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## **Municipal solid waste management of Indore: A review**

**Shraddha Vivekanand Gurlhosur<sup>1</sup>, Mohd Wasif Quadri<sup>2</sup>, Devendra Dohare<sup>3</sup>**

<sup>1,2</sup> PG Scholar, Environmental Engineering, Shri Govindram Seksaria Institute of Technology and Science, Indore, Madhya Pradesh, India

<sup>3</sup> Professor, Environmental Engineering, Shri Govindram Seksaria Institute of Technology and Science, Indore, Madhya Pradesh, India

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### **Abstract**

The management of solid waste has become a major cause of concern over the past few years in both developed and developing countries. With rapid increase of population, urbanization and industrialization, there has been a marked rise in living conditions of people and this had led to the generation of varied types of solid waste that needs to be effectively managed. Since 2016, Indore has eliminated garbage dumps, ensured 100% waste segregation and converted waste into useful products. Indore has been adjudged the cleanest city of India consecutively for three years by the urban development ministry. The paper summarizes the solid waste management practices, strategies, processes and methods used to manage the Municipal solid waste in Indore.

**Keywords:** waste segregation, cleanest city, waste management, solid waste

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### **1. Introduction**

Wastes are inevitable part of human activity. The problems associated with waste can be traced back to the very beginning of civilization, when humans gathered in communities. Wastes generated then were contained and disposed of by natural processes. However, as population increased and villages grew into towns and then into cities, the amount of waste generated increased. Consequently, wastes were dumped indiscriminately into waterways, empty lands and access roads.

Indore is the most populous and the largest city in the Indian state of Madhya Pradesh. It serves as the headquarters of both Indore District and Indore Division. It is also considered as an education hub of the state and has campuses of both the Indian Institute of Technology and the Indian Institute of Management. Located on the southern edge of Malwa Plateau, at an average altitude of 550 meters (1,800 ft) above sea level, it has the highest elevation among major cities of Central India. Indore had a census-estimated 2011 population of 1,994,397 (municipal corporation) and 2,170,295 (urban agglomeration). The city is distributed over a land area of just 530 square kilometres (200 sq mi), making Indore the most densely populated major city in the central province.

On 2nd October 2014, the birth day of father of the nation, Mahatma Gandhi, the 'Swachh Bharat Mission' (SBM) was launched by Govt. of India. This was given the shape of mass movement with Prime Minister, Mr. Narendra Modi leading the mission. The mission was split into two parts – urban and rural. In urban areas, the focus was on building open defecation free (ODF) towns by constructing individual, community and public toilets, and scientific solid waste management. Indore have achieved ODF in the year 2016, also ODF+ as well as ODF++ 2018 - 2019. Since 2016, Indore's municipal corporation (IMC) has eliminated garbage dumps, ensured 100% household-waste segregation and converted waste to usable products, such as compost and fuel.

To keep up the good work, the Municipal Corporation of the city has taken a step towards eliminating single-use plastic cutlery not only in government offices but in food joints and private functions too by creating "Bartan Bank" More than 90 per cent of the litter in the city consists of single-use plastics, that are difficult to collect, clog drainage systems and pose a big threat to the environment being non-biodegradable. These "banks" have been set up through CSR funds in the zonal offices of Bengali Square and Sukhlia each. The corporation plans to extend this service to other 17 zones too, over two months, thus covering the entire city. Every 'Bartan Bank' has more than 3,000 sets of utensils/cutlery (plates, bowls, glasses, spoon, etc.). So, anybody in need of cutlery for occasions can go to the bank and issue these utensils as per their requirements with prior notice of 24 hours, completely free of cost. Once used, these utensils have to be cleaned and deposit it back at the bank. In case a utensil is damaged or lost, the person issuing it will be charged to recover the loss. More than 200 people have used the service, and the response has been exceptional.

### **2. Sources of Waste**

As per CPCB, 1,43,449 TPD of MSW was generated for 34 states and union territories during 2013–2014. The average rate of waste generation in India, based on this data, is 0.11 kg/capita/day. Out of the total waste generated, approximately 1,17,644 TPD (82%) of MSW was collected and 32,871 TPD (22.9%) was processed or treated. In Indore, waste is generated from various sources including households, commercial areas and other institutions like RWAs, hospitals, hotels among others. Major categories of waste include Municipal solid waste, E-waste, Hazardous waste, Bio-medical waste, C & D Waste, Plastic waste. The composition and quantity of municipal solid waste generated is the basis on which the management system must be planned, designed and operated. Composition of the

municipal solid waste collected by Municipal Corporation is represented in the table 1 below:

**Table 1:** Composition of the municipal solid waste collected by Municipal Corporation

Composition	Percentage
Paper	8.2%
Plastics	5.8%
Stones	20.19%
Metals	0.89%
Compostable matter	40.28%
Ash & Fines	45.76%

### 3. Segregation of Waste

Indore has been divided into 19 zones and 85 wards. Each ward has on an average 6,000 households and 600 commercial establishments. The households or residential complexes are covered by the door to door collection system while the semi bulk and bulk generators are covered by the bulk collection system. Indore ensures the 100% coverage of wards through its door to door collection system. In Indore, waste is collected in segregated manner i.e. the waste is segregated at source by the generators. The total waste generation in Indore is 1115 MTPD. Out of the total waste 58.25% is the wet or organic waste, 41.75% is dry waste and 0.5% is household hazardous and sanitary waste. The total wet waste generation is 650 MTPD (Approximately) and dry waste generation is 465 MTPD (Approximately).

The waste generators have been classified as:

**Domestic generators:** the generators that generate less than 25 kg of waste per day. The waste is generated in segregated form as wet waste, dry waste and domestic hazardous waste

**Semi bulk generators:** Generators that generate 25-100 kg of waste per day have been classified as semi bulk generators

**Bulk generators:** The generators generating more than 50 kg of waste have been classified as bulk generators. The bulk generators segregate the waste as wet waste and dry waste.

As per SWM Rules 2016, these bulk waste generators have installed on site composting facility to treat wet garbage generated from their institutes. Daily door to door collection of waste is practiced. This makes the city dustbin free and more hygienic and cleaner. The segregated waste collected is transported to the trenching ground for processing.

### 4. Awareness Campaign for Behavioral Change

The first step of implementation was to create awareness among the people and the community through pamphlets, loud speakers, community rally, meetings and public participation. They were made aware to segregate wet and dry waste, its benefits and consequences on human health & environment. Information, Education and Communication (IEC) is the key to behavior change which lies at the foundation of making a success of Swachh Bharat Mission. IMC adopted and undertook a range of IEC activities including traditional, audio visual, print, electronic media, social/digital media. Some of the novel IEC measures taken up by IMC for behavioral change in Indore are summarized below.

Grassroots innovations street plays, Wall paintings, FM radio constantly upgraded its content itself through incorporating new thematic messages to be communicated and utilizing creative ways of undertaking the same. Cultural events such as Ganesh

festival, Dussehra, Gandhi Jayanti were utilized as events to spread the swachhata message. An important aspect related to IEC was its integration into monitoring activities. These activities verified (monitored) the status of service delivery.

Verification process took place through different means. These included a) 311 app for service delivery, b) surprise checks through online site visits, c) monitoring staff attendance through biometrics. 311 app has emerged as an important means for registering complaints emerging from different residential areas. The complaints are addressed in quick turnaround time. The status of complaints registered and addressed is monitored by the Municipal Commissioner.

The NGOs through IEC not only communicated how waste can be recycled but also how to prepare compost and how these can be beneficial to other stakeholders. Hence a cross partnership was established where the waste turned into a value product serving the needs of others.

### 5. Collection of Waste

Earlier household waste was collected in some locations by municipality workers and in others through private arrangement by housing colonies. Private waste collectors were called "Jagirdars". They had very poor service quality levels and often dumped the garbage in open government land/ empty plots leading to health hazards for citizens. From the central dustbins, waste was removed by a private contractor A2Z Infrastructure Limited and moved to open dumping ground in to Devguradia. The combination of poor collection and transportation of household waste lent a filthy look to the city. The morning trip covers domestic areas and evening trip covers all the commercial areas.

This led to development of effective door to door collection system. In order to implement successful door to door collection system, an identification study was carried out which helped to figure out the amount of waste generated at each ward and the population of each ward. On that basis, a detailed route plan was prepared to cover all wards. Based on the route plan, a detailed vehicle and staff deployment plan was implemented in order to meet the waste collection demand of each ward. The door to door collection is done through the use of partitioned vehicles. These tippers have been partitioned in the ratio of 50:50, 60:40 or 85:

15. The wet and dry waste is collected by these vehicles in separate chambers. The domestic hazardous waste is collected in a separate bin that is attached at the back of the tipper. There are three separate collection bins for wet, dry and domestic hazardous waste in each tipper. These tippers consist of one driver, one helper, and a

NGO person which helps in carrying the waste from households to the transfer station, from where the waste is transported to the trenching ground in hook loaders. All vehicles used in the collection and transportation system are monitored by a GPS enabled tracking system and are equipped with siren, which makes people alert and compel to come to their doorstep and dump the garbage. The GPS system is constantly monitored by the control command center. Any route deviations by particular drivers are penalized and multiple deviations is also grounds for termination

Around 800 new Safaimitra were appointed to expedite the SBM activities. Presently 6200 safaimitra are involved in sweeping ad door to door collection. Aadhaar linked biometric attendance

system also known as ICT (Information and communication technologies) based intervention were also established. IMC have distributed raincoats, hand gloves, fluorescent jackets and mask, ensuring that every employee uses personal protective safety gears while working in the field.

Around 25000 stray cattle and 50000 pigs were removed from the city and stray cattle shelters within the city were removed. Illegal and dangerous hoardings were removed and encroachments on footpaths were also removed. City beautification like wall paintings, back lane cleaning, river and nala cleaning, desludging, improvement of sewerage and water supply system were also done by IMC. All these workers have free bus passes issued by IMC and they are also linked with NGO, which provides their children free education.

## 6. Transfer of Waste

Previously, the waste was being transported to the centralized processing plant which is approximately 20-23 kms from the city. To strengthen and reduce the cost of the Secondary Collection and Transportation System, IMC has constructed eight ultra-modern transfer stations of three types of models such as Ramp based static GTS (Garbage transfer station), portable Compactors based GTS and semi portable Compactors based GTS installed by Hyva and TPS Infrastructure Ltd. at different locations Star Square, Kabitkhedi, F-sector, Sanwer Road, Sangam Nagar, Sirpur, Dhar Road, Lalbagh, Crystal IT Park, Rajshahi, Dakkanwala Kua within the city. From all the transfer stations only Star square transfer station is 100% self-sustainable. The electricity required to run the transfer station is generated at plant itself. 16 KW from fully automatic 5 TPD Biomethanation plant (also known as Green bin or Energy bin) and 22 KW electricity generated from solar panels.

All of the above models have provision of segregated waste collection and transportation through Hook loaders to the disposal site. There are two hoppers one for the collection of dry waste (Blue colour) and second for the collection of wet waste (Green colour). These hoppers are connected to blue and green containers respectively. The segregated MSW is compressed into respective containers. When the containers are filled to capacity, they are lifted by dedicated hook loader and sent to disposal site in a segregated manner. The Hook loader carrying wet waste off load their waste directly to the Centralized Composting Unit whereas dry waste is off loaded to the Material Recovery Facility 1/ Material Recovery Facility 2 at the disposal site.

The weighbridge facility at the processing plant is a computerized facility with boom barriers and bar code scanners which saves man power and reduces interaction between watchman and driver. All the incoming vehicles are weighed upon entering the plant and after they are offloaded. Then a receipt is generated and recorded at the facility. This receipt depicts the quantity of waste transported, type of waste, registration number of the vehicle, source transfer station and the in-out time of the vehicle.

The bucket for the sanitary waste and domestic hazardous waste is off loaded into dedicated drums and is transported to Common Biomedical Waste Facility (CBWTF) as per the rules covered under Biomedical Waste Rules 2016 only on regular basis.

## 7. Waste processing

### 7.1 Processing of Dry Waste

Dry waste which is approximately 50% of the total waste will be sorted in an automatic Material recovery facility. The MRF facility involves separation and sorting of waste materials and preparation of these materials for reuse or reprocessing. Recycling is an important factor in the waste processing. Earlier to handle and process such large quantity of dry waste IMC had developed Material Recovery Facility- II at Devguradiya Trenching Ground. At this material recovery facility firstly pre-sorting is done by 100 mm using trommel machine. The waste passing through is known as inert material whose further recycling is not possible, hence sent to landfill. The waste retaining contains various fractions of dry waste like plastic, rubber, leather, glass, metal, cloth etc. were segregated utilizing registered recyclers (Kabadiwalas).

The non-biodegradable waste was segregated by category at the site. The recyclable low- density polyethylene (plastic bags) gets cleaned in phatka machine then shredded by egloo machine and to plastic briquetting (gatta) unit as shown in figure 1, the plastic briquettes are sold to an irrigation pipe manufacturer. Other smaller-volume recyclables such as paper / carton, glass, metals, HDPE, PPP, and PET are cleaned, sorted, bundled and traded to wholesalers at a cost-plus margin.



**Fig 1:** Briquetting (Gatta) Unit

Some of the shredded and purified plastic is also sent to Madhya Pradesh Rural Road Development Authority for road construction Plastic (HMPE and LDPE) being a petroleum product is mixed with coal tar, reducing the proportion of tar by 15%. The mixture is eco- friendly and it has also proved to be cost effective as the construction of PCC (Plastic Cement Concrete), nearly 45,000 kilos of plastic waste is recycled and reused per day.

IMC has installed India's 1st 300 MT Fully Automatic Material Recovery Facility- I at Devguradia Trenching Ground which costs 30 crores and is spread over an approximately 3 acres. It is designed by Turkish firm Disan this high-tech facility is equipped with an automated sorting system which separates all kinds of dry waste such as plastic, metal, cloths, paper and other substances more efficiently than manual sorting. The unit is installed by NEPRA Environmental Solutions Pvt. Ltd and three optical sorting machines were bought from German company Tomura.

This automatic waste segregation machine is equipped with various devices such as density sensors, gravity separator, conveyor belt etc. The waste is picked up to a height of 40ft and from there it will be segregated with help of separators and conveyors.

All the plastic waste will be processed in state of art processing plants to as to recycle more than 95% of the total plastic waste received. The recycling plant will be divided into three phases sorting, shredding and cleaning, Polymer flake sorting.

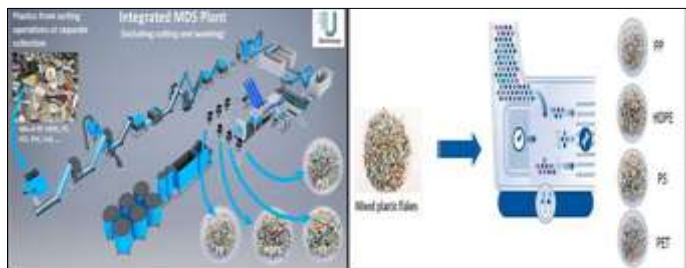


Fig 2: Integrated MDS Plant

The rejects are processed through mechanical process to produce refuse-derived fuel (RDF) and is used in Waste to Energy Plant as Fuel. The electricity thus generated is/ exported to the grid. All the multi-lead plastic (packets of biscuit, chips, etc.) whose further recycling is not possible because it contains lead in high quantity. Plastic to fuel plant capacity of the plant is 8 TPD. It can produce crude oil approximately 3000 Liters, from which 2600 liters diesel, 180 liters petrol and 200 - 300 Kg of carbon black.

### 7.2 Wet Waste

The centralized Organic Waste Processing Unit is the waste-to-compost plant situated at the disposal site at Devguradia. The plant was commissioned in the year 2009 and has an installed capacity to process 500 MT of wet MSW. The plant was installed by a company called A to Z Infra Pvt. Ltd. Under PPP Model and was being operated by it. Due to unsatisfactory performance of the company in the recent times and its inability to regularly process the organic waste, the IMC terminated the services of the company and took over the plant. After the takeover, IMC did a complete overhauling of the plant including repair of the machinery wherever required. As on today, the compost plant is working to its capacity of 600 MT of wet waste per day.

The segregated wet waste transported by hook-loaders from GTS or bulk collection vehicles is offloaded directly onto windrows of the compost plant. It is assumed that one day waste is fitted into one windrow. The Leachate from the waste is collected into two Leachate collection ponds connected to the windrows. The offloaded wet waste is then processed as per the standard procedure. Hence, 600 MT of organic waste is processed and disposed of at the centralized processing unit of the city.

The waste is passed through 32mm connected in a series with 16 mm sieving trommel. The rejects left after screening is sent back to windrows. The material passing is sent to curing section for 12-15 days to reduce moisture. After curing section, the material is then processed through 5mm screening trommel machine and is sent for packing and is sold by IMC at the rate of Rs.4/kg in loose packing and Rs.3/kg in bulk. The reject of 5mm sieve are sent to landfill.

### 7.3 Construction and Demolition Waste

A construction and demolition waste processing plant of 100 TPD capacity has been developed at Devguradiya and 4 transfer points for C&D waste have been developed within the city. Citadel Pvt. Ltd. is responsible for operation and maintenance of the plant. Four major products manufactured are mentioned in table 2 below

The samples of the final product are tested as per code provisions of IS codes. Paver block with finished surface gave a compression strength value of more than 30.00 N/mm<sup>2</sup> which is significantly greater than 25 N/mm<sup>2</sup>.

Table 2: Products manufactured by C&D waste

Product	Quantity generated per day
Paver Block with Glossy Finished Surface	1200
Curb Stone	2200 - 2500
Rough Paver Block	1200
Masonry Brick	10000 - 12000

### 7.4 Common Bio-medical Waste Treatment Facility (CBWTF)

MP's first and biggest unit Common Bio-medical Waste Treatment Facility (CBWTF) is set up in Indore where bio-medical waste, generated from a number of healthcare units, is imparted necessary treatment. Installation of individual treatment facilities by small healthcare units requires comparatively high capital investment, separate manpower and infrastructure development for proper operation and maintenance of treatment systems. The concept of CBWTF not only addresses such problems but also prevents proliferation of treatment equipment in a city. Also, it reduces the monitoring pressure on regulatory agencies. By running the treatment equipment at CBWTF to its full capacity, the cost of treatment of per bed of waste gets significantly reduced. Hoswin Incinerator Pvt. Ltd is the authorized facility for Indore situated on Sanwer road.

### 7.5 E- Waste

Recycling activities commences with the receipt of e-waste material from various clients' locations. The material is initially weighed, and is separated product-wise (monitors, CPUs, printers, keyboards, etc.) for easy retrieval. The material is then checked by qualified technicians to ascertain whether the equipment are working or non-working. If the equipment is in working/ near-working condition, then the technicians attempt to repair/ upgrade the equipment to ensure that they become re-marketable and can be resold. If the equipments are not in working condition, attempts are being made to salvage components. Accordingly, the technicians dismantle the equipment into components and try to retrieve any working parts. The residual components are then passed on for shredding into the twin-shaft shredder. The shredder, which is capable of accepting feed of around 1,500 kgs per hour, helps to open up sealed components, separating metals from plastic. The shredder accepts manually dismantled components through a hopper at one end, passes the feed through the shredding chamber where two counter rotating hexagonal shafts fitted with circular blades shred the components, and the shredded items are dropped onto a moving conveyor belt.

An inbuilt overhead magnetic band ensures automatic separation of ferrous component of the field, whereas employees, wearing appropriate safety equipment such as gloves and helmets, stand by to physically separate other metals such as aluminium and copper from the moving conveyor belt. All plastic components are deposited at the end of the conveyor belt. These metals (aluminium, steel, copper) and plastics which are of high purity in nature are then usually sold to smelters.

Certain components of the computer such as printed circuit boards (PCBs) contain precious metals such as gold, silver, etc. These PCBs are not sent for shredding and are instead accumulated and would be used for precious metal extraction. The portion of e-waste which contains hazardous elements and cannot be recycled is sent to authorized hazardous waste treatment and disposal facilities for final disposal as per the norms of the Pollution Board.

### 7.6 Street Sweeping

Respirable suspended particulate matter is an important parameter used by pollution control board to check the quality of sanitation and solid waste management in the city. Initially, the RSPM was very high in Indore at the level of 140-145 Microgram per Cubic Metre. One of the reasons for this high RSPM was dusty roads. Cleaning the roads manually was a difficult task in the main areas which are busy during most of the day. Night road sweeping was a critical aspect of road cleanliness.

#### Some of the features of road cleaning service were

- Road sweeping of 450-500 Kms per day is done with ultra-modern road sweeping machines (USA make, Elgin machines) during night between 10.00 pm to 6.00 a.m. Twelve such machines were operational in May 2017. Their machines have sturdy vacuum suction and very strong brushes.
- Litter picking is done on both sides of the road up to 10 meters
- Road sweeping on 1710 Kms roads less than 24 m width is done manually by sanitary workers of the IMC.
- Day time morning 8 am, evening 4 pm approx. 20 kms of road sweeping and litter picking is done by Municipal Corporation owned TPS company road sweeping machines.

Due to Mechanical road sweeping RSPM level has come down from 142 Microgram per Cubic metre in 2014 to 76 micrograms per Cubic metre in 2017. This has made city dust free and has resulted in improvement of health index of the city. Respiratory and other diseases were reduced by 50%.

### 7.7 Biomining of Legacy Waste

It was estimated that approximately 12 lakh MT old waste was dumped at Devguradiya. The complete waste was cleaned by the process of biomining. In 2018, the municipal corporation rented machines to segregate the legacy waste and clean the facility up. A part of this cleaned-up dumping ground was planted with trees and is being converted to a park. 100% legacy waste remediated and 100 acres land worth Rs. 300 cr. reclaimed. The proposed plan to develop Golf Course/ City Forest. Delhi, Ahmedabad and various other cities are now undertaking a similar exercise to

clean up its dumping ground.

### 7.8 Decentralized Processing of Waste

Decentralized processing for wet waste has been developed at Nandlalpura vegetable and fruit market, Rajkumar mill vegetable market through aerobic pit composting method and Khajrana Ganesh Mandir for converting flower waste into compost through Organic waste converter System. Mobile Composting Vans by swaaha for onsite treatment of Organic Waste generated from small food joints and restaurants has been deployed on contract basis. Several different types of composters have been installed in schools, parks, zoo etc. Indore has also targeted 150 TPD reduction in waste collection and transportation through in-situ treatment of organic waste.

Waste derived from the tea sellers was also taken care by IMC. They eliminated disposable material used by tea stalls and street food vendors in all 85 wards. Bottle crushing machine is also incorporated in Chappan Dukhan, railway stations etc.

### 7.9 Biomethanation

It is unique initiative taken up by Indore Municipal Corporation to produce and utilize Bio CNG produced from processing of Municipal Solid Waste. Indore has setup a biomethanation plant of 20 TPD capacity in Choithram Mandi which is basically a whole sale fruit and vegetable market and generates a huge quantity of wet waste. The present biogas project is one such project, where it fulfils all the thrust areas of the mission, namely providing the greener fuel for transportation, treating of waste water, wet solid waste with zero discharge, enhancing the amenity value by reducing the pollution. This initiative was taken up by ISCDL (Indore Smart City Development Limited) and IMC in association with Mahindra as a technology partner to establish a Bio-methanation project which generated Bio CNG for public transport. It is based on 3 R principle that is reduce, reuse and recycle and also generates a methane gas which is converted into CNG gas which is further utilized.

At Choithram mandi the digestion capacity of the installed biogas plant is 20 tons/day. The organic manure production from the plant is around 6 tons/day. The plant produces around 2000m<sup>3</sup> / day of raw biogas. The raw biogas is further enriched to meet the gas quality which is equivalent to the standards specified by BIS (IS: 16087 2016). At present 15 buses in Indore are running on the Bio-CNG and consuming nearly 500 kg of gas per day & running more than 2000 km per day

A 15 TPD capacity biomethanation plant is also present at Kabitkhedhi sewage treatment plant. This plant is dealing with all the hotel waste of the city. One unit of biomethanation plant of capacity 200 TPD at Trenching Ground is also sanctioned.

### 7.10 Hazardous Waste Disposal

Madhya Pradesh Waste Management Project (MPWMP), a Division of Ramky Enviro Engineers Ltd., has been operating a Common Hazardous Waste Treatment Storage and Disposal Facility (CHWTSDF) with Secured Landfill (50,000 TPA), Stabilization (20,000 TPA), and Incineration (20,000 TPA) at Pithampur MPWMP now proposes to enhance the treatment capacity of existing facilities— Secured Landfill (from 50,000 TPA to 75,000 TPA), Stabilization (from 20,000 TPA to 1,00,000 TPA)

## 8. Conclusion

IMC presently generates about 1100 Ton waste per day. IMC has developed the capacity to Collect transport and treat this 1100 Ton waste on daily basis.

With efforts of IMC and support from citizens and stakeholders, Indore has achieved the following: -

- Source segregation of waste in dry and wet waste.
- Door-to-door collection from all residential and commercial establishments
- Transportation of waste to processing facility on daily basis.
- Treatment of wet by composting or Biomethanation.
- Treatment of wet waste generated by bulk generators at source.
- Treatment of dry waste in two material recovery facility.
- Utilization of all rag pickers in the city in material recovery facility
- Recovery of land from old dump by Biomining process
- Vehicles equipped with GPS with geo tagging and real time monitoring through control room
- Workers registration with biometric system and wages directly to their accounts.

Separate facility for construction and demolition waste, E Waste and Domestic Hazardous waste. The valuables will be recycled for the waste and the rejects will be sent to Waste to Energy plant for Disposal. Further research is done to recover raw materials can be recovered from baby diapers and sanitary pads for high-quality reuse. The installation will sterilize diapers and process them to secondary raw materials such as plastics, cellulose and absorbent materials.

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