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.

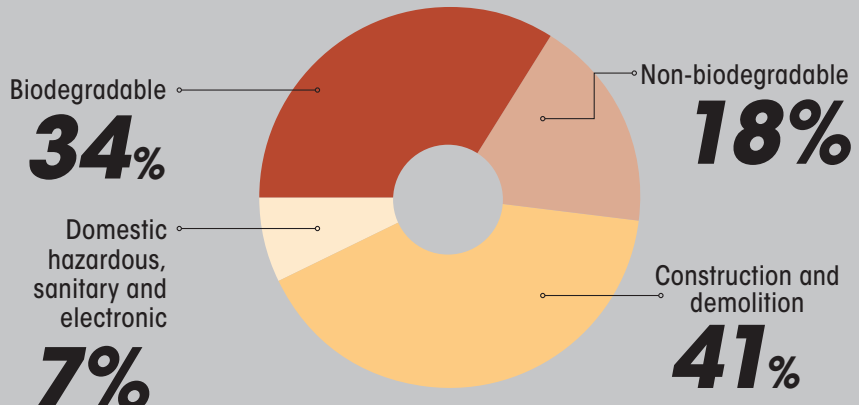
ANDHRA PRADESH

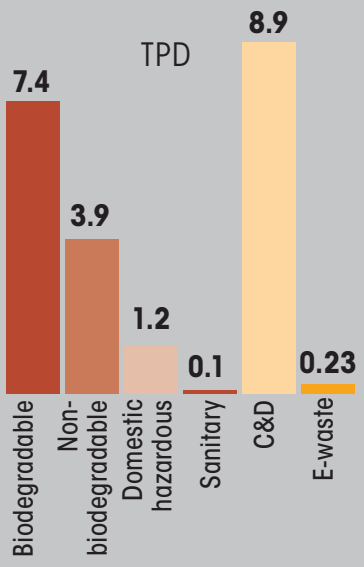
BOBBILI

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

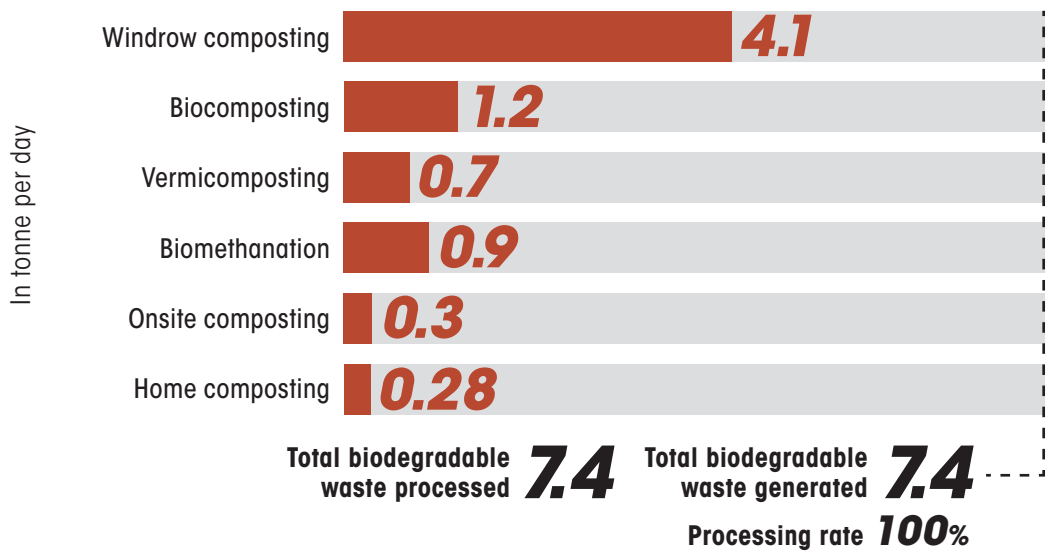
The city generates 7.4 tonne of biodegradable waste daily which is pulverised through shredding and volume reduction before being fed into composting units. Leachate and cow dung are used to produce biogas at the biogas plant.

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.

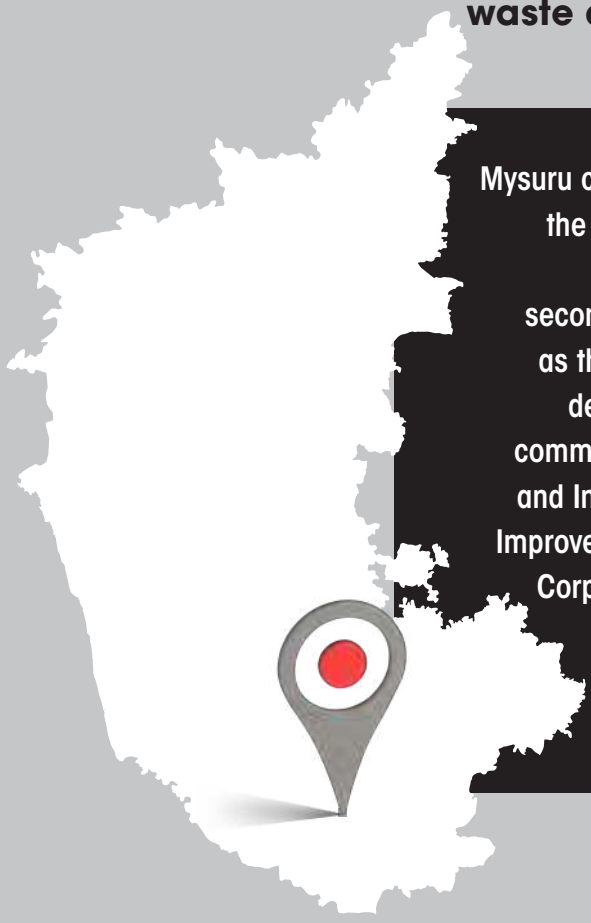
REPLICABILITY

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

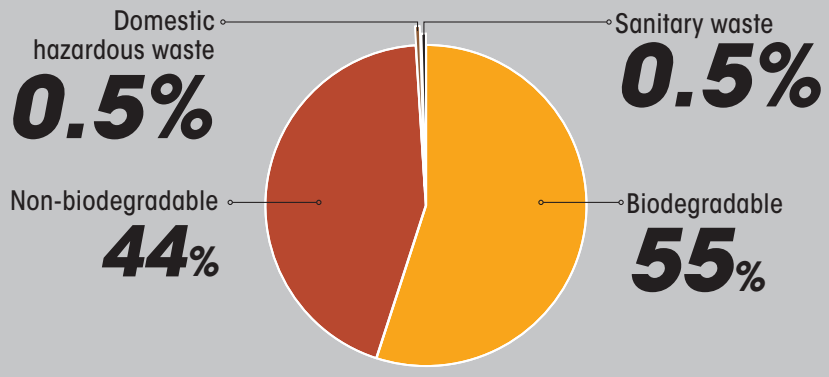
MYSURU

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

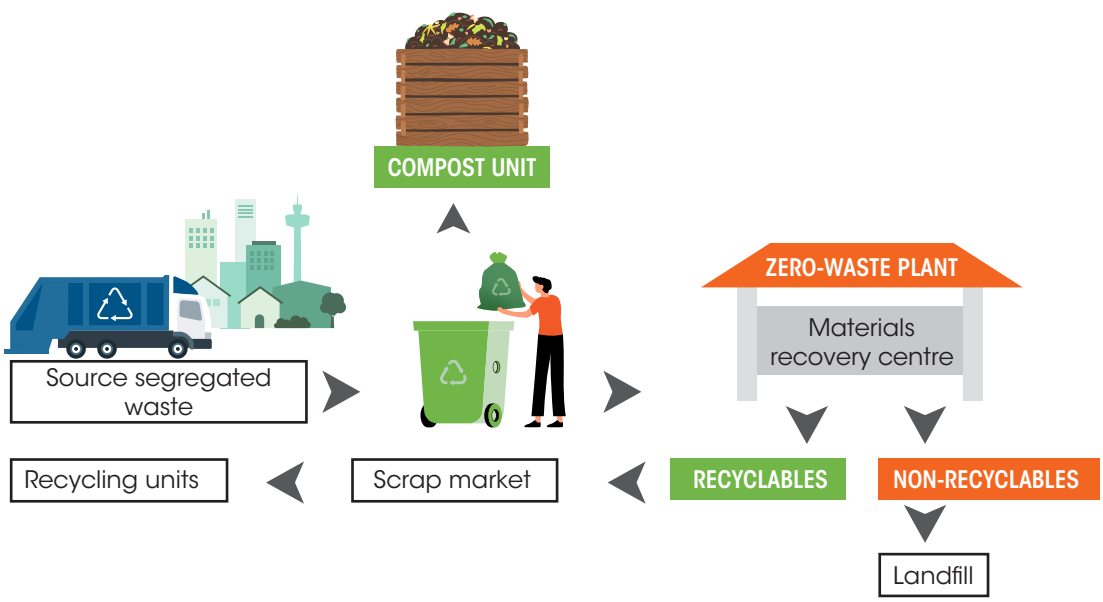
Facility	Capacity (TPD)	Number
Centralised compost plant	200	1
Decentralised waste management plant	35	7
Dry waste collection centre	43	43
Centralised landfill	90	1

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

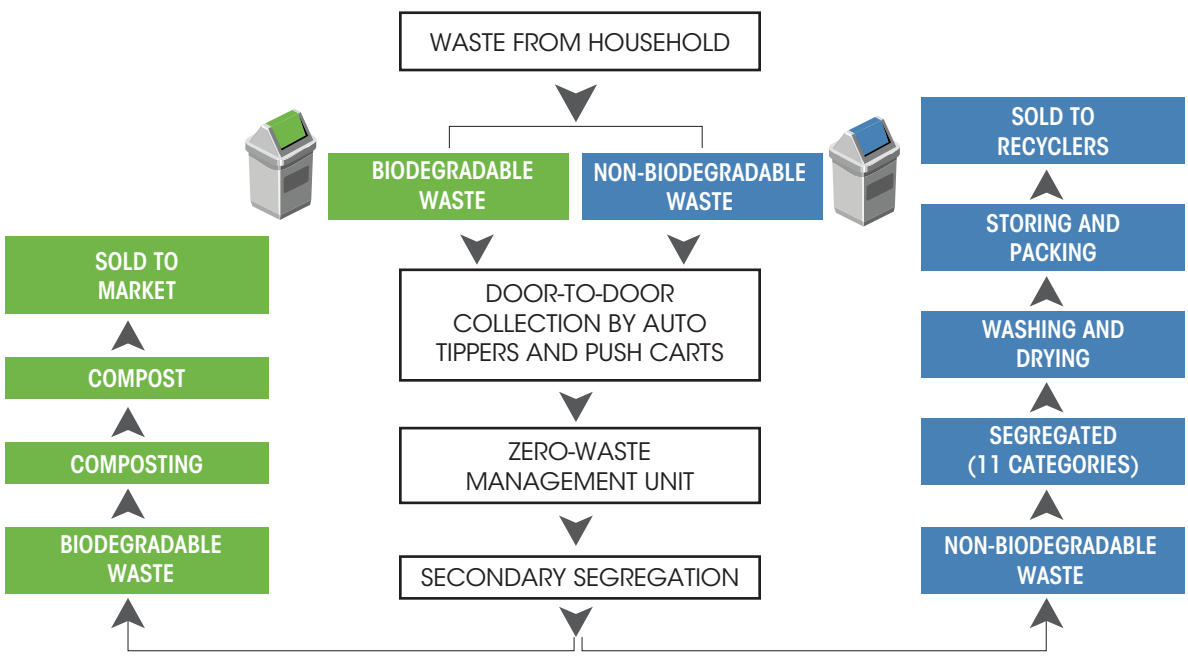
Mysuru City Corporation has one centralised biodegradable waste-processing plant. The city is on the way to achieving 100 per cent segregation, but mixed waste is still generated in some parts. Mixed waste collected is not sent to the decentralised unit but to the centralised unit for processing.

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.

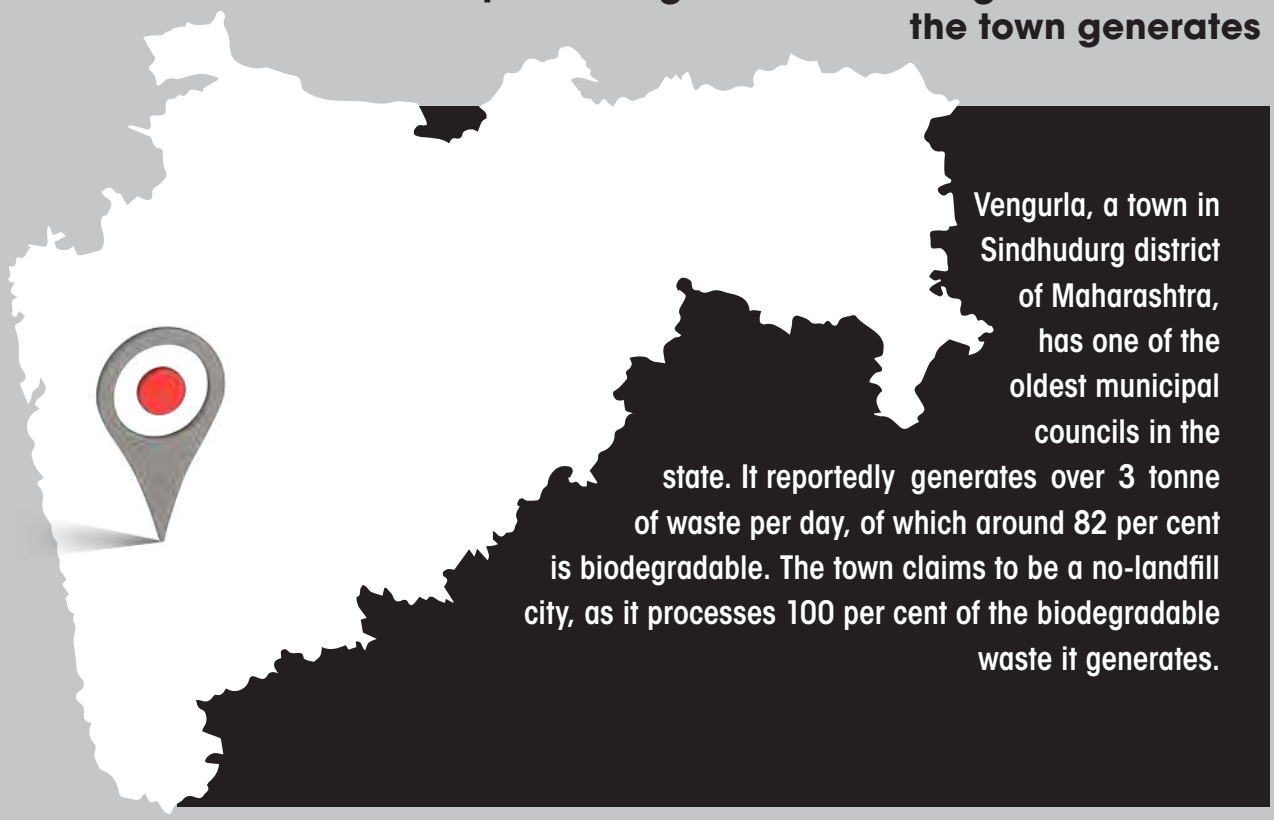
Urban local bodies generally focus on recyclables, putting aside biodegradable waste management on the assumption that it will degrade naturally. However, the biodegradable fraction needs to be handled scientifically as this is a major fraction of our municipal solid waste. If not managed properly, it 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

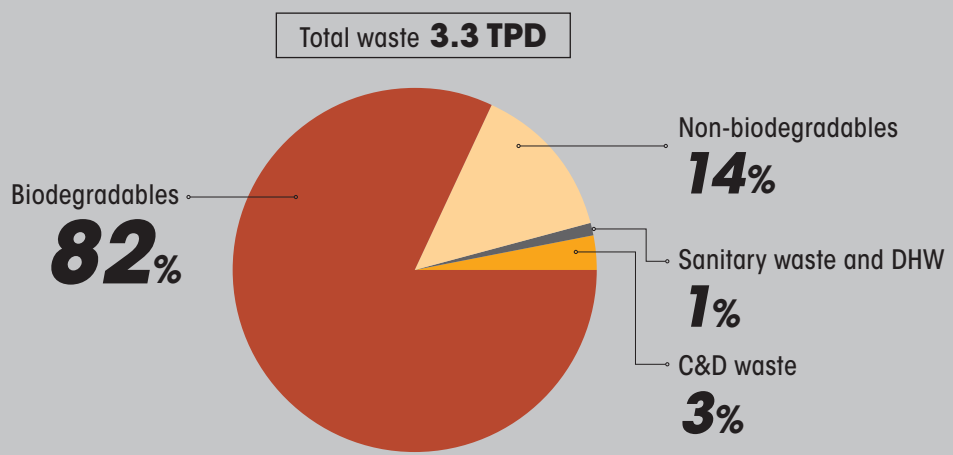
VENGURLA

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.

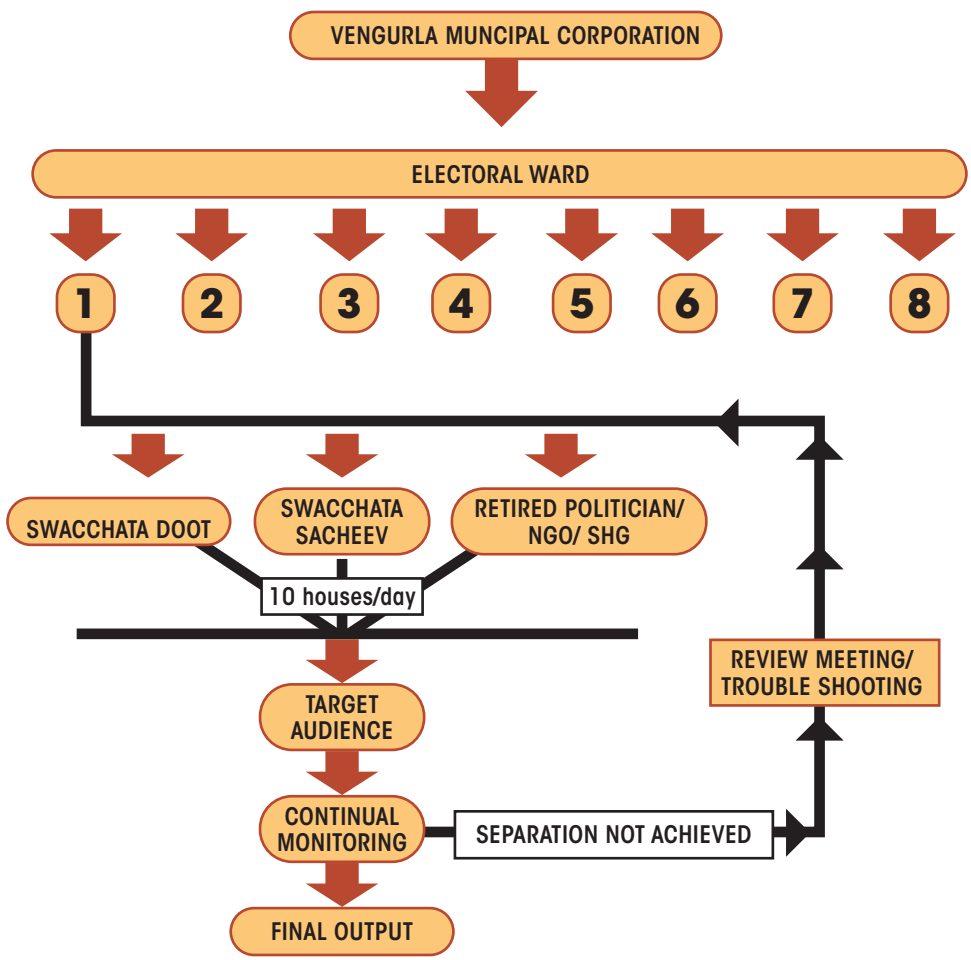
Review meetings were held every fortnight. These meetings helped the team identify, understand and address all the issues.

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