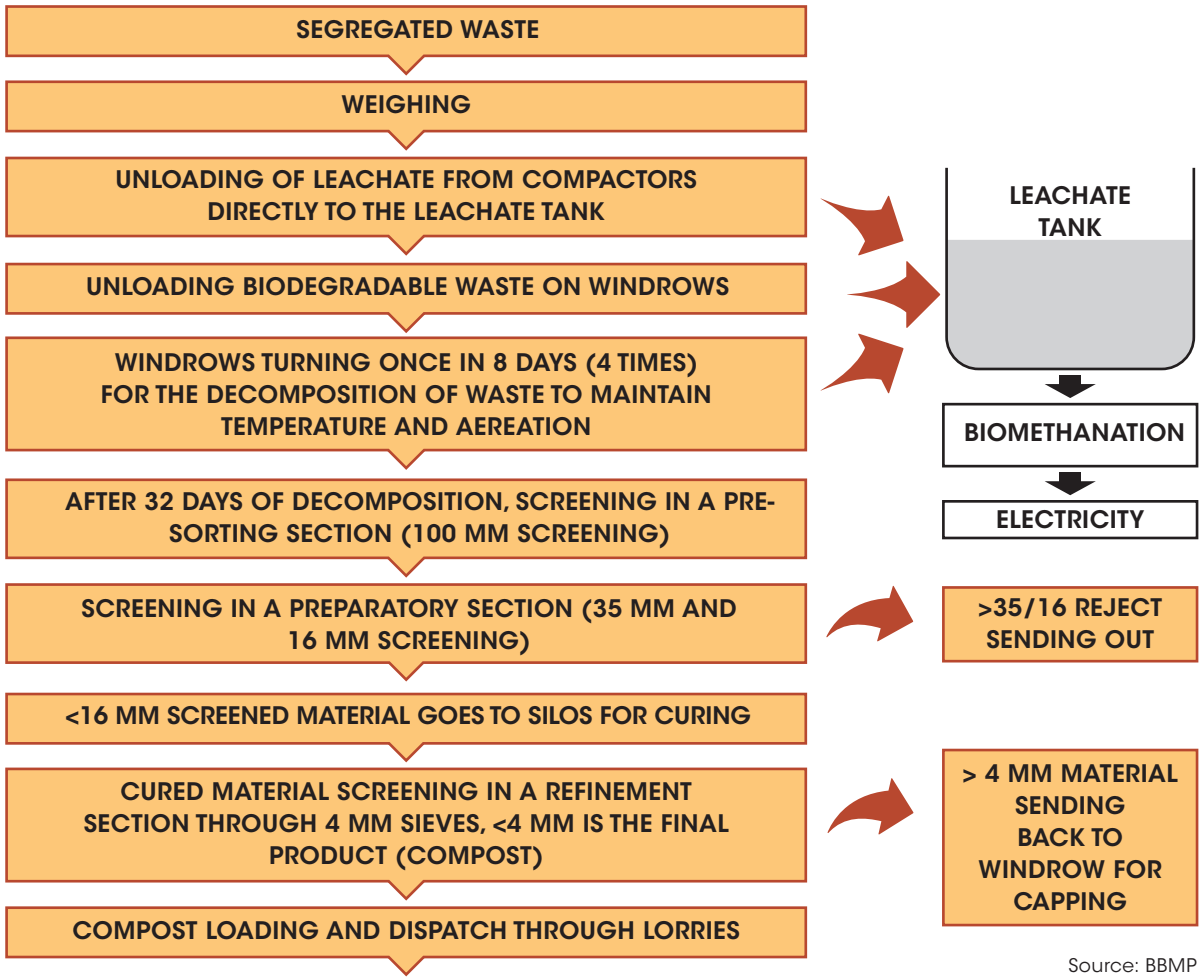
- At the mustering point, the attendance of each auto-tipper is recorded. Mustering points and transfer stations are defined and geo-fenced (work-in-progress for some areas).
- When the auto-tippers arrive with loads at the secondary transfer station, their RFID cards are scanned, images are taken and geo-coding is captured. All this data is stored in the server.
- The process is repeated whenever the auto-tipper visits the transfer station again.
- If the attendance of an auto-tipper is recorded at a mustering point but not at a transferring point, it is reflected in the reports.
- Each auto-tipper can be scanned three times a day.
- Monthly analysis is done using a Python-based algorithm to evaluate the overall performance of collective and individual auto-tippers.

Monitoring at processing and disposal site

From the secondary transfer station, compactors transfer the waste to the facility centres (biodegradable waste processing sites) or the landfill (in case of mixed waste).

- The RFID system is also used for spot attendance of compactors at the processing sites.
- When a compactor arrives at the processing centres, its RFID is scanned, an image is taken, the time is recorded, weight of the garbage is noted, and all this data is sent to the server.
- A detailed report is generated on a plant-by-plant basis.
- Each zone has one plant. Zone-wise report is prepared and rankings are given. Further steps are initiated based on the rankings.

Process followed for biodegradable waste



Source: BBMP

Biodegradable waste processing plants

The BBMP generates 1,200 TPD of biodegradable waste. There are eight plants with a total capacity of 1,570 TPD. All biodegradable waste is transported to the processing sites in compactors. The waste is subject to windrow composting.

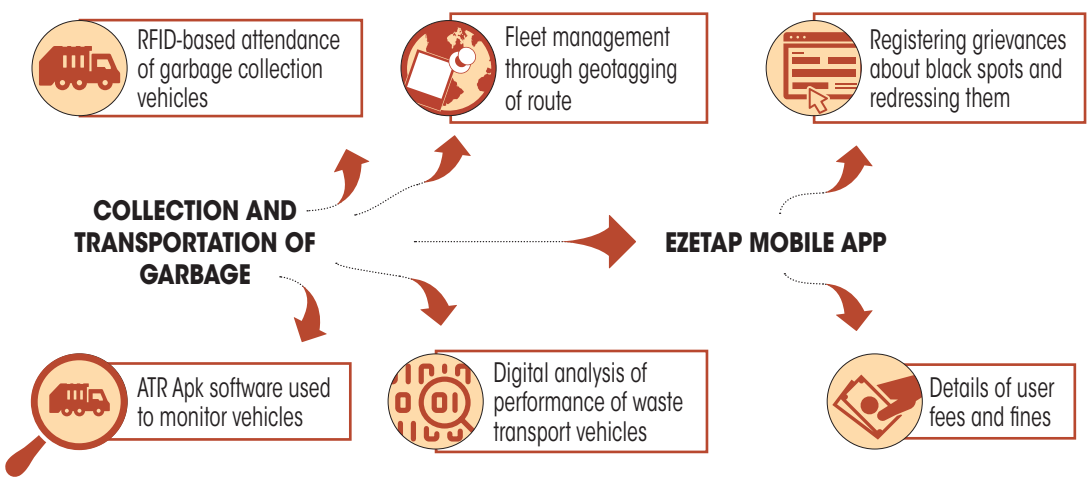
Odour control system for composting plants: The process of composting involves the emission of gases like ammonia, carbon dioxide, methane, oxides of nitrogen, siloxanes, bioaerosols, particulate matter and volatile organic compounds that pose a threat to the staff working in the compost plant as well as to the local environment. To counter the odour, Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC), with the help of National Institute for Interdisciplinary Science and Technology (NIIST), has developed an odour control system based on gas-biofiltration technology, which is one of its kind in India. Gas bio-filtration technology uses microbes as odour removal agents. When passed through the bio-filter, the compounds causing odour are absorbed by microbes, which degrade into nitrogen oxide, nitrates, sulphates and sulphuric acid, later neutralised by limestone.

WHAT HAS WORKED

To improve waste management in Bengaluru, BBMC took some bold steps and digitised the whole waste management chain from collection to processing/disposal. Aiming at better service, better monitoring, and a better way to manage scattered waste piles, BBMP undertook technological innovations.

1. **Accountability:** RFID-based attendance allowed BBMP to keep a tight check on working time. Every driver is made accountable for garbage collection. It gives them work satisfaction and a sense of responsibility along with the opportunity to improve their performance.
2. **Service assurance:** Assigning fixed routes allows BBMC to get a detailed picture of the number of households served. It also reduces the number of complaints regarding missed households. The driver can't shirk work, as an alert is generated for any delay, over-speeding or missed lanes. This ensures 100 per cent coverage of the geo-fenced area.
3. **Hassle-free garbage collection:** The app gives residents freedom to check the location of their door-to-door garbage collection vehicle. Depending on the vehicle's location, they can leave their dustbin outside the gate for collection if they have to engage in other household activities. Along with increasing trust among citizens, this also reduces waiting time for the vehicles.
4. **Mess-free transfer:** Each time the auto-tipper arrives with loads at a secondary transfer station, RFID cards are scanned and images and geocodes are captured and stored in the server. The exact process is repeated if the auto-tippers come again. This helps in keeping track of the number of trips made by any particular auto-tipper. This also helps track vehicles from mustering points to transfer points.
5. **Discipline and rigidity:** After ensuring door-to-door garbage collection, it is necessary to change the behaviour of residents by imposing penalties. BBMP developed an app for this purpose as well. The app provides a detailed report on how many times a person has been penalised and how many people from a particular ward have been penalised. This provides an insight into people's behaviour and allows for the strategisation of IEC activities.
6. **Transport affirmation:** A compactor transports the garbage from the secondary transfer station to the processing plants. Each compactor belongs to a particular

Powered by information technology



Impacts

- Door-to-door garbage collection increased from 65 per cent to 100 per cent after technological intervention. The daily burden on residents to find a place for dumping garbage has reduced. Door-to-door service increased trust among citizens and reduced the stinking piles at the end of the colony.
- Data-driven IEC activities enhance behavioural change and citizen participation. More and more citizens now participate in workshops and adopt community waste management practices for reducing waste.
- There is transparency in payments based on number of trips, and amount of waste collected and transported. Contractors are now more attentive towards service as better service is the only way to get higher payments.
- Reduced fuel, and operation and management cost of vehicles due to fixed routes and RFID which make the system easy, seamless and mess-free.
- After technological intervention, the number of incidents reported regarding fleet mismanagement have reduced from about 280 per year to zero.

processing plant. Once the compactor enters the plant, the RFID is scanned, and the image and weight of the garbage are recorded and stored on the server. The RFID cannot be scanned twice. That ensures accountability.

LESSONS LEARNT

The USP of the model is the use of **digital monitoring** to increase the efficiency and transparency of the waste management system. Usually, ULBs have GPS-installed vehicles but lag in adopting technology that provides accurate data, and dependency on manual work makes the practice short term and unreliable. More than 3,000 ULBs still rely on manual monitoring systems. The integrated digital system enables BBMP to track garbage collection, processing, and material recovery in a data-oriented way. The vehicle tracking system has changed the behaviour of field staff, making them accountable and attentive towards their service.

REPLICABILITY

The technological innovation of BBMP presents a viable, easy, and practical model for adoption by other municipalities. Installation of RFID cards in all vehicles and fixing their routes reduces transportation time and carbon footprint. Hierarchical digitisation allows BBMP to obtain a start to end report of collection, transportation and processing. The data-driven report helps in efficient planning, strategisation and implementation.

Tier 2 and tier 3 cities depend on the age-old practice of manual work, making the system more people-oriented and less efficient and unaccountable.

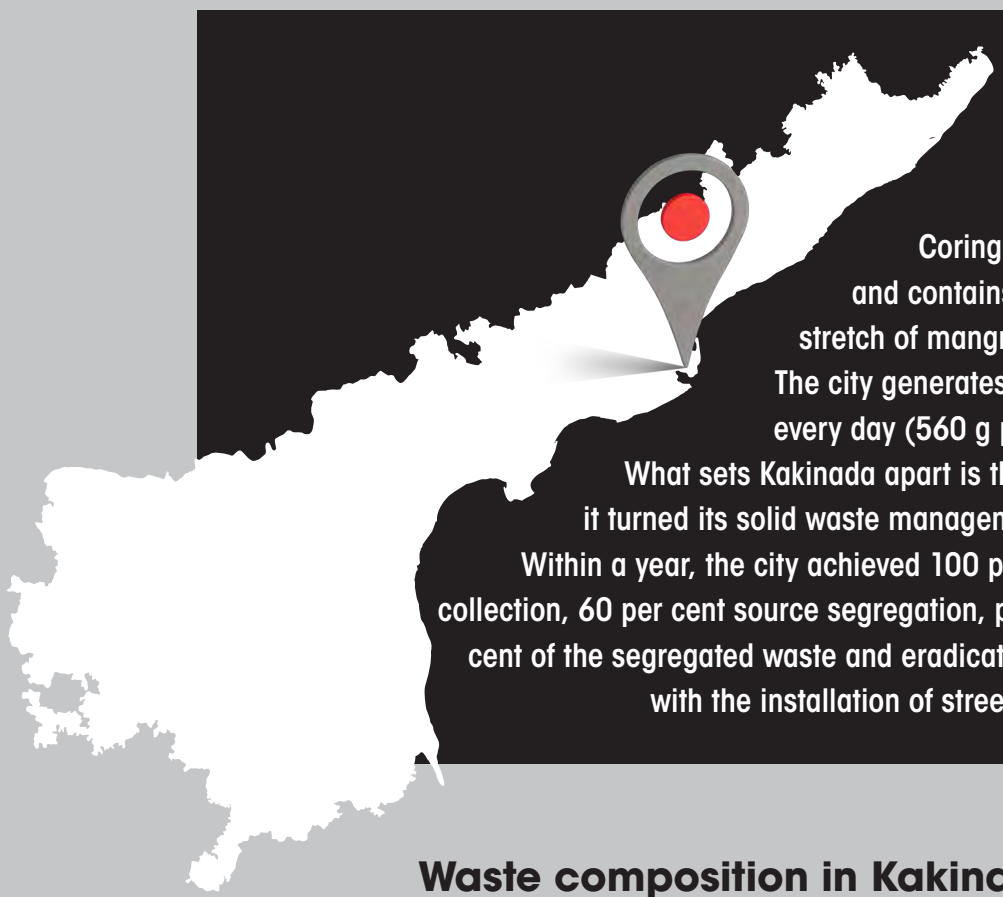
Big municipalities like Pune, Lucknow, and Dehradun are also adopting RFID and geo-fencing to better monitor door-to-door waste management practices.

Hence, BBMP's digital model is reliable and replicable in big and small urban local bodies for efficient monitoring and transparency in waste management.

ANDHRA PRADESH

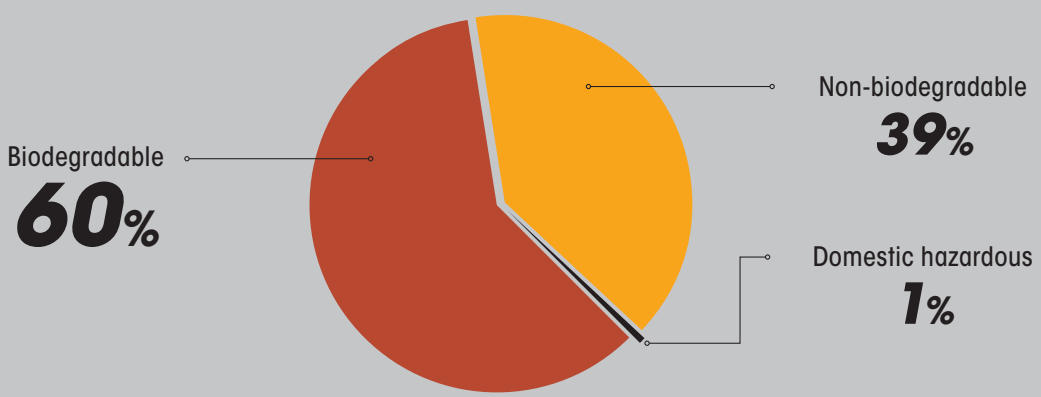
KAKINADA

Kakinada uses technological innovation to leap into a new paradigm of waste management at lightning speed



Kakinada city is situated in East Godavari District, which is host to the Coringa Wildlife Sanctuary and contains the second largest stretch of mangrove forests in India. The city generates 213 tonne of waste every day (560 g per person per day). What sets Kakinada apart is the speed with which it turned its solid waste management system around. Within a year, the city achieved 100 per cent door-to-door collection, 60 per cent source segregation, processing of 84 per cent of the segregated waste and eradication of garbage piles with the installation of street-side garbage bins.

Waste composition in Kakinada



Source: Kakinada Municipal Corporation

Population (in million, as per 2011 Census)
0.31

Estimated current population (in million)
0.38

Estimated floating population (daily)
10,000

Area (sq. km)
31

Number of households (in million, 2021)
0.12

Number of wards
50

Number of zones
4

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
213

Number of sanitation workers
1,206

Number of community bins
51*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
184

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
60

Percentage of waste processed
51

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Kakinada Municipal Corporation

THE TRANSFORMATION

Kakinada Municipal Corporation (KMC) has evolved an efficient mechanism for the collection and processing of solid waste only within the last year. Before June 2020, every street was a dump yard. Municipal staff collected garbage irregularly and 90 per cent of the daily complaints reviewed by the municipality were related to municipal solid waste. Community bins used to overflow and attract stray animals. The corporation was understaffed and clearing those bins on a daily basis was next to impossible. While residents were unhappy with the shoddy solid waste management, KMC was also unhappy with residents for littering with abandon on roads and in public places.

Daily collection of waste from households was limited to about 38 per cent of the city's population, despite deploying as many as 447 personnel to collect solid waste at source. Even the waste collected from these 38 per cent households was unsegregated and transported in 43 vehicles to the dumpsite. Households collection charges were between Rs 30–60 per month. Income through garbage collection was very low and solid waste management was a huge financial burden on KMC, even though it was not being done up to acceptable standards.

The prolonged lockdown due to COVID-19 exacerbated this situation. After a series of deliberations to deal with the situation, the city introduced advanced technology and innovative solutions. Technological innovation helped in collection, transportation and processing of waste. Web-based solutions helped the municipality institute a state-of-the-art monitoring system for oversight of waste management operations. Reducing the number of complaints around solid waste management was taken as one of the yardsticks to measure the performance of the new regime.

Scanning of QR code at a household to confirm collection of waste from the doorstep

HOW THE SYSTEM WORKS

The city prepared a comprehensive sanitation plan in which the roles of citizens, local leaders, municipal staff, corporators, MLAs, SHGs, and NGOs were clearly defined. The plan stressed upon monitoring of waste management systems using the latest technologies. The concept of integrated solid waste management was introduced to ensure end-to-end management of municipal solid waste with a heavy focus on increasing awareness using Information, Education and Communication (IEC) campaigns in the entire city. In order to ensure efficient collection, timely transportation and optimum processing, the city introduced the following technologies:

Radio Frequency Identification (RFID) tags

RFID-based technology was one of the key drivers to improve door-to-door waste collection efficiency across all wards. Each household and bulk waste generator has been given a sticker with a unique QR code. Waste collectors are equipped with QR code scanners and mandated to scan the code upon collection of waste at the doorstep. The handheld device is used to send the details of the household or bulk waste generator with its location and date and time of collection to the centralised command centre at the office of the city corporation. The software connected to the RFID system compiles the data in real-time, which is presented in a dashboard showing the number of sources covered at a given point.

Global Positioning System (GPS)

GPS technology has been in use for more than a couple of decades in various service sectors, including transportation. The city of Kakinada introduced this technology to track the movement of its waste collection vehicles. Every vehicle has been fitted with a GPS device connected to the centralised command centre, where their movement is tracked on the city map. While KMC tracks vehicles to ensure that they are travelling

through the intended route, it also ensures that vehicles collect waste from the source at the right time and transport it to the destination in a timely manner. With the use of the GPS, KMC makes sure that the travel time of every vehicle is consistent with the distance it is meant to cover.

Facial Recognition System (FRS)

Facial recognition is a way of recognising a human face through technology. FRS is used to confirm the identity of a person by mapping their facial features and comparing the information with a database of known faces to find a match. Kakinada implemented FRS to register the attendance of its workers and to ensure that they reach their respective reporting locations on time in order to provide waste management services to the citizens. Implementation of FRS technology by Kakinada made attendance monitoring much easier through a centralised real-time monitoring system.

Human Resource Management System (HRMS) mobile app

The city introduced the HRMS app for its day-to-day waste management operations. This system basically automates HR tasks and helps save money and time as the authorities no longer have to manually keep track of every worker. HRMS has helped authorities identify and trace each worker in every micro-pocket of all wards in the city. HMRS has made it possible to ensure 100 per cent presence of sanitary workers on ground. Whenever a worker is absent due to any reason, the app makes it simple to replace them and get the work done without hiccups.

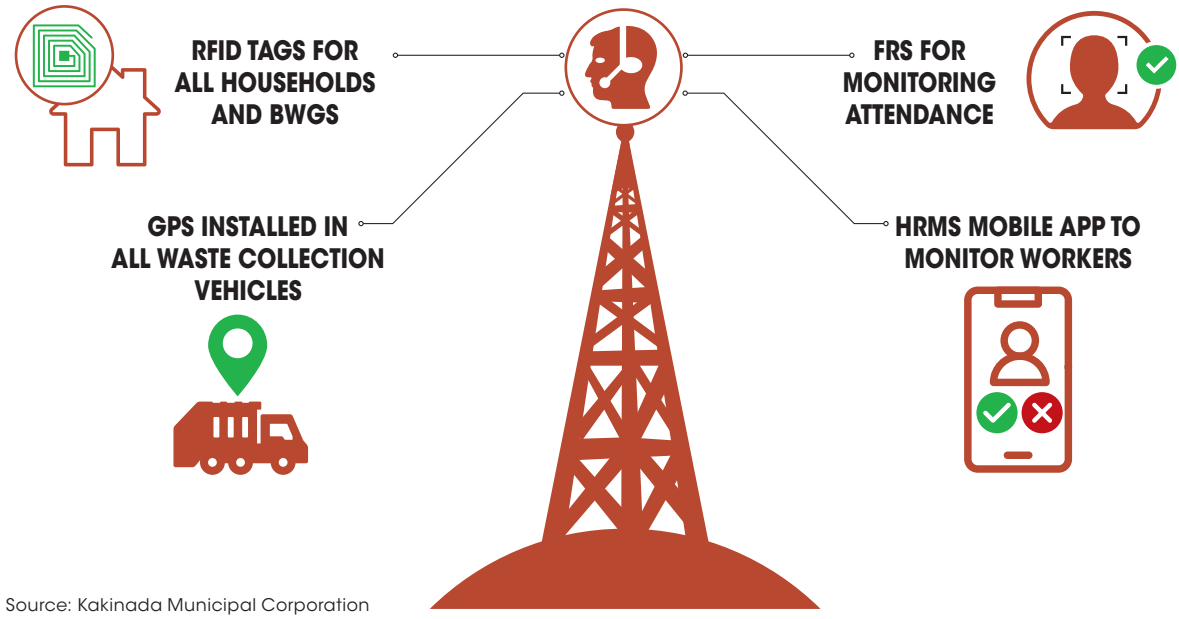
Integrated Command and Communication Centre

Kakinada city set up an Integrated Command and Communication Centre (ICCC) at the office of the city corporation. All the technologies put in place are connected to this centralised facility where a team of trained professionals keep an eye on big monitors to ensure waste management operations are proceeding as planned. They continuously monitor the RFID tags database to check whether the collection target for the day is met within the stipulated time. Simultaneously, they check movement of vehicles to ensure that all vehicles are travelling on only authorised routes. FRS shows the number of sanitation workers reporting for duty at their respective stations. SMS alerts are sent to respective authorities in case of any inefficiency or deviation noticed so that corrective measures can be initiated in a timely manner. Data shows that complaints reduced substantially over time as the system emerged to be an effective tool.

WHAT HAS WORKED

KMC realised that technology alone could not address the challenges of waste management and that participation of citizens is indispensable. Ahead of introducing new technologies, KMC ran a comprehensive campaign across the city to sensitise citizens on the need for source segregation. The campaign also addressed the need to stop littering, while making people aware about various elements of waste processing. Due to this campaign, the level of source segregation increased from zero to 60 per cent within a year, which is a huge change, especially considering source segregation continues to be a challenge in most cities of India.

Integrated command and communication centre



Source: Kakinada Municipal Corporation

The city has so far managed to achieve a processing rate of 84 per cent of collected segregated waste. In addition, total annual revenue earned from waste processing has reached 26 per cent (Rs 45.76 lakh) of the total expenditure (Rs 1.76 crore). This surge in revenue generation has been possible due to increased collection of user charges with the help of a good monitoring system and consistent services to the citizens. Currently, the city is processing 72 TPD of biodegradable waste in two waste-to-compost plants that produce 18.7 TPD of good quality compost. The city is channelising 35.3 TPD of non-biodegradable waste to various recycling facilities. Revenue from waste management operations is expected to increase further with increase in the rate of segregation and improvement in processing efficiency. KMC is also planning to set up an integrated waste processing centre to treat all streams of waste under a single roof.

Some additional initiatives

People's representatives have a larger access to citizens and can impact them more. KMC realised this potential and harnessed it by initiating a programme called Corporator's Emphasis on Sanitation Transformation (CREST). It is a competition among corporators to make their respective wards achieve all the parameters as listed in the Swachh Survekshan 2021 toolkit.

As most of the students in municipal schools of Kakinada are from slum areas, sanitation of slums has been given top priority. Swachh school drives were undertaken to inculcate awareness about segregation at a young age. These students are also expected to go back home and tell their parents and communities about this, hence forming a reliable chain between the city's authorities and the slum dwellers. Other things that have been introduced in all municipality schools under the Swachh school drive are the Green Report Card, Dry & E-waste Collection Passbook, training for preparing eco-bricks, and Swachh School Rankings Assessment programme.

Impacts

- Residents of Kakinada have been sensitised on managing waste and 60 per cent have already started segregating at source.
- Littering in public places has almost stopped completely.
- Complaints about solid waste management in the city have reduced substantially over the past year from 591 in June 2020 to 17 in August 2021.
- 107 tonne of waste is processed daily, thus reducing the pressure on the landfill.
- Good quality compost is generated from processing biodegradable waste while recyclables are segregated from other non-biodegradable waste and sold in the market to generate revenue

LESSONS LEARNT

Waste management is a shared responsibility: KMC successfully ran a campaign in the city which was led by elected representatives and other opinion makers. Each of them was given the responsibility to ensure that their respective wards became litter-free and started segregating waste.

Efficient use of technology: The city utilised available technologies. It not only improved monitoring and quality of services, but also significantly improved recovery, recycling and processing of municipal solid waste.

Adopt the right strategy: KMC managed to maintain a nice blend of technology, people's participation and management systems to turn municipal solid waste into a useful resource.

REPLICABILITY

For replicating the Kakinada model of municipal solid waste management, city governments need to understand the key elements that made it successful. Approach to waste management must always begin by engaging with citizens. Thus, citizens were made aware of the new technologies being used to improve services. In addition to improving the quality of services, the city should also be able to demonstrate that waste can actually be a resource if processed properly in various facilities. The Kakinada model also showcases the use of advanced technology which has redefined 'real-time monitoring' by city authorities. To put things in perspective, KMC's Integrated Command and Communication Centre achieved something with a handful of trained people which is otherwise done by hundreds of people in other cities. The government of Andhra Pradesh recognised KMC's contribution and advised other cities within its jurisdiction to learn from the Kakinada model.

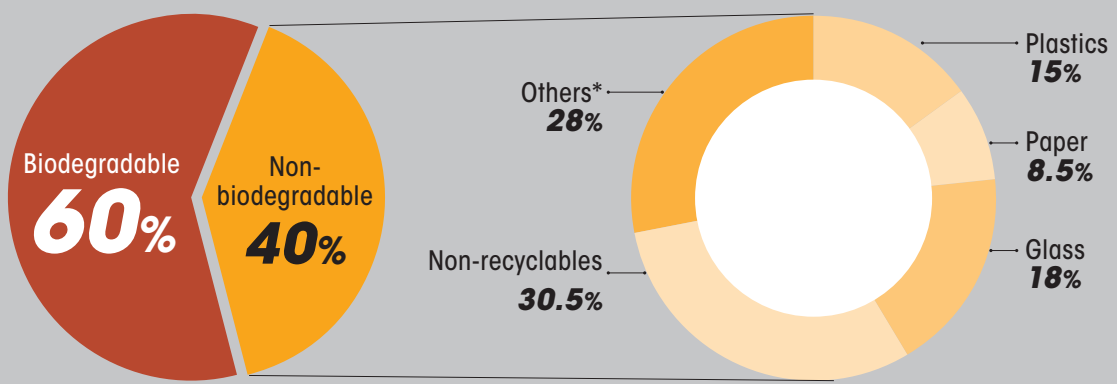
ODISHA

KEONJHAR

Information technology and decentralised wealth centres have helped Keonjhar create an efficient and transparent waste management system

Keonjhar in Odisha, a district with multiple tourist spots, produces about 26.5 tonne of waste daily (400 g per person per day). It has been able to harness the power of information technology to improve the efficiency and transparency of its solid waste management system. Its decentralised 'wealth centres' have opened a window of dignified employment opportunity to the city's women self-help groups.

Waste management in Keonjhar



*Others includes domestic hazarduous waste and sanitary waste

Source: Keonjhar Municipality

Population (as per 2011 Census)
60,590

Estimated current population
67,000

Estimated floating population (daily)
3,000

Area (sq km)
21.93

Number of households (2021)
13,627

Number of wards
21

Number of zones
0

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
24

Number of sanitation workers
182

Number of community bins
0*

Number of garbage vulnerable points
0*

Waste management vehicle fleet size
18

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
100

Percentage of waste processed
100

* According to the Swachh Survekshan ranking (Star Rating for Garbage Free Cities) parameter, zero community bins and zero garbage vulnerable points are strong indicators of an efficient solid waste management system.

Source: Keonjhar Municipality

THE TRANSFORMATION

Keonjhar used to follow a typical Indian model of waste management. Door-to-door collection was carried out in some wards, but it was not regular or effective. There was no source segregation. The city was dotted with garbage vulnerable points. The municipality outsourced a substantial portion of the work (like road sweeping, bush cutting, and drain and tank cleaning) to third part contractors on a tender basis. These contractors would hire cheap labour not trained to handle municipal solid waste systems. There was a dumping site at Judiaghat, but it was not scientifically developed. Some of the waste was also burned – at the dumping site as well as at collection points. A foul smell and smoke used to emanate from the dumping ground continuously, and leachate from it posed a threat to the city's water bodies.

In order to make Keonjhar dumping yard-free, promote source segregation and empower women's self-help groups, the city administration passed bye-laws on August 23, 2017, that were based on the *Model Bye-laws for Urban Local Bodies* issued by the Odisha government earlier that year. A 'waste-to-wealth' programme was envisaged as the vehicle of this change. The programme began in Keonjhar in 2019 and many local self-help groups were roped in to be part of it. The members of these self-help groups were housewives and female daily wagers, who got a source of income and improved social status due to their association with the programme.

HOW THE SYSTEM WORKS

The programme began with an awareness campaign. Members of the self-help groups were trained first and then they conducted a door-to-door campaign with municipal officials regarding the need for improvement in solid waste management, particularly the importance of source segregation.

Households have been provided two types of bins to segregate waste, blue bins for non-biodegradable waste and green bins for biodegradable waste. Door-to-door collection is performed by trained *swachhakarmis* under the supervision of *swachhasathis*, who have also been trained for the job. Local WhatsApp groups

Female self-help group members working at a micro-composting centre

have been created with *swachhakarmis* and residents as members, for everyday communication and better coordination on waste management, and to register grievances. The state government has developed the 'Ama Sahar' app, easily accessible to the general public, providing updated information related to solid waste management. Citizens can also pay user fees through the app.

Segregated waste is directly transported to micro-composting centers and material recovery facilities, which are also known as 'wealth centres'. At the material recovery facilities, non-biodegradable waste is further segregated into different categories like plastic, metal, paper and glass. Recyclable material is sold to registered vendors at rates fixed by the government. Non-recyclable combustible wastes are sent to authorised cement factories for co-processing.

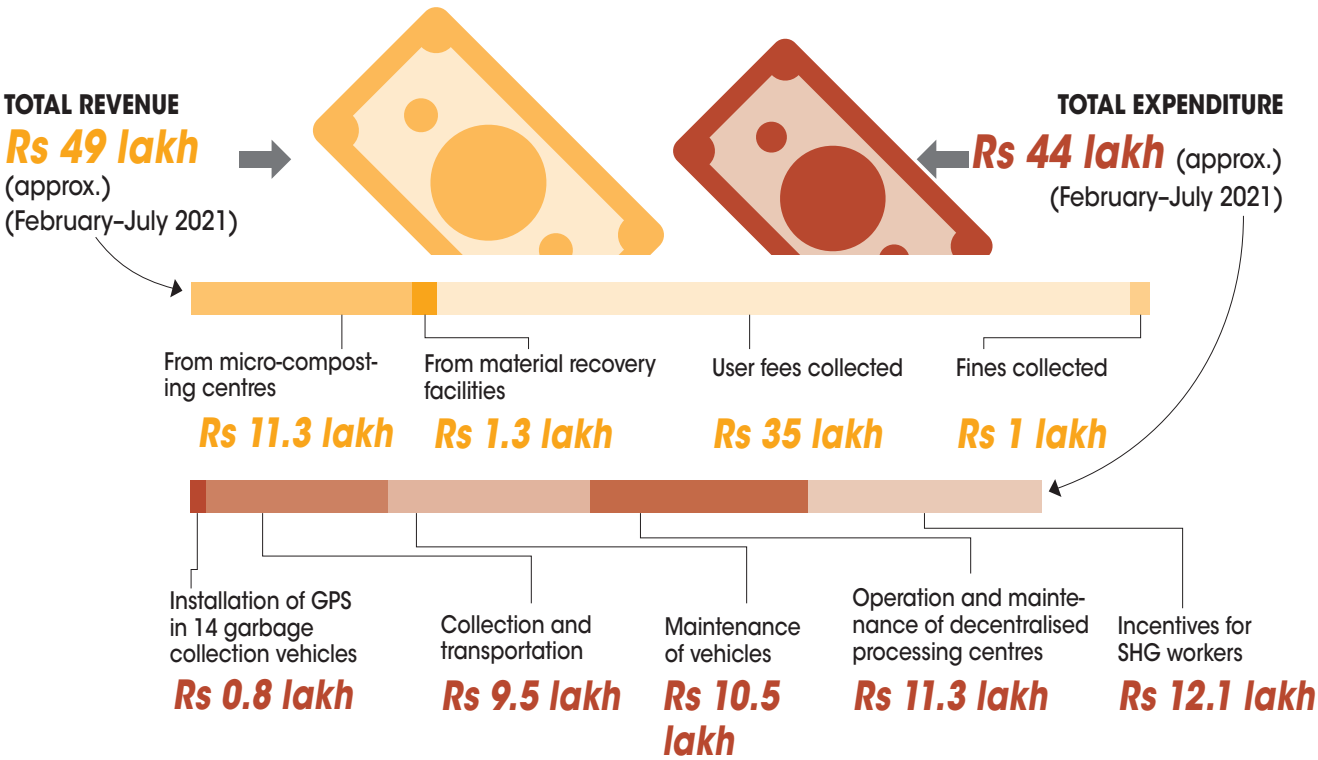
At the micro-composting centers, biodegradable waste is subject to aerobic composting. The organic manure thus produced is branded as 'Mo Khata' and sold at Rs 20 per kg at designated outlets throughout the state.

There are a total of 109 *swachhakarmis* managing solid waste in the city's 21 wards, and its micro-composting centers and material recovery facilities. Initial funding for infrastructure and base development of the decentralised processing facilities came from the government, but now they have become self-sustaining (see *The solid waste management budget of Keonjhar*).

Harnessing information technology

The city has also taken several technological steps to improve its waste management system. First of all, sector mapping was done and route charts of vehicles transporting waste were prepared. After this, all transport vehicles were equipped with GPS to frequently monitor movement. Segregated waste from households is transported in collection vehicles with separate chambers for non-biodegradable and biodegradable waste. The vehicles also have a separate space for transporting sanitary and domestic hazardous waste.

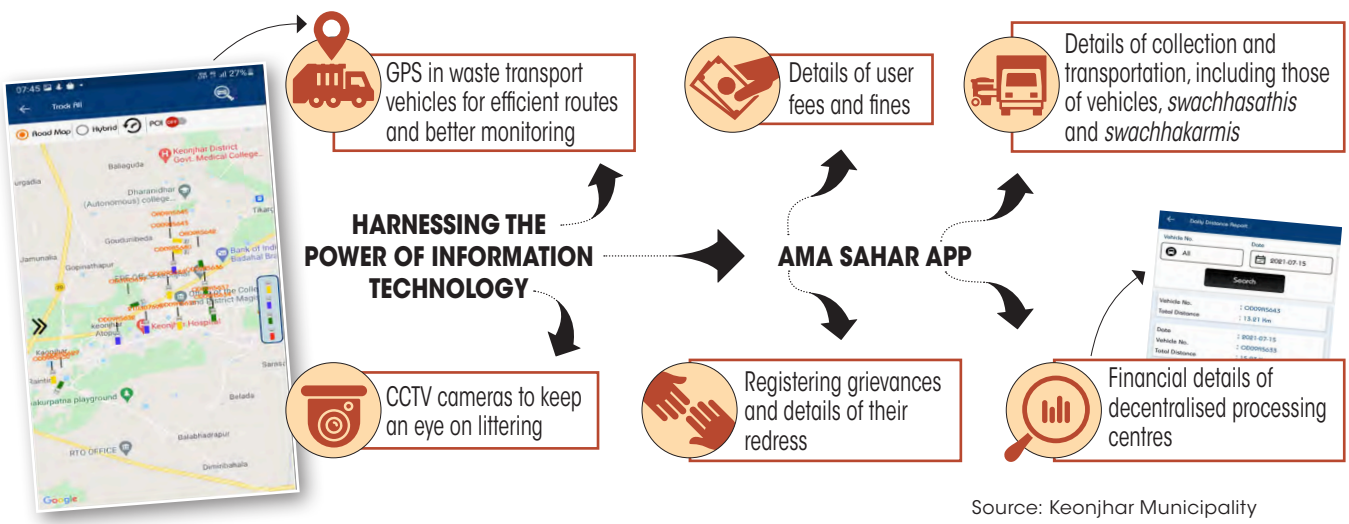
The solid waste management budget of Keonjhar



Note: No cost has been incurred on installation of CCTVs and app development by Keonjhar Municipality. The former are paid for by the district administration under a non-solid waste-related vertical and the latter is paid for by Odisha Housing and Urban Development department

Source: Keonjhar Municipality

Use of information technology in solid waste management



Source: Keonjhar Municipality

A conveyor belt segregating components of biodegradable waste at a micro-composting centre in Keonjhar

Keonjhar Municipality monitors littering through CCTV cameras installed at public places. There is a fine of Rs 75 for individuals, Rs 500 for shops, Rs 1,000 for hotels and restaurants, and Rs 2,500 for other commercial institutes for littering. This has almost put an end to the practice of garbage dumping.

The operational details of wealth centres are recorded in the Ama Sahar app by facility managers. These details include the quantity of biodegradable waste collected by the dedicated garbage collection vehicles; details of *swachhasathis* and *swachhakarmis* accompanying each vehicle; the quantity of compost generated, packaged and sold, and the revenue generated from selling it; as well as the quantity of non-biodegradable waste segregated and sold, and the revenue generated from selling it. Details of fines collected for use of plastic by shopkeepers, public littering, open defecation, urination, and burning of dry leaves and other solid wastes are also recorded in the Ama Sahar app.

WHAT HAS WORKED IN KEONJHAR

Koenjhar has been able to harness communication technology to improve its waste management system. GPS-enabled collection and transportation has made these processes efficient and smooth. By putting details of fees and fines collected, and the finances of micro-composting centers and material recovery facilities, on a publicly accessible app, the city has ushered in a new era of transparency.

The city municipal administration also lays emphasis on timely redress of grievances related to solid waste management. Grievances received through different social media platforms are transmitted immediately to the relevant staff members and a strict timeline of less than 24 hours is adhered to. The complainants are then intimated about the action taken.

Impacts

- Keonjhar has a number of tourist places; with a visibly cleaner environment, it has been able to attract more tourists.
- Occurrences of dengue, malaria and diarrhoea in the district have abated by about 60 per cent.
- The dumping site at Judiaghat has been developed into a tourist attraction.
- Women involved with the self-help groups handling waste have been empowered socially and economically.
- Public grievances related to solid waste management have been reduced by 70 per cent.

LESSONS LEARNT

A change of attitude among government officials as well as citizens (through properly planned awareness programmes) can bring about the change needed to invert the traditional perspective on waste. Keonjhar's waste-to-wealth programme not only generates revenue from the city's waste, but **has also provided dignity of employment** to the women traditionally involved in the waste business, usually the lowest of the low strata of the Indian society.

A well-directed technological intervention can be a force multiplier in a municipal solid waste system. IT-based solutions, like GPS-enabled vehicles as well as apps to pay user fees and fines, track the financial situation of 'wealth centres', and address grievances in a time-bound manner and have helped Keonjhar achieve substantial improvements in its waste management system rapidly.

By making these apps accessible to the general public, **the municipality made people closer participants in the management of solid waste**, thus ensuring their cooperation. When everything else fails, there is the element of punitive action in the form of CCTV monitoring and fines.

REPLICABILITY

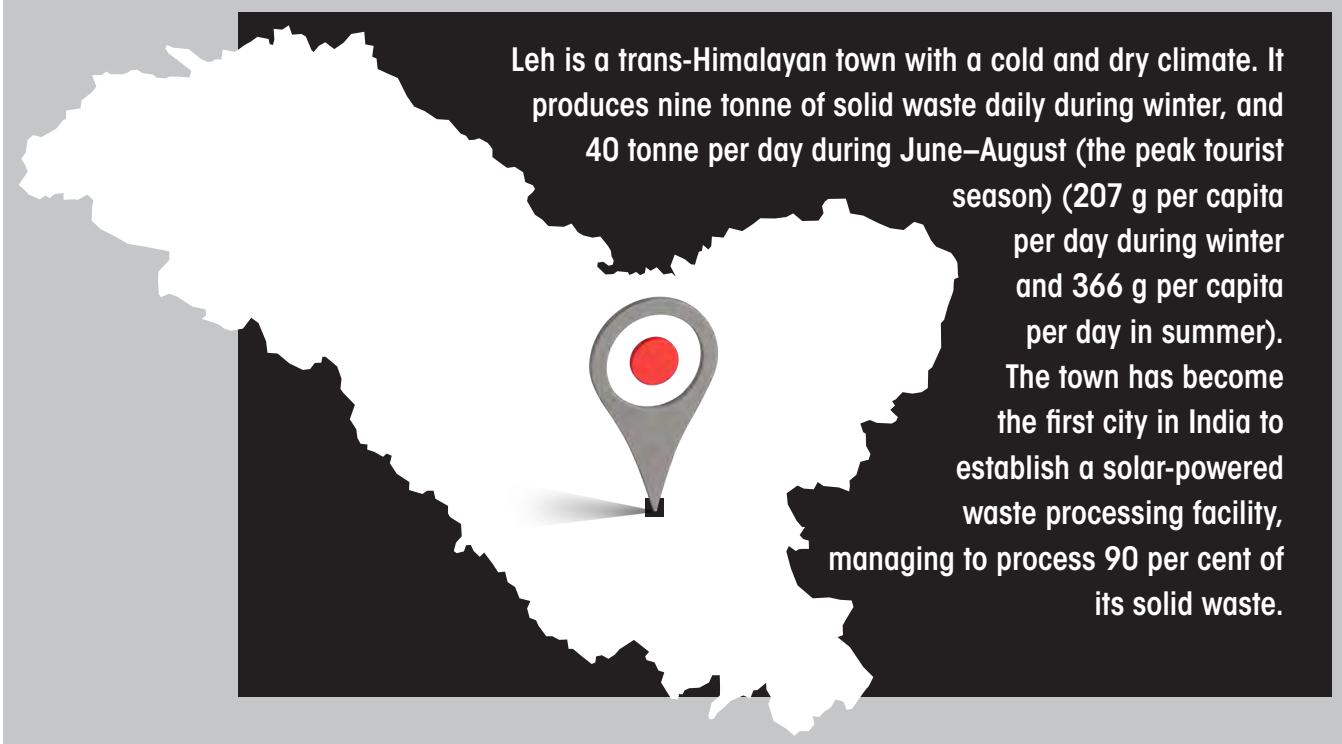
Keonjhar's IT-based interventions are easily replicable in other urban local bodies. In fact, the apps used in Keonjhar (and in other places in Odisha) can be adopted and contextualised by other cities and states. This will result in demonstrated augmentation in the efficiency (and thereby capacity) and transparency of solid waste management systems.

Decentralised treatment of waste in micro-composting centres and material recovery facilities, and roping in the informal sector, are also excellent ideas that can be replicated across the board.

LADAKH

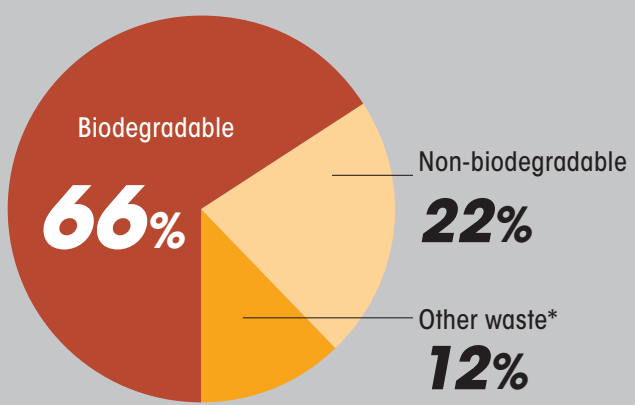
LEH

The tourist town receives abundant sunlight, which it utilises to power its efficient waste processing facility



Leh is a trans-Himalayan town with a cold and dry climate. It produces nine tonne of solid waste daily during winter, and 40 tonne per day during June–August (the peak tourist season) (207 g per capita per day during winter and 366 g per capita per day in summer). The town has become the first city in India to establish a solar-powered waste processing facility, managing to process 90 per cent of its solid waste.

Solid waste composition in Leh

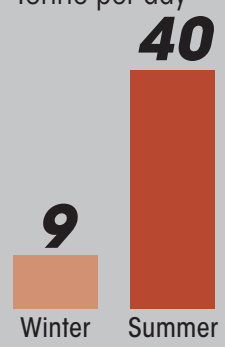


Huge seasonal variation

(because of tourism)

Municipal waste generation

Tonne per day



*Others includes domestic hazarduous waste and sanitary waste

Source: Municipal Committee Leh

Population (as per 2011 Census)
30,870

Estimated current population
43,500

Estimated floating population (daily, summer)
66,000

Area (sq km)
9.1

Number of households (2021)
6,820

Number of wards
13

Number of zones
0

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
45

Number of sanitation workers
50

Number of community bins
0*

Number of garbage vulnerable points
0*

Waste management vehicle fleet size
9

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
100

Percentage of waste processed
95

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage vulnerable points are strong indicators of an efficient solid waste management system.

Source: Municipal Committee Leh

THE TRANSFORMATION

Till 2019, Leh did not have a proper mechanism for the treatment and scientific disposal of solid waste. Waste collection was poor, and community bins were overflooded with mixed waste, resulting in a public health hazard and poor aesthetics in the hilly tourist town. Even when solid waste was collected from the city in tippers, it was dumped at an open dumping site – locally known as Bomb Garh – near the Diskit Buddhist temple. Some manual scavengers and waste pickers would separate plastics and other recyclable materials from the dumped waste, and sell them in Jammu or other places to big *kabadiwalas*, but most of the dumped waste remained unprocessed. This practice continued for many decades, creating a 2 km-long open dumping belt.

Waste remained untreated because of lack of funds for a treatment facilities and to buy machinery to segregate and treat waste as well as to pay for the electricity needed to run the machinery.

Due to a constant influx of tourists, Leh faced a growing problem of waste disposal. The Swachh Bharat Mission directives made the city understand its problems with greater clarity in order to figure out a way its waste needs to be managed.

HOW THE SYSTEM WORKS

Project Tsang-da Urban Mission, initiated by the district administration of Leh in December 2017, aimed at sustainable waste management in rural and urban areas of the district. The project has created a setup to turn waste into revenue-generating goods, such as curtains, toys and cushion covers. Wine or beer bottles and broken glass are reused in construction of roads and buildings by local construction companies.

The Union territory government has created a Waste Management Committee of 12 members, which includes members from the municipal committee of Leh, the government of the Union territory, and Ladakh Autonomous Hill Development Council (LAHDC), Leh as well as residents and technical and management experts to plan infrastructure and activities pertaining to waste management.

Solar-powered material recovery facility

LAHDC started awareness programmes and campaigns like street clean-up drives (under the Urban Infrastructure Development Scheme for Small and Medium Towns) and recycling camps to raise awareness among residents on the importance of minimising waste. Two dustbins — a blue one for non-biodegradable waste and a green one for kitchen and other biodegradable waste, were provided to each household so that they could segregate waste. The municipal committee removed community bins to make Leh a garbage-free town. For 100 per cent door-to-door collection from all households, shops, hotels and restaurants, proper collection routes of vehicles were charted.

The committee also decided to build a self-sustaining solid waste management plant with adequate capacity to properly manage all waste streams in an economically and technologically feasible manner.

In 2020, the municipal committee installed a 30 tonne per day capacity solar power-based solid waste management plant (see Box: *Solar powered waste management in Leh*).

Currently, the city is efficiently collecting segregated waste from households and commercial establishments. For collection and channelisation of the waste, the city has nine vehicles. Each vehicle has two workers to collect the waste and directly transport it to the solid waste management plant. The town has a very small area so these vehicles are sufficient to collect waste twice a day in commercial areas and once a day in small residential areas.

Solar powered waste management in Leh

Leh Municipal Committee installed a 30 tonne per day capacity solid waste management plant in 2020. The plant is spread over 38 acres of land. Electricity to run the plant comes from the 100 kW solar power supply installed by Ladakh Renewable Energy Development Agency.

The plant has the following units:

Manual segregation and waste processing unit: Incoming tippers filled with municipal waste are weighed and unloaded at the manual segregation unit, where 15 workers segregate the waste. The workers are provided masks and hand gloves, and work in eight-hour-a-day shifts. They segregate multi-layered plastic, cardboard, milk and juice packets, and water and plastic bottles. These items are then crushed with the help of a baling machine so that it can be transported easily. Compressed blocks are sent to recyclers in Jammu and Kashmir. In this way, the city is able to recover a huge quantity of materials for various gainful applications. Nearly 90 per cent of the material is recovered. A glass shredder, a high-density polyethythene (HDPE) shredder and a paper shredder have also been installed at the site.

Composting unit: The composting unit consists of two parts. The first part is a treadmill with a shredder to disintegrate biodegradable waste (to increase the rate of composting). The second part is the composting chamber. Tippers unload biodegradable waste near the belt of the treadmill, from where it is fed into the shredder. The resulting mixture is carried on the belt to the composting chamber, where composting takes about four–five weeks. Most of the compost is utilised by the municipal committee in gardens, parks and monasteries, the rest is sold to farmers.

A scientific landfill facility is under construction near the solid waste management plant for disposal of inerts and rejects generated at the processing unit. The construction is expected to be completed by 2022.

Solar panels installed on the roof of the plant supply sufficient energy for all mechanical operations

The money flow

Solid waste management services are free for households. To recover the cost of the services, the Waste Management Committee has created a tariff structure for all commercial shops and hotels. Annually, Rs 1,200 are collected from every shop, and Rs 6,000 from every hotel. The administration has also implemented surcharges and limitations on the sale of polluting products. In 2018, it generated about Rs 64 lakh in revenue and spent Rs 38 lakh on waste management.

Impacts

- Leh is the first city in the country to adopt solar power to drive operations at its waste processing facility.
- Leh secured the first position in innovation in sanitation under Swachh Bharat Mission in 2018.
- Leh is one of the cleanest cities in the country because of the intervention of community-level awareness programmes for source segregation and participation of all stakeholders in waste management.

WHAT HAS WORKED IN LEH

Use of renewable energy to run the processing and material recovery facility has been a success in Leh because it has ensured that the operation of the facility is a low-cost affair. Ladakh receives high-intensity solar radiation, with 320 sunny days in a year, and the low temperatures allow solar panels to work efficiently. The average solar energy intensity in Leh district is 6–12 kWh per square metre. Another factor for sustenance of solar power-driven waste management plant in Leh is the availability of spare land that the government itself owns.

Efforts to achieve 90 per cent material recovery at the facility to generate revenue from recyclables and compost have been successful and the system works efficiently. The overall processing percentage of the town is 95 per cent.

LESSONS LEARNT

Utilising renewable energy (solar energy) in waste processing is an innovative technological solution that is cost-effective and environmentally sustainable (as it does not contribute to any form of pollution and is an efficient substitute to conventional fuel-driven applications). Small towns and cities with limited funds for solid waste management but having suitable climatic condition to harness solar power could be an ideal place for solar power-driven waste management plants. A larger lesson can also be drawn here:

Processed non-biodegradable waste ready to be transported to recyclers in Jammu and Kashmir

Technological interventions that reduce operational costs of solid waste processing facilities can provide urban local bodies a short in the arm, provided their initial capital costs are not unbearable.

In addition, **participation of the people is very critical to make a solid waste management system successful**. Therefore, it is crucial to conduct awareness campaigns from time to time. In addition, efforts to ensure source segregation and efficient collection of waste are also necessary.

REPLICABILITY

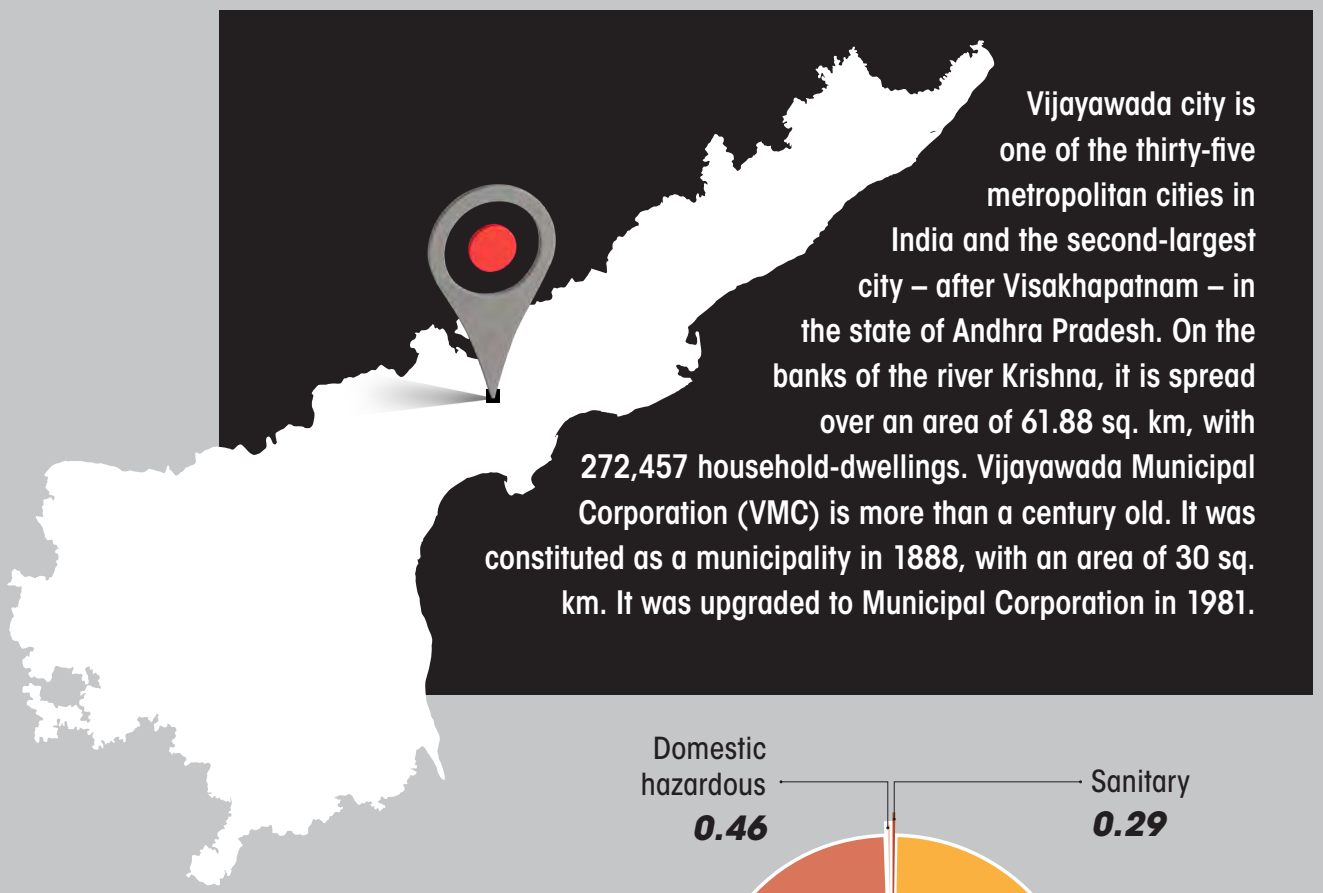
Solid waste management is more challenging in highlands than in plain areas due to the remote location, uneven topographical configuration, vulnerability to natural hazards and disasters, and insufficient funds. Leh has set an emulation-worthy example on technological innovation under such conditions.

Reportedly, the largest solar power-producing states are found in the west and south of the country. Urban local bodies in states like Andhra Pradesh, Gujarat, Karnataka, Rajasthan and Telangana can easily harness solar power for solid waste management.

ANDHRA PRADESH

VIJAYAWADA

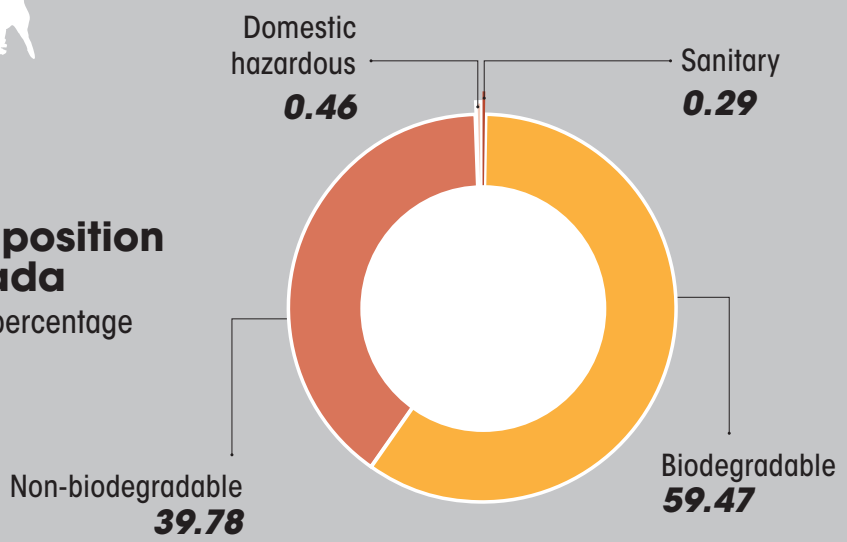
Innovation in collection, transportation and treatment of municipal solid waste brought a sustainable standard of sanitation, improving livelihoods, health and the economy in Vijayawada



Vijayawada city is one of the thirty-five metropolitan cities in India and the second-largest city – after Visakhapatnam – in the state of Andhra Pradesh. On the banks of the river Krishna, it is spread over an area of 61.88 sq. km, with 272,457 household-dwellings. Vijayawada Municipal Corporation (VMC) is more than a century old. It was constituted as a municipality in 1888, with an area of 30 sq. km. It was upgraded to Municipal Corporation in 1981.

Waste composition in Vijayawada

Daily quantity in percentage



Vijayawada Municipal Corporation

Population (in million, as per 2011 Census)
1.04

Estimated current population (in million)
1.19

Estimated floating population (in million, daily)
0.2

Area (sq. km)
61.88

Number of households (in million, 2021)
0.27

Number of wards
64

Number of zones
3

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
496.7

Number of sanitation workers
3,779

Number of community bins
100*

Number of garbage-vulnerable points
3*

Waste management vehicle fleet size
225

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
100

Percentage of waste processed
92

*According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Vijayawada Municipal Corporation

THE TRANSFORMATION

Vijayawada is divided into 64 sanitary divisions and municipal wards for the purpose of solid waste management. Around 516.6 tonne per day (TPD) of municipal solid waste is generated (excluding construction and demolition waste) of which approximately 275.5 TPD is biodegradable waste, 239.9 TPD non-biodegradable waste and 1.16 TPD is domestic hazardous waste segregated (including sanitary waste). Around 2 tonne is floral waste from two major and 10 minor shrines in the city.

The city processes 458.983 TPD of total waste of which 239.9 TPD is biodegradable waste. The biodegradable waste is used to produce compost and other materials of commercial value through various service providers such as waste composting units, waste recycling units and biomethanation units. The remainder, i.e. 81 tonne, is sent it to the landfill site for final disposal.

During the festive season and other auspicious days, floral waste is about 3 tonne. Currently, sanitary workers collect floral waste from wholesale markets, temples, mosques and churches across the city and shift it to composting yards. After it is segregated it into biodegradable and non-biodegradable waste at the yards, it is turned into bio-compost.

In 2015, the city government began looking at technology options to strengthen its solid waste management operations in the city. The technologies were introduced after careful consideration of their efficiency at scale as solutions to manage various waste streams and technologies for source segregation, door-to-door collection, attendance and timely arrival of sanitation workers. A real-time monitoring unit at the city level and timely course-correction measures were also considered.

Source segregation

To optimize source segregation and efficient collection, Vijayawada Municipal Corporation divided human settlements in the city into 1,256 micro-pockets, each with a different road length. Biodegradable and non-biodegradable waste were collected separately. All 64 wards of Vijayawada currently have source segregation.

Decentralised treatment of biodegradable waste

Processing of organic waste

All 64 wards in the city have 100 per cent door-to-door garbage collection. Each worker collects garbage from about 300 households per day. Vehicles for primary collection vehicles are fuelled by CNG so that the process is greener and more cost-effective. Vijayawada has deployed one primary collection vehicle for two micro-pockets. The entire volume of 198 tonnes of organic waste is processed for composting in four decentralized waste-to-compost plants.

Eco-friendly technologies that contribute to reducing the cost of operation and maintenance include:

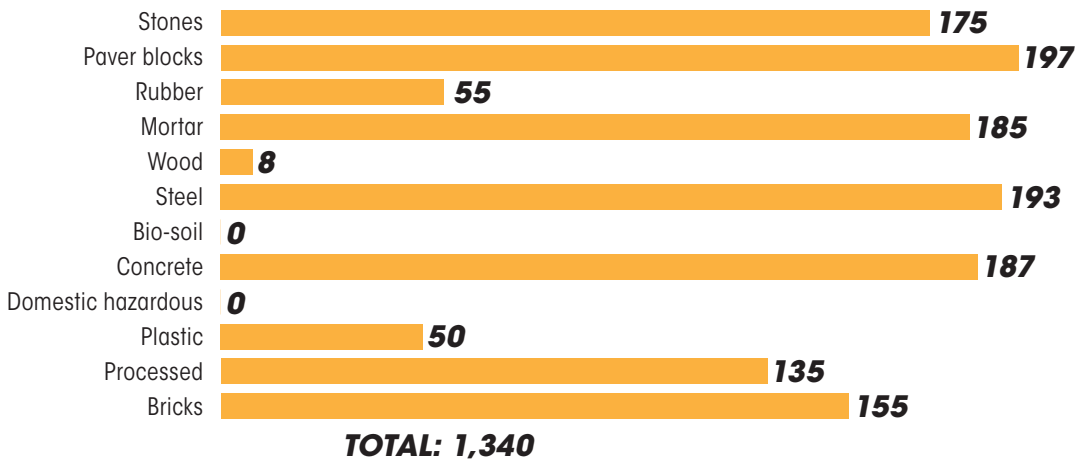
On-site composting: Vijayawada Municipal Corporation has promoted on-site composting for reduction and recovery of waste at source and for following the 3R's, i.e. reducing waste, reusing and recycling. The city has enforced on-site treatment of organic waste in all the residential welfare associations (RWAs), which accounts for about 18 per cent of the total volume of organic waste generated. The Corporation monitors the implementation of in situ management closely.

Biomethanation: The city has modernised one of its existing biomethanation plants to run on a turnkey basis to process 20 tonne of biodegradable waste to produce 125 KW of energy per day. The captive energy plant is utilized to power 100 KW stations for sewerage treatment plant motors running for four hours a day.

Fully automatic biodegradable waste compost: Biodegradable waste compost technologies are used for production of biodegradable waste much faster than traditional methods. The city has also introduced smart semi-underground waste collection bins that trigger an alarm once they are full by means of an ultrasonic weight sensor to monitor the real-time status of the smart bins.

C&D waste processing

(IN TONNE)



By saving fuel and energy, these technologies contribute to reducing operation and maintenance cost of the city by up to 28 per cent.

Technologies for monitoring of waste management operations: VMC has adopted quick response code (QR Code)-enabled radio frequency identification (RFID) tags for waste collection. The system is connected to the centralised monitoring cell at the city level. As a result, as many as 52 out of 64 wards have been declared bin-free. The Corporation has also installed 45 smart bins at various locations that sends alerts to authorities as soon as they are full. The remaining 12 wards consisting of bins are closely monitored through closed-circuit cameras that are connected to the Command Control Centre in the Corporation. Waste from these bins are collected and cleaned as soon as they are filled.

Underground garbage collection bin system: VMC has installed 32 smart semi-underground garbage collection bins – with capacity of 1.3–3 m^3 – at various places in the city to avoid overflowing of garbage from existing dumper bins.

Mechanized sweeping: Mechanized sweeping avoids spilling of garbage – which happens in regular dumper bins – and saves time. The vehicles are fitted with GPS devices for effective monitoring through the Command Control Centre (CCC) placed in VMC.

Construction and demolition waste: VMC has established collection, transportation, processing and management of construction and demolition (C&D waste) for a capacity of 200 tonne per day.

C&D waste processing facilities in Vijayawada

E-waste: With the explosive growth in use of electrical and electronic equipment, management of e-waste has emerged as a formidable challenge. Segregating e-waste generated in city has become a herculean task for VMC. To address the problem, VMC has joined hands with a private company. The city has strategically positioned e-waste collection points to collect about 20 TPD of e-waste every day.

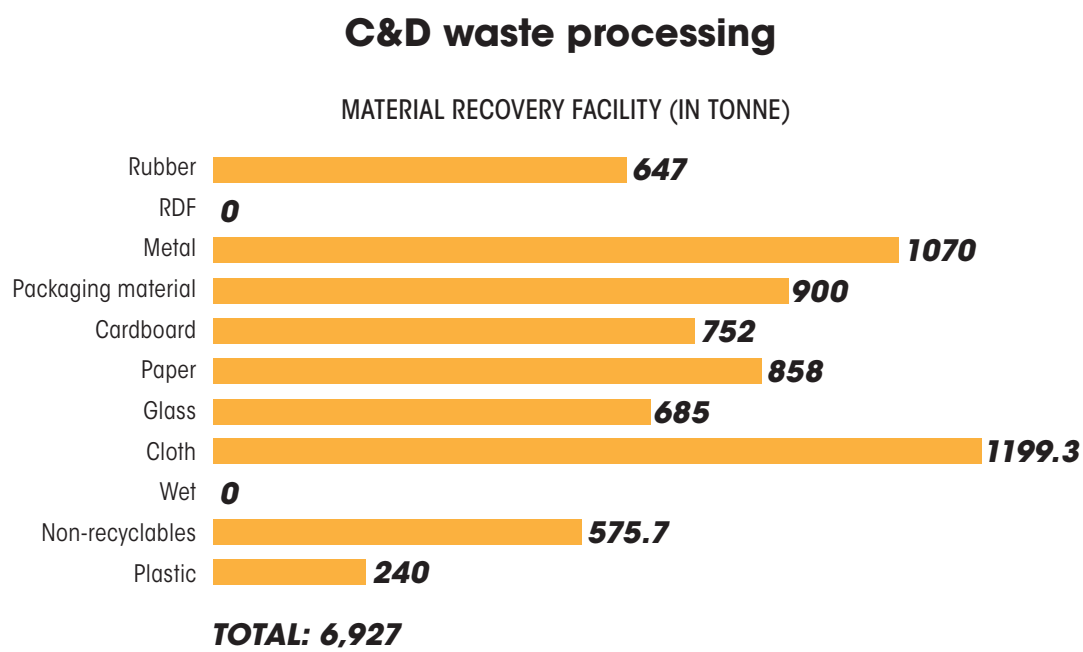
Remediation of existing dumpsite: The existing municipal solid waste dumpsite at Ajith Singh Nagar has been remediated through biomining in Vijayawada Municipal Corporation on the basis of a Design-Build-Operate contract with a private company. The reclaimed land is being developed as a park.

Handling of cigarette butts: In view of the hazardous nature of cigarette butts – they are carcinogenic and can contaminate water if disposed of in waterbodies – VMC has collaborated with a socio-entrepreneurship start-up to collect cigarette butts from all the wards in Vijayawada. The hired agency collects the butts for scientific management. This initiative has created a revenue source for VMC.

Plastic vending machines: Vijayawada has a population of 1.19 million and has large numbers of visitors in the city as well. Consumption of beverages and packaged drinking water has gone up significantly. As a result, large quantities of plastic bottles are dumped into trash binds. Dumping plastic bottles in drains causes a problem for sanitation workers as the bottles can block the main channels. To handle plastic bottles and beverage cans, VMC has partnered with private entrepreneurs and installed seven plastic bottle recycling kiosk (reverse vending machine) at strategic locations. Through this initiative, VMC has been making efforts to eradicate single-use plastic by sensitising the public about its ill effects.

Flower waste processing: VMC's initiative to collect and process flower waste from flower markets and other sources of flower-waste generation is one of its unique practices. The flower market located adjacent to the canal near Rajiv Gandhi Park is one of the main sources of flower-waste generation. Around 85 flower shops exist in the flower market adjacent to the VMC office. About 40 tonnes of flowers come to the flower market daily and approximately 1 tonne of flower waste is generated per day from the market. VMC has tied up with a private partner to institute a system for collection, segregation and treatment of the flower wastes in making eco-products like incense sticks (*agarbatti*), seed paper, leaf and flower manure, eco-colour dyes from colour extraction (from petals) and other eco-products.

Community kitchen with methane gas: VMC is setting a new benchmark in eco-friendly sanitation technology in the city. It has set up a community kitchen fuelled by methane generated from faecal waste of the toilet complex and discarded vegetables from the surrounding market. The kitchen with reactor has five single-hob stoves that can be used through the day. The urban slum of Vijayawada has



2,000 residents for whom the kitchen is free. Residents of slums are often forced to cook with firewood stoves on pavements because their tenements are very small, and this hall gives them the opportunity to make food in a hygienic manner.

Implementation strategy adopted by the city government

VMC has a robust door-do-door collection system in place for all 64 wards in the city. It has divided all the houses in the city into 1,256 micro-pockets, each with a different road length. Biodegradable and non-biodegradable waste are collected separately. The city has about 3,779 sanitary staff, of which 2,984 are from Development of Women and Children in Urban Areas (DWCUA) groups, self-help groups that have taken up the task of cleaning the roads every day. The rest, i.e. 795, are public-health workers for sanitation.

VMC transports wet and dry waste through closed compacted vehicles to various processing facilities and the landfill site. A community bin is followed placed at the point of storage. Of the 64 wards in Vijayawada city, 52 are bin-free. The remainder have bins. A total of 315 loader points operate throughout the city of which 241 are in bin-free wards and 74 are in wards with bins.

WHAT HAS WORKED

VMC has adopted numerous technological measures to improve SWM operations such as implementation of quick response code (QR Code)-enabled radio frequency identification (RFID) tags for waste collection. In other words, the civic body has introduced an online waste management system allowing sanitation workers to use QR code scanners while collecting garbage bins from houses that could be, in turn, monitored in real time through the commissioner's dashboard. Following the change, as many as 52 wards out of 64 have been declared bin-free. VMC also installed 45 smart bins at various locations that send alerts to authorities as soon as they are full.

VMC has enforced and instituted segregation of waste at source, door-to-door garbage collection, home composting and vermicomposting, and installed adequate

Impacts

Improved solid waste management through a well-designed system for collection, transportation and treatment coupled with appropriate technology adoption resulted in Vijayawada winning the Cleanest Big City award in the 2019 Swachh Survekshan in the category for cities with population of 10–40 lakh. The technologies instituted for real-time monitoring of waste management operations made the turnaround possible in a short span of time. The city not only looks clean but – with more than 80 per cent of recycling and recovery and only inerts disposed of to the landfill – has also achieved a sustainable standard of sanitation environment, impacting livelihoods, health and economy of the local people.

numbers of public and community toilets for improved cleanliness and plastic vending machines for collection and channelisation of plastic waste. VMC has also provided livelihoods to ragpickers by systematically allotting them at dumpsites to segregate and collect plastic waste around the city.

LESSONS LEARNT

The VMC model demonstrates that solid waste management operations in cities need to addressed in a comprehensive manner rather than in isolation. Various processes with regard to SWM right from the generation, segregation, transport and disposal are linked to each other and should be managed in a holistic manner.

Once the entire operation chain is conceived and planned, suitable technology options at each level of operations should be explored, tested and implemented at a smaller scale initially and then replicated city-wide.

VMC's focus on reduction of waste at source and decentralised management with a real-time monitoring system aided by state-of-the-art technologies played a pivotal role in a complete overhaul of the performance of waste management in the last few years. Because of its simplicity, inclusiveness and efficient use of technology, the VMC model of waste management is good and replicable.

9

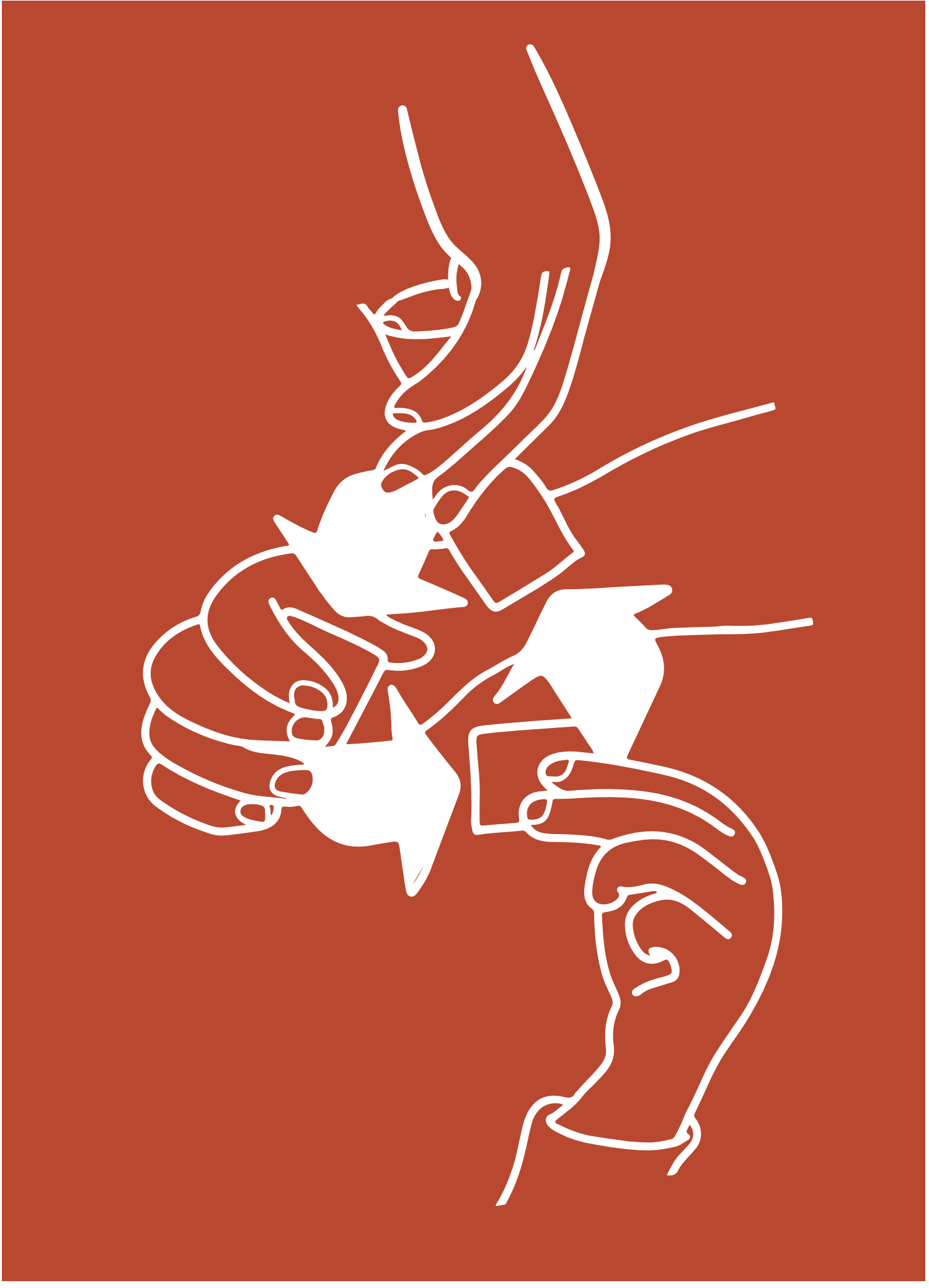
INNOVATIVE MODELS

In waste management, there is no one-size-fits-all model that can be applied in urban centres across the country. Cities apply the model that best suits their needs. This leaves a lot of space for innovation, customisation and cross-learning – this section showcases some of the avenues that innovation can take. These can be used as inspiration by others to design their own specific systems.

Panchgani: Being an 'eco-sensitive zone', certain waste management practices like waste-to-energy are prohibited in the town, so it has invested in material processing and recovery systems, using pollution tax levied on tourists to create and operate these systems.

Paradeep: With active involvement of women and third-gender groups and ragpickers' associations, the city has created a new waste management model that is inclusive as well as economically sustainable.

Thiruvananthapuram: Has adopted a sustainable economic model and supported long-term economic growth without adverse social, environmental, or cultural impacts on the community.



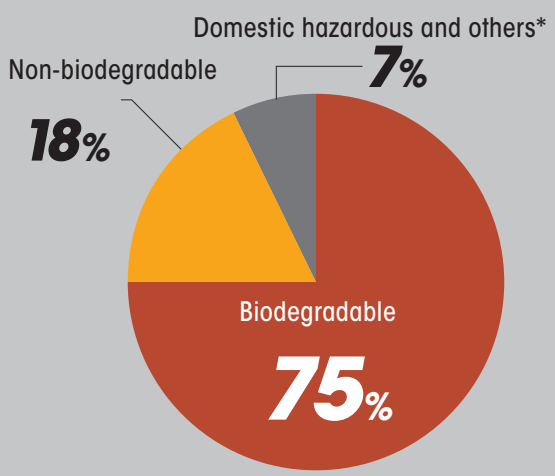
MAHARASHTRA

PANCHGANI

Leveraging the pollution tax levied on tourists, Panchgani has created a well-oiled material processing and recovery system

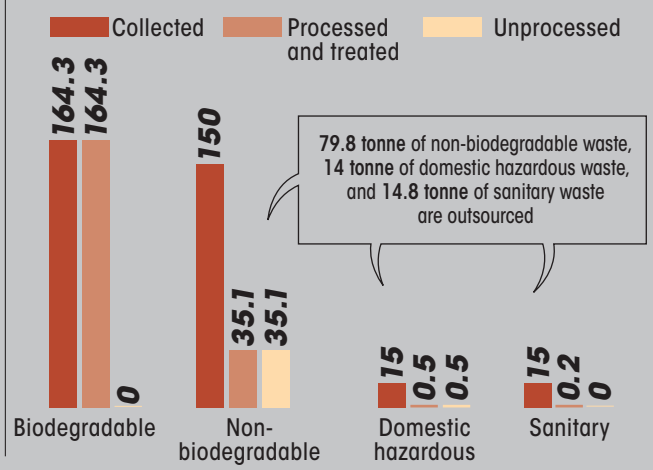
Panchgani is a small hill station in Satara district, Maharashtra. It generates about 7.2 tonne of waste daily (484 g per person per day). Pollution tax levied on visitors powers the town's efficient waste processing and recovery, ably backed by home composting and an excellent IEC programme. With help from Centre for Science and Environment (CSE), the town's municipality has also developed a set of bye-laws as per the Solid Waste Management Rules, 2016.

Waste composition in Panchgani



*Others include e-waste, sanitary waste and C&D waste.
Source: Panchgani Municipal Council

Average monthly waste statistics
(in tonne)



Source: Panchgani Municipal Council

Population (as per 2011 Census)
14,894

Estimated current population
18,000

Estimated floating population (daily)
2,200

Area (sq km)
6.2

Number of households (2021)
2,697

Number of wards
17

Number of zones
4

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
7.2

Number of sanitation workers
35

Number of community bins
26*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
5

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
100

Percentage of waste processed
100

* According to the Swachh Survekshan ranking (Star Rating for Garbage Free Cities) parameter, zero community bins and zero garbage vulnerable points are strong indicators of an efficient solid waste management system.

Source: Panchgani Municipal Council

THE TRANSFORMATION

A British-era tourist place nestled in the Western Ghats, Panchgani accumulated so much waste over almost a hundred years that it earned the unflattering moniker of 'Kachra Point'. Garbage lay strewn everywhere. Dogs, pigs, cows and buffaloes would hover around, competing with vultures and eagles for leftovers. A foul smell could be sensed from miles away. Restaurants operating at the hill station watched helplessly as business dwindled. There were literal garbage landslides.

In 2001, the Central government declared Panchgani an 'eco-sensitive zone'. It became mandatory for Panchgani Municipal Council (PMC) to ensure segregation and processing of the waste generated by the hill station. But being accorded the status of an 'eco-sensitive zone' also meant that technologies like incineration of waste and waste-to-energy were forbidden.

The first task before PMC was to clear legacy waste through bioremediation. Separating plastics from the organic waste was an uphill task so the council sought professional help from Aaradhya Enterprises, an expert concessionaire. They managed to clear an acre of land containing 1,485 tonne of waste between July and December of 2015.

However, PMC's efforts to clear legacy waste would have amounted to nothing if fresh waste continued to pour in. The city produces over seven tonne of waste daily. Under new leadership, PMC was quick to realise that the city needed to apply the philosophy of 'reduce, reuse and recycle' urgently to manage its waste efficiently. If waste was to be recycled, it had to be segregated first. Thus began Panchgani's IEC programme.

A private contractor was hired to carry out IEC activities. A group of 40 workers was assigned various tasks under the project. Initially, when segregation rates were lower, the staff of the private contractor would segregate garbage collected from households.

Following the initial success of its IEC programme, PMC roped in a team of cleanliness supervisors, health inspector, class 4 municipal council staff, office staff members and *swachhagrahis* (a group of local women and other informal sector actors). The team conducted intense door-to-door trainings and live demonstrations. Students of schools and colleges were trained first, after which they joined

the IEC campaign. As the health inspector, supervisors and *swachhagrahis* were local residents, they could coordinate, convey their intentions, deliver training and carry out other functions smoothly. Commercial properties, schools and households were targeted for compulsory segregation. It took nearly six months, but the town was able to improve its segregation percentage significantly.

HOW THE SYSTEM WORKS

The city has adopted a two-bins-one-bag system. Under this system, every household is provided two dustbins, one for biodegradable and the other for non-biodegradable waste. As the quantity of sanitary and domestic hazardous waste generated is lesser, they are collected in bags. Thus, waste is segregated into three streams at source. Money for the two-bins-one-bag infrastructure was provided by local units of a few banks from their CSR funds.

Collection vans have been compartmentalised to transport segregated waste. Non-biodegradable waste and rejects are segregated further in the collection vehicles by waste workers into eight streams: 1) Plastic bottles and plastic waste, 2) Glass materials, 3) Clothes, 4) Plastic wrappers, 5) Sanitary napkins and diapers, 6) Footwear, 7) Medical waste, and 8) Coconut shells and wood pieces. Different bags are provided in the van for storing waste after secondary segregation.

Cleanliness supervisors, the health inspector and *swachhagrahis* accompany the collection vans to supervise and inspect the whole process. If a household has made a mistake regarding segregation, it is corrected right away by the team. People facing any difficulty or raising a query regarding waste management are

Panchgani's waste processing facility complements its decentralised processing of biodegradable waste

In search of an appropriate processing technology

Panchgani's search for an appropriate processing technology has been an interesting and edifying one. Initially, the city tried vermicomposting to process its organic waste. Within six months, it became clear that climatic conditions were not ideal for the process. So the city invested in three organic waste composting machines, each with a batch capacity of 100 kg per hour. The machines were inadequate for the 5 TPD organic waste generated in the town. Their handling and maintenance was also a difficult job. Through trial and error, PMC finally designed a machine with a conveyor belt (to cut labour cost) that shreds and mixes organic waste with compost. This machine has been a grand success.

PMC has also installed a 6 TPD capacity biomethanation plant to convert the organic fraction of waste into electricity. The plant will generate approximately 0.26 million kWh of electricity annually and produce approximately 44 tonne of compost and 1,800 kl of liquid fertiliser. The estimated revenue generated will be Rs 70 lakh.

The city has a functional material recovery facility. Non-recyclable plastic waste is pre-processed for road making as per the guidelines of Indian Road Congress. The plastic crusher machine has a capacity of 4 kg per batch, processing nearly 120 kg per hour. It runs for four hours every day. The remaining plastic is sent for recycling. Paper, cardboard, clothes and other materials are baled and stacked and sent for recycling.

The city also generated about 511 kg of hazardous waste daily. It is collected and handled separately and sent to Maharashtra Enviro Pvt Ltd, Pune for further processing.

assisted by the moderating team. A toll-free complaint number has also been provided.

PMC has developed a set of bye-laws on solid waste management with assistance from CSE. The bye-laws mandate a fine for non-segregation amounting to Rs 500 for households and Rs 5,000 for hotels, lodges and other commercial establishments. For better surveillance, PMC has set up CCTV cameras at important places. Photographs of those found throwing garbage are circulated on social media.

Efforts to segregate started on October 2, 2013 and by October 2, 2017 Panchgani had achieved 100 per cent source segregation.

WHAT HAS WORKED IN PANCHGANI

Panchgani's IEC programme, ably carried out by *swachhagrahis*, has been a thumping success as the town has managed to achieve 100 per cent source segregation. Secondary segregation in collection vehicles has been an efficient and smooth initiative.

The hill station has made the best of its unique economic and geographic conditions. Being an eco-sensitive zone, it could not go down the incineration or waste-to-energy route. Instead, the town has invested in a plethora of material processing and recovery systems, using the pollution tax levied on tourists to create and operate these systems.

The city's waste infrastructure has matured to gain the ability to process almost all of the city's waste. The centralised organic waste processing unit works in tandem with decentralised composting at the household and bulk waste generator levels. The material recovery facility and biomethanation plant have been successful as well. By installing solar and wind power at the processing centre, the town has taken another step towards a green waste management system.

Monthly solid waste management budget of Panchgani

Parameter	Monthly cost
Expenditure on collection and transportation of municipal solid waste	Rs 12 lakh (approximately)
Expenditure on municipal solid waste processing	About Rs 2.75 lakh (contractual) + About Rs 1.5 lakh (*swachhagrahis* as part of IEC and informal sector cost)
Expenditure on municipal solid waste disposal	Included in processing
Total expenditure on municipal solid waste management	Rs 16.2 lakh (approximately)
Users fees collected	Rs 1.5 lakh (approximately)
Revenue generated from sale of compost and biogas	Rs 0.4 lakh (8.2 tonne per month @ Rs 5,000 per tonne in January 2020, i.e., before the lockdown) + About Rs 1 lakh (19.55 tonne per month; self consumed @ Rs 5,000 per tonne)
Revenue generated from sale of recyclables and refuse-derived fuel	Rs 1.6 lakh
Revenue generated from other sources	About Rs 1 lakh (waste management income through property tax) About Rs 0.75 lakh (penalties) About Rs 11 lakh (pollution tax)
Total revenue generated	Rs 17.2 lakh (approximately)

Note: Capital investment for the processing centre was either through CSR or local donations. The difference between expenditure and revenue is about Rs 1 lakh per month. PMC not only breaks even, it ends up generating revenue.

Source: Panchgani Municipal Corporation

LESSONS LEARNT

A systematic approach is necessary to achieve transformation in waste management systems. PMC started with remediation of its legacy waste. Simultaneously, it sought to overhaul Panchgani's waste management chain from the first link. It initiated an IEC programme through *swachhagrahis* to promote segregation at source. Then it modified its collection and transport equipment to ensure that waste that had been segregated remained segregated. It initiated a secondary segregation practice in the collection vehicles and then it sought to improve the city's waste processing methods and capacity.

People are the key. PMC's IEC programme forms the heart of the waste management transformation in the town. It ensured 100 per cent source segregation, which made the entire management chain efficient.

A trial and error approach finally bore fruit when the municipal authority was able to find a cost-effective method to process its organic waste. By **combining centralised infrastructure** for organic waste processing, material recovery facility, plastic waste crusher machine and biomethanation plant **with decentralised methods** like home composting, for both individuals households

Impacts

- Around 2,697 households and 120 commercial entities have been sensitised about the benefits of at-source segregation and waste management.
- About 17,907 individuals have been trained on appropriate methods of disposal and recycling.
- A quantity of about 2,631 tonne of municipal solid waste is processed every year in PMC's centralised and decentralised organic waste management facilities, averting emission of 944 tonne of methane and 2,503 tonne of CO_2 per year into the atmosphere.
- PMC has installed a windmill and solar plant at its processing centre, making its energy consumption zero.
- The city has gained several points on the cleanliness scale. It looks visibly neat and a far cry from the days of garbage landslides.
- Panchgani was adjudged the cleanest city in the West Zone by the Swachh Survekshan, 2018.

and bulk waste generators (like resident welfare associations), the town has been able to have the best of both worlds and optimise its waste management potential.

Most importantly, the town has managed to think through two common misconceptions in waste management. **Waste is not a liability but a resource**. Panchgani's material recovery and processing facilities amply testify this statement. **An economic and geographic hurdle can be turned upside down into an advantage.** The town has used the fact of being a hill station (and an eco-sensitive zone), which prevents it from making use of certain waste processing technologies, to generate revenue through a pollution tax to invest in other, better technologies.

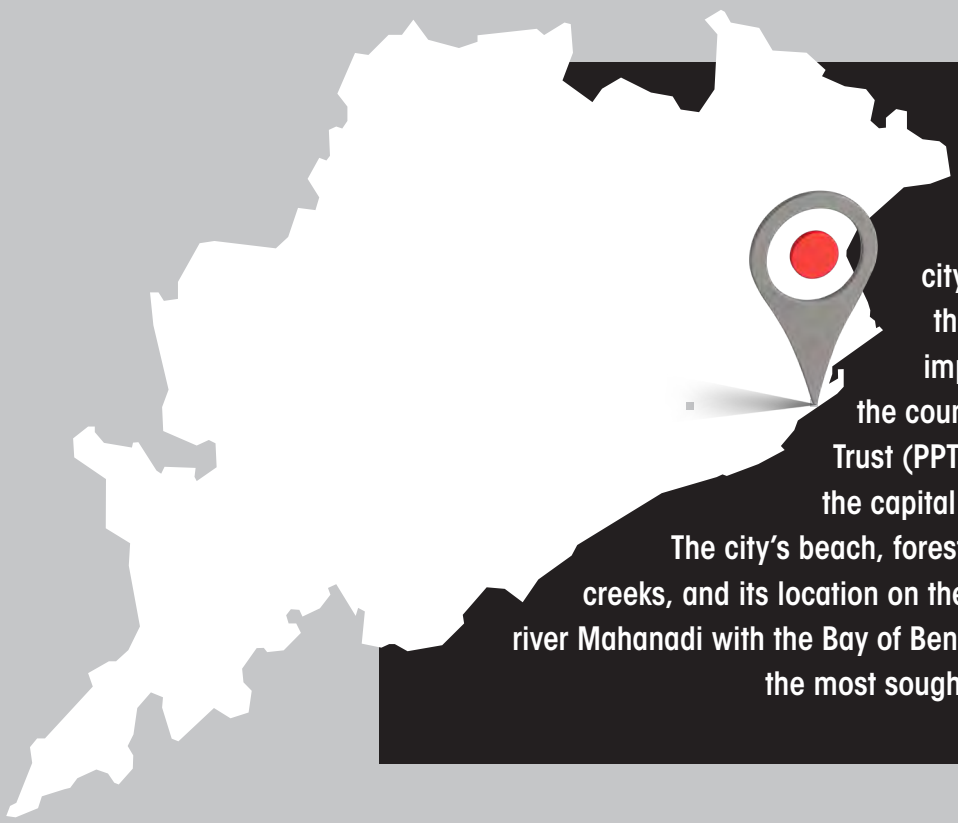
REPLICABILITY

PMC's IEC programme for segregation of waste can be replicated. Capacity building at every income level (high, middle and low) is important for any city. Though it ticks the boxes of social acceptability, environmental sustainability and technical feasibility, PMC's waste management system is primarily funded by the pollution tax levied on visitors. Panchgani is a hill station and the floating population in the form of tourists is equal to 15 per cent of the town's own population. It will be difficult to replicate the financial model of PMC's waste management system in other cities step-for-step. However, the spirit behind it, to think outside-the-box to convert apparent economic hindrances into advantages, will live on and multiply.

ODISHA

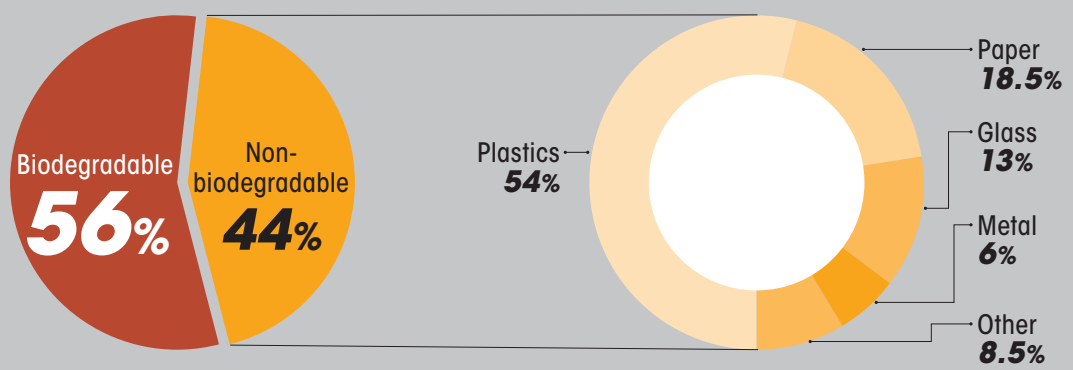
PARADEEP

A decentralised women-driven model made a self-sustainable solid waste management system a success



Paradeep, in Jagatsinghpur district, is a major city of Odisha. One of the largest and most important seaports in the country, Paradeep Port Trust (PPT) lies 125 km from the capital city Bhubaneswar. The city's beach, forest cover and natural creeks, and its location on the confluence of the river Mahanadi with the Bay of Bengal, make it one of the most sought after in the state.

Waste management in Paradeep



* Others include domestic hazardous and sanitary waste.

Source: Paradeep Municipality

Population (as per 2011 Census)
68,585

Estimated current population
82,000

Estimated floating population (daily)
4,100

Area (sq. km)
32.40

Number of households (2021)
17,411

Number of wards
19

Number of zones
0

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
16.2

Number of sanitation workers
369

Number of community bins
0*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
39

Percentage of households covered under door-to-door waste collection
100

Percentage of households segregating waste
95

Percentage of waste processed
100

*According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Paradeep Municipality

THE TRANSFORMATION

Solid waste management in Paradeep Municipality was scant before 2019. Source segregation was not practised, door-to-door collection systems were irregular due to which the people dropped off their household waste into community bins, which only a few wards were provided with. When the bins were full, people disposed of their garbage on the roads or in drains or vacant spaces. Municipal solid waste was not properly managed due to shortage of sanitation staff and primary and secondary waste collection vehicles. Waste was carried from community dustbins by pushcarts to the nearest transfer station then unloaded onto tractors and tippers, which is disposed in the dumpsite without any treatment. The opportunity of generating revenue from waste that could be processed or sold through proper channels was often lost. Untrained sanitation workers and ragpickers carried out collection, transport and disposal or dumping and manual handling of municipal solid waste carried out in the absence of personal protective equipment (PPE) kits led to occupational health hazards. The dumping site was not at all managed properly. Dry waste was burned at the dumping site as well as at the collection points. The dumping site emitted a foul smell due to disposal of mixed waste.

The State Department for Housing and Urban Development, Government of Odisha, issued an order on July 16, 2019, where cities were given a clear mandate to adopt decentralised systems as a matter of state policy. The government of Odisha initiated the project "Waste to Wealth" in all urban local bodies. Paradeep Municipality adopted the concept of waste to wealth in 2019. Local women self-help groups were empanelled to be a part with the initiative. Municipality officials conducted several awareness programmes in domestic solid waste management to educate and train households. Municipality officials carried out the door-to-door survey to calculate exact quantities of solid waste generation per capita per day so that the design of processing facilities can be constructed accordingly. Subsequently, women self-help group members – known as swaccha sathis – initiated the door-to-door awareness campaigns for households. For eco-friendly transport of municipal solid waste, battery operated vehicles – with capacity of 0.5–1 tonne – were procured, which were also

All photos by Paradeep Municipality

Women from self-help groups managing compost at a micro-composting centre in Paradeep

driven by members of the self-help groups. Micro-composting centres were constructed to process wet waste and material recovery facilities for processing dry waste.

Women self-help groups were involved in the operation and maintenance of the micro-composting centres and material recovery facilities to enable them with better means of livelihood. Members were selected and appointed as *swachha karmi*, *swachha sathi* and *swachha* supervisor based on their education. *Swachha karmis* were initially trained by municipality officials, after which they engaged in door-to-door collection, transportation, and handling of waste at micro-composting centres and material recovery facilities. They were also trained for operation and maintenance of micro-composting centres and material recovery facilities. The women self-help groups were also given the opportunity to collect user fees and revenue by selling products processed at micro-composting centres and material recovery facilities.

HOW THE SYSTEM WORKS

Paradeep Municipality was constituted as a Notified Area Committee (NAC) on September 27, 1979 and converted to municipality on December 12, 2002. While some areas come under, and are maintained by, the Paradeep Port Trust (PPT), the rest of the city is maintained by Paradeep Municipality.

Paradeep Municipality generates 16.2 tonne of solid waste daily, which is treated in the micro-composting centres and material recovery facilities. Paradeep is the first city in Odisha to construct and have a functioning MRF.

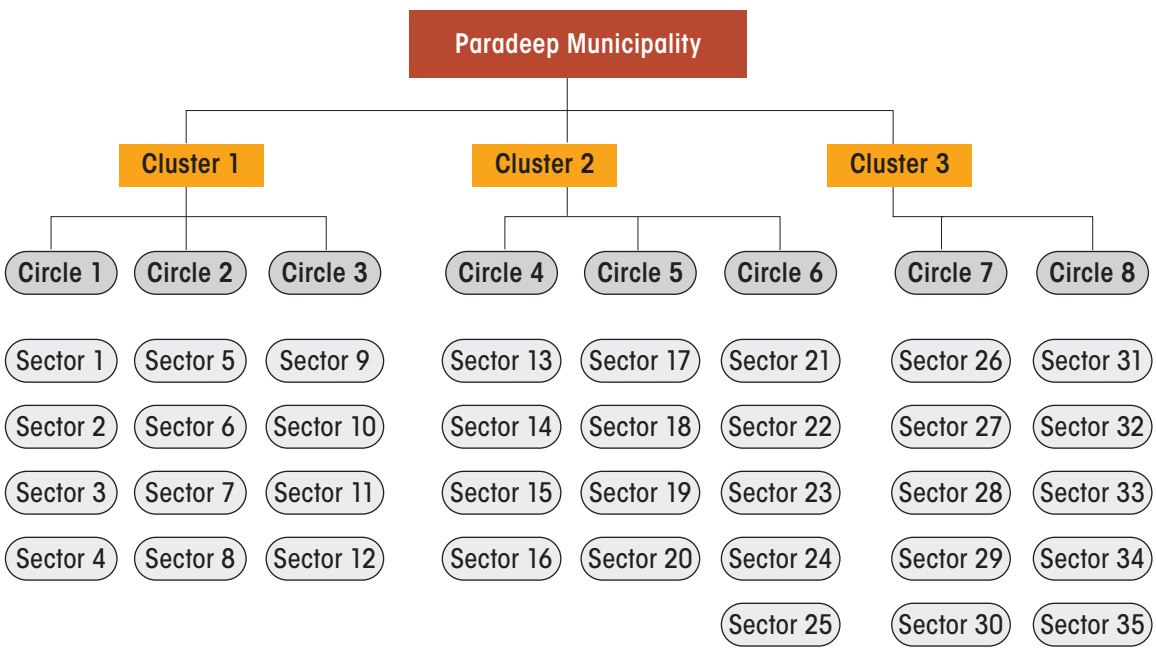
Door-to-door collection is done by *swachha karmi* under the supervision of *swachha sathi*. Households hand over segregated waste, which is collected by a multi-compartment vehicle. The primary collection vehicles are battery operated – BOVs transport the waste directly to the micro-composting centres and material recovery facilities – which is eco-friendly and easily managed by women self-help group drivers.

Households are instructed to store biodegradable waste and non-biodegradable waste in separate blue and green bins. When the sanitation staff arrives they put biodegradable waste in the green bin and non-biodegradable waste in the blue bin. Non-biodegradable waste undergoes further source segregation. Households keep domestic hazardous and sanitary waste separately to be collected in different bags in the transport vehicles.

At the micro-composting centres and material recovery facilities, biodegradable and non-biodegradable waste are weighed and quantities noted in a register. Biodegradable waste is treated through aerobic composting using tubs. Non-biodegradable waste is further segregated into recyclable and non-recyclable materials. Recyclables are sold to registered vendors. Non-recyclable combustible waste is sent to authorised cement factories for co-processing.

With the aim to have a plastic-free city, Paradeep Municipality has signed a memorandum of understanding (MoU) with a private entrepreneur. It has integrated

Paradeep Municipality: Clusters, circles and sectors



Source: Paradeep Municipality

Different stages of dry waste processing at a material recovery facility

six ragpicker groups into self-help groups and engaged them in material recovery facilities to support the private entrepreneur in processing plastic waste. The Municipality will clean the city without needing to make any investment while also providing livelihood to ragpickers. In this model of public–private partnership, the private entrepreneur sets up machinery with their own investment and the municipality sets up material recovery facilities. The private entrepreneur pays members of self-help groups as per the statutory pay scale requirement of the Odisha government.

At the plastic recycling plant, self-help group members segregate non-biodegradable waste into recyclable and non-recyclable waste. Recyclable plastic waste is cut uniformly by a shredder machine and thoroughly washed and dried. The materials are processed into granules, which are sold to factories for processing into a new product.

A wealth centre comprises one micro-composting centre and one material recovery facility. It is operated as a separate profit centre in a self-sustainable model. A corpus fund is created for each wealth centre wherein the resources generated are deposited and admissible expenditure is incurred by the urban local body. Wealth centre income from selling organic compost and plastic recyclable products and from user fees from garbage generators is deposited in the corpus fund and operational expenditure is met from this revenue.

Aerobic composting is done in the micro-composting centres. This is a controlled process involving microbial decomposition of the biodegradable waste collected from households and/or other establishments and converting it to organic compost, called Mo Khata, sold at the rate of Rs 20 per kg.

WHAT HAS WORKED IN PARADEEP

Special about the initiative

Paradeep Municipality involved the transgender community in the frontline of solid waste management. The introduction of transgender people in the chain of solid waste management is the first initiative of its kind in the state. Transgender people were organised into a self-help group and appointed for operation and maintenance of the micro-composting centres and material recovery facilities, thus improving their livelihoods as well as socialising them into the mainstream.

Revenue generation in 2019–21 (in Rs)

Expenditure					
Financial year	User fees collection	Revenue generated from Mo Khata selling	Revenue generated from dry recyclable waste selling	Incentive of swachha karmi	Total expenditure towards solid waste management
2019–20	15,21,926	3,480	3,900	2,73,060	10,24,000
2020–21	26,90,185	1,08,240	1,99,803	6,82,650	21,12,000
Total	42,12,111	1,11,720	2,03,703	9,55,710	31,36,000
Subtotal	**45,27,534**			**40,91,710**	

Source: Paradeep Municipality

Paradeep Municipality: Details of Income and expenditure on solid waste management (February–July 2021) (in Rs)

Monthly expenditure	Figure					
Month	July 2021	June 2021	May 2021	April 2021	March 2021	February 2021
Collection and transport	1,41,550	1,32,350	1,36,400	1,31,600	1,22,750	1,24,300
Maintenance of vehicles	52,000	47,000	62,000	53,000	41,000	46,000
O&M at micro-composting centres and material recovery facilities	25,000	19,000	27,000	22,000	28,000	16,000
Incentives	1,36,530	1,36,530	1,36,530	1,36,530	1,36,530	1,36,530
Total	**3,55,080**	**3,34,880**	**3,61,930**	**3,43,130**	**3,28,280**	**3,22,830**
Revenue generated						
From micro-composting centres	84,000	25,000	32,000	14,000	12,000	24,000
From material recovery facilities	56,000	52,000	61,000	43,000	58,000	50,000
User fees collected	3,20,000	2,80,000	3,15,000	2,92,000	2,75,000	3,35,000
Fine collected	350	220	0	0	550	720
Total	4,60,350	3,57,220	4,08,000	3,49,000	3,45,550	4,09,720

Paradeep Municipality

Impacts

- **Environmental:** The zero-dumping initiative of management of municipal solid waste ensures that no waste is dumped at any stage from collection to treatment. It minimises the risk of soil contamination, groundwater contamination and surface-water contamination due to dumping of waste. Harmful smoke generated from burning of dry combustible wastes and foul smell from decomposition of wet waste – a significant threat to air environment – is minimised due to the modern treatment and disposal facilities.
- **Social:** Social conditions have improved significantly as a result of the sanitization facilities provided. Because of job security and regular incentives, workers associated with the management of municipal solid waste have social respect in their communities. Their lives have improved due to the facilities such as health, education and ease of transportation. Their transformation from housewives or ragpickers to municipality workers has empowered them.
- **Economic:** The model for this initiative is based on economic sustainability. The revenue generated or collected from user fees and from selling of product is always higher than the budget expenditure in this model. Records show proper management by the municipality and associated workers ensures profit increases consistently.

Paradeep Municipality recognises the necessity of creating awareness to change the behaviour of citizens towards source segregation. They have empanelled women self-help groups as their source of communication in the chain of solid waste management. The rigorous door-to-door campaign organised by the swachha sathis brought a significant change in behaviour of the citizens. They now hand over segregated waste to waste collectors on a daily basis, which makes the next process more efficient. The overall aesthetic of the city has improved as there is no littering.

Self-help group members who had meagre or no incomes are now gainfully employed in the solid waste management sector. They are responsible for the overall waste management in the city and the decentralized facilities, i.e. micro-composting centres and material recovery facilities, are also maintained by them.

Initially, to strengthen the system of decentralised solid waste management, the municipality paid self-help group members associated with it. But once the system started functioning full scale, revenue generated from the units was sufficient to meet the requirements of operation and management of the facility. Additional revenue met the salary requirements of the self-help group members, making the system self-sustainable. Cycles were provided to women workers so that they were not dependent for transportation and could reach work on time.

Every month a "bada khana" programme is organised by the municipality, where sanitation and municipality officials eat together and socialise. The Municipality previously spent large sums of money on improper management of solid waste and in return never generated any kind of revenue aside from fines. For the first time their model has become self-sustainable. All the expenditure on the solid waste management is from revenue generated from micro-processing centres and material recovery facilities as well as from user fee collection.

Members of the transgender community at a micro-composting unit

REPLICABILITY

The Odisha government has been working to make the city clean and to simultaneously improve the socio-economic status of the workers. To make solid waste management economically sustainable, Paradeep Municipality follows the concept of waste to wealth at every step from collection to disposal. This helps in reducing waste in the city as well as contributes to the socio-economic development of community-based organisations.

Paradeep Municipality has adopted the decentralised and community-driven model with micro-composing centres and material recovery facilities. With the active involvement of women members of Mission Shakti, transgender groups and ragpicker groups, Paradeep Municipality created a sustainable waste management system while empowering self-help groups and transgender and ragpicker groups.

The decentralised model enabled the municipality to manage its solid waste with a sustainable solution. Other urban local bodies can adopt this model and improve solid waste management along with empowering women, transgender and ragpicker groups. By integrating them into the mainstream, urban local bodies can, along with waste management, improve the socioeconomic environment.

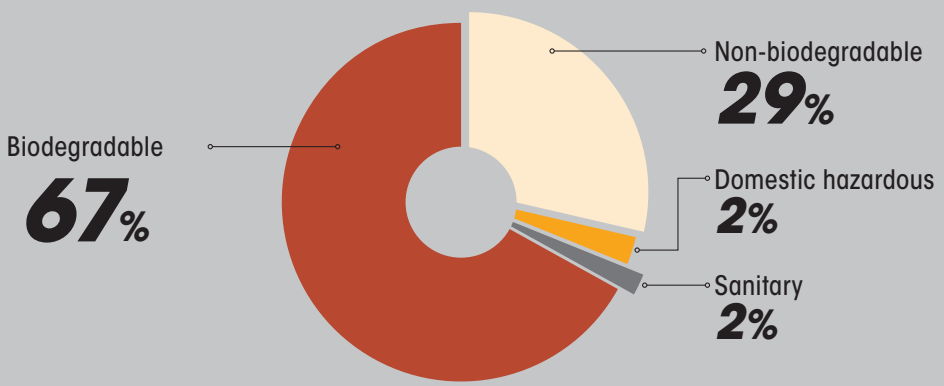
KERALA

THIRUVANANTHAPURAM

An inclusive economically sustainable decentralised approach to solid waste management has kept Thriuvananthapuram clean and free of landfills

Thiruvananthapuram, capital of the southern state of Kerala has an estimated population of 1.34 million and is among the most highly populated cities of the state. It produces 325.3 tonnes of waste per day. Handling this huge amount of waste is a challenge for the Thiruvananthapuram Municipal Corporation (TMC).

Waste composition in Thiruvananthapuram



Source: Thiruvananthapuram Municipal Corporation

Population (in million, as per 2011 Census)
0.95

Estimated current population (in million)
1.34

Estimated floating population (daily)
50,000

Area (sq. km)
214.86

Number of households (in million, 2021)
0.38

Number of wards
100

Number of zones
25

Municipal solid waste generation
(in tonne per day or TPD, excluding C&D waste and inerts)
325.3

Number of sanitation workers
1,195

Number of community bins
65*

Number of garbage-vulnerable points
0*

Waste management vehicle fleet size
39

Percentage of households covered under door-to-door waste collection
10

Percentage of households segregating waste
100

Percentage of waste processed
54

* According to the Swachh Survekshan ranking (Star Rating for Garbage-Free Cities) parameter, zero community bins and zero garbage-vulnerable points are strong indicators of an efficient solid waste management system.

Source: Thiruvananthapuram Municipal Corporation

THE TRANSFORMATION

Until 2011, the management of waste was not economically sustainable for Thiruvananthapuram Municipal Corporation (TMC). Expenditure was high and the results unsatisfactory. Of the total waste generated in the city, just 20 per cent was segregated and recovered and the remaining quantum, nearly 80 per cent of waste generated, was dumped at Thiruvananthapuram's dumpsite, Vilappilsala.

In 2011, the city was forced to shut down the Vilappilsala dumpsite following local protests over unscientific management of waste on the site. Following the shutdown, TMC adopted a decentralised approach to resolve the crisis under the aegis of the Kerala Suchitwa Mission, a technical support initiative under the Local Self Government Department, Government of Kerala. The Mission is responsible for providing technical and managerial support in waste management to local self governments in the state. Under this Mission, TMC engaged with private agencies and self-help groups that undertook door-to-door collection and treatment of waste generated in the city.

The city conceived the waste management system as a social and inclusive campaign by coining the slogan "My Waste My Responsibility" and named the campaign Green Protocol. Extensive information, education and communication (IEC) activities were undertaken to achieve source segregation. As a result, the crisis became a source for income generation. Private agencies and self-help groups shared the responsibility of bearing the costs for management of waste with TMC. In addition, TMC opted for an inclusive approach towards sustainable and community-driven waste management in the city, with participation of migrant workers, the public, and members of self-help groups.

Since 2013, TMC has followed decentralised solid waste management wherein on-site treatment of biodegradable waste is given utmost priority. The city currently does not have any centralised solid waste management

Material recovery facility (MRF) in Thiruvananthapuram

plant, landfill or waste dumpsite, making decentralised waste management a sustainable economic model for the city. TMC has received national as well as global recognition for its performance in waste management.

TMC initiated the treatment of legacy waste in the dumpsite and transformed reclaimed land into Sanmathi Park to generate awareness among citizens to demonstrate that waste can be converted into resources if segregated at source and treated scientifically. By involving workforce and machinery for six months to segregate 1,600 tonne of mixed waste, the government succeeded in fostering the ethos of "my waste my responsibility" among citizens.

HOW THE SYSTEM WORKS

TMC is divided into 25 zones and 100 wards spread over an area of 214.86 sq. km. For ease of operations and functioning, a ward-level Health Sanitation Committee has been formed.

Model for collection calendar for non-biodegradable waste

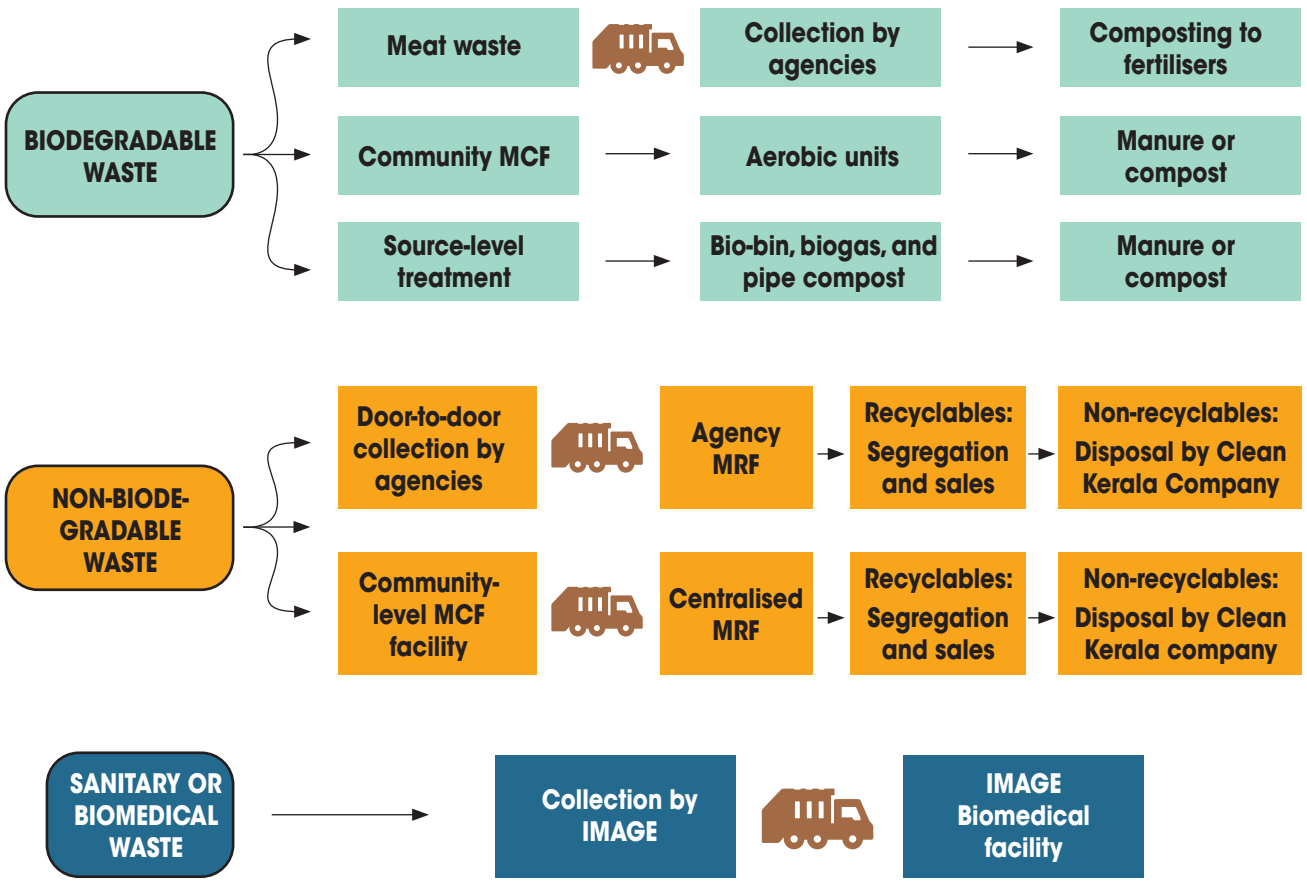
Month	Item collected
January	Footwear, bags and leather items
February	Glass bottles, mirrors, medicine strips, etc.
March	Rubber, tyres, etc.
April	Footwear, bag and leather items
May	Glass bottles, mirrors, etc.
June	E-waste
July	Footwear, bag and leather items
August	Glass bottles, mirrors, medicine strips, etc.
September	Clothes
October	Footwear, bag and leather items
November	Glass bottles, mirrors, etc.
December	E-waste

The city initiated door-to-door collection of waste as a common strategy. TMC empanelled private agencies for door-to-door collection, minimising the financial burden of the Corporation. Collection, segregation and transportation is done by private agencies for non-biodegradable waste.

It is important to note that waste management operations in Thiruvananthapuram is a unique model as they collect waste from a meagre 10 per cent of households. The remaining households deposit their waste in a nearby material collection centre which are run by private agencies. As a result, the cost incurred in collection, transportation and treatment of waste from households is nominal for TMC. The city is home to 384,503 households of which 20,563 pay user fees for door-to-door waste collection. The other households use community material collection

Baling machine inside a material recovery facility

Thiruvananthapuram Municipal Corporation waste management



facilities (MCFs). In addition, there are 19,851 institutions and 167 bulk-waste generators which also treat their waste in a decentralised manner.

To support these efforts, TMC provides subsidies to households for setting up on-site residential composting and biomethanation facilities. Due to the extensive awareness campaigns and capacity-building programmes, nearly 40 per cent of households properly managing their biodegradable waste at source by individual compost units or community-level facilities. Additionally, households can pay to the authorized service providers (private agencies) for handling and treating the waste. For biodegradable waste, recyclables are extracted from the material recovery facility and non-recyclables are disposed of by Clean Kerala Company, a state-government-owned company. Biomedical wastes generated in the city is handled by IMAGE (Indian Medical Association Goes Eco-Friendly). To avoid hurdles during collection, households were provided with collection calendars.

A total of 1,195 sanitation staff for door-to-door collection; 500 staff for transportation; and 185 staff for processing are actively involved in the waste management project.

TMC does not earn revenue from waste management as they have engaged the self-help group's federation Kudumbashree and other private agencies in public–private partnership (PPP) mode. Timely monitoring from the Health Sanitation

Aerobic compost unit in Kalippankulam

Capital and operational cost incurred in SWM (per month)

Parameter	Cost (in lakh rupees per month)
Expenditure on MSW collection and transportation (managed by private companies and SHGs in PPP mode)	Nil
Expenditure on MSW processing (managed by private companies and SHGs in PPP mode)	Nil
Expenditure on scientific disposal of inerts and rejects and making of refuse-derived fuels	38.94
Total expenditure	**38.94**
User fee collected	3.26
Revenue generated from selling compost and biogas	7.71
Revenue generated from selling recyclables	14.92
Revenue generated from selling refuse-derived fuel	1.77
Revenue generated from chicken waste disposal fee	1.85
Revenue generated through imposing penalties	1.16
Total revenue	**30.67**

Committee has brought systematic and professional functioning of ward-level waste collection. TMC has also implemented the Green Protocol for reducing waste generation and mitigation measures for waste management, grading of waste and its scientific way of disposal. They continue to create awareness among citizens to reduce use of plastic and similar materials to decrease the amount of waste generated. Additionally, the authorities imposed fines and penalties for those who violated the Green Protocol.

TMC's app Smart Trivandrum enables users to find the nearest waste management or recycling facility, stay updated about periodic clean-ups, and receive pick-up calendar reminders. People can ask for assistance through the app for properly managing their trash. TMC's goals include achieving smart growth, cost saving and long-term sustainable values. By implementing an economically sustainable strategy, it has ensured developmental goals are realised and economic sustainability indicators fulfilled.

Sustainable economic model

TMC adopted a sustainable model and supported long-term economic growth without adverse social, environmental or cultural impacts on the community. Both the community and administration are performing their duties so that not just the administrative wing but also the community is responsible for resolving problems caused by improper waste management. For instance, segregated wet waste such as chicken or meat waste is treated on-site by home composting or community composting and converted into manure that has a reasonable market value. The involvement of private companies in the public–private

Impacts

- Thiruvananthapuram is a classic example of how a decentralised model of waste treatment can minimise the cost burden for urban local bodies.
- Application of public–private partnership improved the waste management scenario of Thiruvananthapuram. The government body delegated responsibilities to private agencies, with a positive impact on the overall project.
- TMC has created green job opportunities for women to give them financial stability.
- Sanmathi Park was used as a tool for information, education and communication (IEC) to make people socially responsible and create awareness about sustainable waste management.
- Imposition of fine and penalties for violation of Green Protocol generated awareness among citizens about their activities around handling of waste.
- Introduction of the Smart app gave visibility and transparency of the project and made citizens more connected.

partnership (PPP) model has been one of the significant factors contributing in the sustainable economic model of the city. Currently, 22 service providers in the city provide door-to-door services for waste collection, treatment, transportation and disposal.

WHAT HAS WORKED

Thiruvananthapuram has become one of a pioneer cities in decentralised waste management in India. This model also incentivises segregation at source by providing subsidies for on-site treatment of waste. This was possible because of the cumulative efforts of TMC, Government of Kerala, external service providers and communities. Extensive information, education and communication (IEC) activities by the corporation and active engagement of the communities have borne fruit.

LESSONS LEARNT

TMC's model of decentralised waste management that is economically viable has set an example. While over 1,195 people received financial assistance, the financial burden for the authority was only for disposal of municipal solid waste. Public–private participation (PPP) brought increased transparency as well as reduced financial burden to the government authorities.

Environmental and economic aspects of solid waste management were recognised as being interdependent and enabled TMC's sustainable development goals. The living conditions and health of stakeholders have improved significantly as a result of efficient waste management practices.

By creating Sanmathi Park, TMC demonstrated how resources can be used judiciously. The transformation of the dumpyard into a park is inspirational, and many

Home composting in progress

people from around the state visit Sanmathi Park to understand the benefits. During the period of the pandemic, the initiative also provided job opportunities.

REPLICABILITY

TMC appointed an external agency that was responsible for door-to-door collection, transportation and segregation. This enabled financial management for the project to become more feasible.

TMC has also brought a new paradigm to waste management by prioritising environmental and economic sectors equally and set an example by combining profit with sustainability. They took innovative steps towards finding solutions for mismanagement of waste and to inculcate the idea of equality among the citizens with respect to waste management.

Public–private partnership has aided the cost efficiency of the project. Several parts of Kerala are considering TMC's efforts in waste management to implement economically feasible strategies.

Waste-wise Cities
A CSE-Niti Aayog Survey

28 cities. Multiple initiatives.
Alappuzha, Ambikapur, Bengaluru, Bhopal, Bicholim, Bobbili, Chandrapur, Delhi (NDMC), Dhenkanal, Gangtok, Gurugram, Indore, Jamshedpur, Kakinada, Karad, Keonjhar, Kumbakonam, Leh, Mysuru, Panchgani, Paradeep, Pune, Surat, Taliparamba, Vengurla, Vijayawada, Thiruvananthapuram

This report brings together some of India's best practices in the management of municipal solid waste. Surveyed and assessed by a team of on-field researchers, these practices and initiatives inform us about the unique challenges that cities and towns in India face, and offer both specific as well as general lessons, each valuable in its own right.

NITI Aayog