Konrad Adenauer Stiftung

Confederation of Indian Industry

STUDY ON

REALIGNING INDO-GERMAN COOPERATION WITH THE INITIATIVES OF THE INDIAN GOVERNMENT

A CASE OF WASTE MANAGEMENT

Project Report for

Realigning Indo-German Cooperation with the Initiatives of the Indian Government: A case of waste management

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1. DESCRIPTION OF CURRENT STATUS OF SWM IN INDIA

Due to rapid economic growth, India's urban population has been increasing from 286 million in 2001 to 377 million in 2011 (Ministry of Home Affairs, 2011a) and it is expected to reach 590 million by 2030 (McKinsey, 2010). The amount of MSW generated by Indian urban population was 1,41,064 TPD in year 2014-15 (CPCB, 2016). Out of which, 127,531 TPD of MSW was collected in urban areas (around 90% of all waste generated in urban areas), and only 34,752 TPD of waste (around 24% of all waste generated) was processed or treated by using mitigation options like composting or vermicomposting or waste-to-energy plants. The remaining quantity of collected waste is dumped into solid waste disposal sites (SWDS) without any treatment.

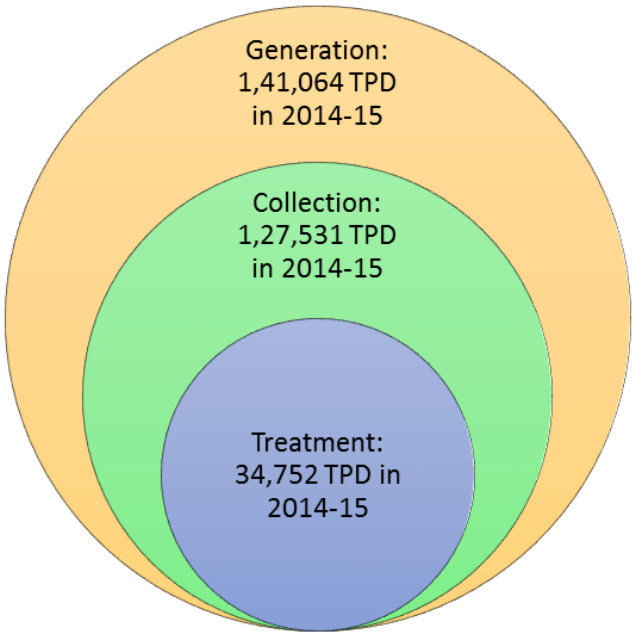


Figure 1: Status of Waste Management in India

Management of such a huge amount of MSW in the country has emerged as a severe problem not only because of the environmental, hygienic and aesthetic concerns but also because of the sheer quantities generated every day that need to be collected, transported, treated and disposed. In addition, enormous pressure is being built on the limited yet essential resource land. The Ministry of Finance (2009) estimates a requirement of more than 1400 sq. km of land for solid waste disposal by the end of 2047 if MSW is not properly handled.

In India, SWM falls within the purview of the state government. The activities are delegated to Urban Local Bodies (ULBs) through state legislations. MSWM is a part of public health and sanitation, and is delegated to the Civic Bodies for execution as per the respective Corporation/Municipal/Panchayat Acts. Central government provides rules and advisory for solid waste management in India. The MSW Rules (2016) (MSW, 2016) contained directives for all ULBs to establish a proper system of waste management and provide annual report to State Pollution Control Boards (SPCBs)/Pollution Control Committees (PCCs) and in turn SPCBs/PCCs will forward annual reports to the CPCB.

In 2014-15, out of total 4,003 ULBs, only three fourth, i.e. 2,958 ULBs have reported the status of the implementation of the MSW Rules (2016) to the CPCB (CPCB, 2016). This indicates poor compliance to the MSW Rules by ULBs in the country.

Most Indian cities lack waste treatment facility or sufficient capacities of those and therefore most of the waste is disposed of in an unsustainable manner leading to environmental hazards with respect to land, water and air pollution (Kansal, 2002) as well as considerable human health risks.

ULBs are facing several difficulties like budget constraint and lack of capacity in executing solid waste management projects. Such difficulties are paving the way to building waste-energy (WTE) plants, biological treatment solutions and landfill sites through private participation or through involvement of other stakeholders like NGOs.

Government of India (GOI) has initiated **Swachh Bharat Mission** (SBM) to clean the streets, roads and infrastructure of the country. Under SBM, the municipal solid waste management (MSWM) is an important admissible component, comprising of primary waste collection, secondary storage, transportation, processing and final disposal in engineered landfills.

GoI has revised MSW rule in 2016. As per the revised MSW Rules 2016, the waste generated should be processed and only un-usable waste should go to landfill. CERC has revised tariff for power generated from waste to energy projects. All these initiatives have supported waste to energy projects in India. As a result, MoUD has received 53 proposals from 22 states with potential to generate 405.3 MW of power from waste under Swachh Bharat Mission (WtE plant, 2016).

1.1. GENERATION, COLLECTION & TREATMENT

Urban India generated 1,41,064 TPD of waste with states like Maharashtra, Tamil Nadu, Uttar Pradesh and Gujarat alone generating more than 50% of this waste. Some 90% of this generated waste (1,27,531 TPD) is collected out of which only 27% (34,752 TPD) of

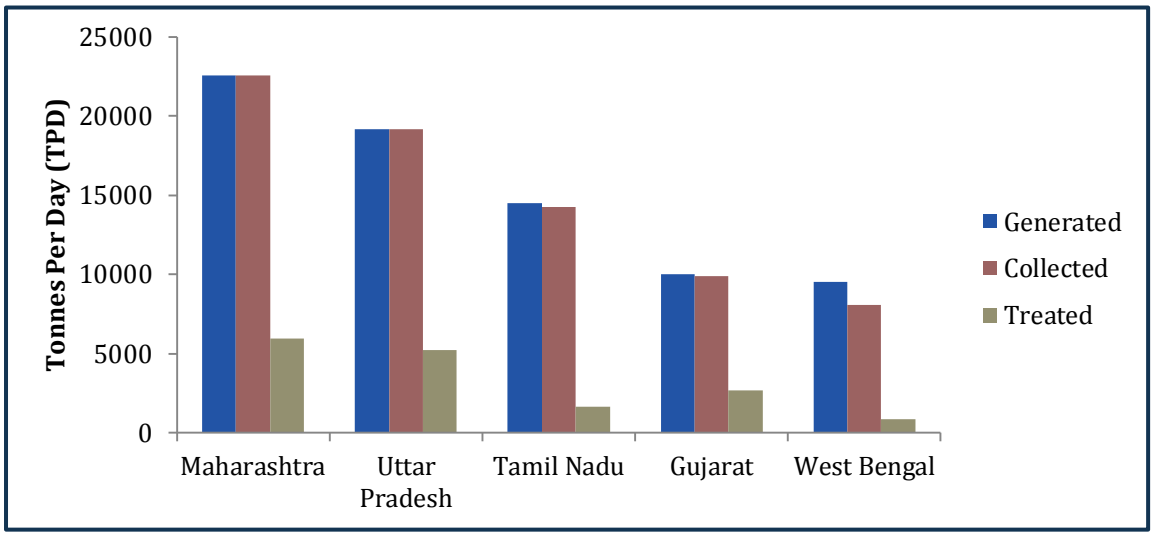


Figure 2: Waste generation, collection and treatment for top 5 waste generating states

waste is treated and 4,515 TPD of waste is landfilled (CPCB, 2016). The remaining waste is conveniently and unscientifically dumped into heaps of waste in open land.

Generation rate and its composition

The per capita waste generation in India is 339 to 430 gm/capita/day (GIZ, 2015). This depends upon the diversified life style, primary occupation of workforce, climate, cultural habits, religious & tourist importance etc. For e.g. the waste generated at cities like Varanasi, being a religious and tourist destination will be wet and organic whereas the waste generated in cities like Gurgaon which host lot many office spaces will be dry combustible waste including paper, cardboard etc. The municipalities with fruit and vegetable *mandis* will have wet organic waste which can be more suitable for composting. In the same way, in hot humid climate conditions near coastal areas, there will be lot of coconut shell in the MSW and so waste characterisation is a highly subjective matter.

Waste composition also widely varies across India. The composition varies with life style and social status of the populations in urban cities (Sharholy et al., 2007). Table below provides detailed waste composition for cities above 1 million population.

Table 1 : Detailed waste composition for cities above 1 million population (GIZ, 2015)

City groups	Food	Garden	Paper	Wood	Textiles	Nappies	Plastics, other inert
1-5 million	54.4%	18.9%	6.9%	3.3%	2.8%	0.0%	13.6%
Above 5 million	44.8%	18.3%	6.6%	4.2%	3.8%	0.0%	22.3%

Collection & Transportation

In many Indian cities door-to-door waste collection exists in which waste is collected from households. However, the same is not possible where access to household is difficult due to a high population density, narrow lanes and thus limited access to households. In such cases, waste is left to decay in the open or is collected by corporation staff infrequently.

Wastes are generally collected with small vehicles (auto trailer) or thela/rhedri (hand pulling rickshaw) by corporation staff or private contractors. Usually these vehicles do not have separate chambers for dry and wet waste. Private contractors make some effort to separate recyclable parts from the waste to make extra money.

Waste collectors normally charge 30-50 INR/household/months in many Indian cities (ITC, 2016). They also gets gifts on festive occasions from households in lieu of waste collection. In many cities (like Bhopal, Rewa), ULBs have fixed a user fee of 30 INR/household/months which includes the cost of collection, transportation and treatment of waste.

Waste collected from households and other sources is carried to a collection point. These collection points are also referred to as transfer stations as waste from these

collection points is transferred to trucks. These trucks are owned and maintained by municipal corporations or private contractors. These trucks collect waste from collection centers generally in the afternoon and carry the waste to dump sites or waste treatment facilities for processing of waste before disposal.

Recycling

In India, it is general practice by households to segregate high worth recyclable materials (like newspaper, plastic bottles, glass, metals etc.) and sell it to Kabariwalas (itinerant waste buyers) on direct payment. Recyclables of less value (torn paper, plastic pieces, glass pieces, metal pieces etc.) are mixed with MSW.

Treatment of waste

As per CPCB (CPCB, 2016), Waste to compost processing plants are setup by 595 ULBs for treatment of MSW. However, these facilities treat MSW fully or partially. There are total 666 waste to energy units set up viz. RDF-12, Power plant-03 and Biogas plant-648 units in India. In Thiruvananthapuram (Kerala) has alone 600 Biogas plant at household level.

Disposal of waste

As per CPCB (2016), there are 95 landfill facilities constructed till the reporting year 2014-15 in India. Initiatives for construction of new landfills are taken by 242 ULBs and new sites are identified by local bodies for construction of 1285 landfills.

1.2. INCENTIVES AVAILABLE FOR THE WTE PROJECTS

Government of India (GOI) is providing several incentives for waste management projects under Swachh Bharat Mission (SBM). Central government is providing 100% cost reimbursement for preparation of DPR for Municipal Solid Waste management. Other incentives from government is listed below:

1.2.1. INCENTIVES FOR SETTING UP WASTE TO ENERGY PROJECT

Capital Subsidy

In order to promote projects of waste to energy, central government is providing Grant / VGF fund, either upfront or as generation based incentive for power generated for a given period of time. Central government incentive for the SWM projects will be in the form of a maximum of 35% Grant / VGF for each project. States will contribute a minimum of 25% funds for SWM projects to match 75% Central Share (SWM, 2014). This grant/VGF will be based on approved capital cost in DPR.

Tax Holidays

Under Section 80-IA, Deductions are allowed in Respect of Profits and Gains from Industrial Undertakings or Enterprises Engaged in Infrastructure Development. This includes generation and distribution projects also.

Concessional custom/excise duties

CBEC notification (CBEC, 2005) has exempted the equipment used in generation of compressed bio-gas (Bio-CNG) using municipal and urban waste can avail for availing customs and excise duty concessions.

Accelerated Depreciation

The MSW projects are eligible to claim accelerated depreciation. The projects book value can be depreciated to upto 80% in first year itself, helping the investor to offset the taxable income from its other businesses.

IEC and Public Awareness

A total of 15% of the total central allocation will be earmarked for this component.

Capacity Building and Administrative & Office Expenses (A&OE)

3% of the total Central Government allocation under the mission will be earmarked for capacity building, administrative and office expenses of States and ULBs.

1.2.2. INCENTIVES FOR PROCESSING OF WASTE

Committed supply of MSW by ULBs

The concessionaire is promised a fixed quantum of waste for the waste to energy project as committed by the municipality or ULB in the concessionaire agreement. This ensures the continuous feed of raw material for the project. ULBs also provide land on lease at nominal fee for processing of waste.

Tipping fee

The tipping fee is determined by the local authorities or any state agency authorised by the State government to be paid to the concessionaire or operator of waste processing facility or for disposal of residual solid waste at the landfill;, which is in range of INR. 1000-2500/tonne.

Mandatory use of RDF in cement kilns

Preference shall be given to decentralised processing to minimize transportation cost and environmental impacts such as waste to energy processes including refused derived fuel for combustible fraction of waste or supply as feedstock to solid waste based power plants or cement kilns.

All industrial units using fuel and located within 100 km (SWM, 2016) from a solid waste based PDF plant shall make arrangements within six months from the date of notification of these rules to replace at least 5% of their fuel requirement by RDF so produced. The incentives and mandatory provision to utilize 5% of RDF by nearby industries will support the waste to energy plants, and reduce consumption of fossil fuel.

1.2.3. INCENTIVES/ PREFERENCE FOR SALE OF POWER AND BY-PRODUCTS

Right for use of by-products

The concessionaire has the right to make commercial use of the by-products from the waste to energy plant. This includes but not limited to leachate and compost.

MSW Rules 2016 has notified Department of Fertilizer to ensure promotion of co-marketing of compost with chemical fertilisers in the ratio of 3 to 4 bags and 6 to 7 bags by the fertiliser companies to the extent compost is made available for marketing to the companies.

In a new effort to manage Municipal Solid Waste (MSW) in a sustainable manner, the Ministry of Urban Development (MoUD) is supporting ULBs (urban local bodies) to market compost directly to farmers and claim market development assistance (MDA) of INR 1500 per tonne (SBU, 2016).

RDF price

Many state regulatory commissions have considered RDF price as 1600-1800 INR /MT for determination of tariff with 3% annual escalation from the second year onwards.

Sale of Power

The power generated by the power plant is purchased by the distribution licensee at preferential tariff determined by the state/central regulatory commissioning or at a tariff discovered under bidding process for fixed term of say, 20 years. The tariff determined by CERC is as follows:

Table 2 : CERC determined tariff for MSW projects, FY16

Technology	Levelised Cost (INR/kWh) Accelerated Depreciation	Levelised Cost (INR/kWh) Normal Depreciation	Fixed Cost (INR/kWh)	Variable Cost (INR/kWh)
Mass burn	6.50	7.04	7.04	0.00
RDF based MSW	7.59	7.90	4.34	3.56

The different state regulators have either reference to the CERC tariff or have calculated their own tariff as per state specific conditions. The state specific tariff for MSW projects for some of the states follows:

Table 3 : State wise tariff for Waste to Energy projects

State	Tariff for Waste to Energy project
West Bengal	INR. 5.12/kWh for 10 years
Bihar	MSW: 7.14/kWh RDF: 8.13/kWh
Chhattisgarh	MSW: 7.22/kWh RDF: 7.95/kWh
Jammu & Kashmir	MSW: 7.04/kWh RDF: 7.90/kWh
Punjab	MSW: 7.04/kWh RDF: 7.90/kWh

Projects are also awarded through bidding process. Some of the recent waste to energy projects with applicable tariffs:

Table 4 : Tariff for Waste to Energy projects

Sl. No.	Name of the Developer	City Name	Capacity (MW)	Quoted Tariff as per Bid (INR/kWh)
1	JITF Urban Infrastructure Ltd	Visakhapatnam	15	6.226
2		Guntur	15	6.165
3		Tirupati	6	6.794
4	Essel Infra Projects	Ananthapur	4	7.50
5		Tadepalligudem	5	7.50
6		Kadapa	5	7.50
7		Machilipatnam	4	7.50
8		Vizianagaram	4	7.50
9	Nexus Novas	Kurnool	1	7.50
10	Envikare LLP	Nellore	4	7.50

1.2.4. SUPPORT PROVIDED BY KFW

KfW is supporting the Indian government in finding ways to pursue socially responsible yet climate-friendly growth. The supports entails, for instance, loans to promote renewable energies and to finance credit for small and medium-sized enterprises, or investments in environmentally friendly municipal infrastructure projects. The overall support provided to Indian government is EUR 1 bn (8,400 crores INR).

In urban area, KfW focuses on the development of environmental related infrastructure such like water supply, sanitation and solid waste management. KfW is doing so by providing specialized financial intermediaries with financial assistance coupled with capacity building measures. KfW also addresses the lack of experience and know-how of partners on how to properly conceive, develop and implement Public Private Partnership-based projects.

Cooperation partner includes:

- National Bank of Agriculture and Rural Development (NABARD)
- Ministry of Development of North Eastern Region (DoNER)
- Govt of Tripura
- Tamil Nadu Urban Infrastructure Fund (TNUDF)
- Orissa Urban Infrastructure Development Fund (OUIDF)
- National Capital Region Planning Board (NCRPB)

KfW-DEG Financing

Within KfW, DEG finances and supports private enterprises to invest in developing and emerging markets. DEG finances promising entrepreneurial involvement with long term loans, equity stakes, mezzanine finance & guarantees all at market terms. For finance to be provided by DEG, an enterprise must either operate in a developing country or

intend to invest there. DEG finances green-field undertakings and instruments for expansions, subsidiaries and joint ventures.

If a medium-size European enterprise is planning to invest in a developing country and wants to obtain a feasibility or environmental study, a legal or market analysis, DEG may bear a proportion of the cost up to EUR 2,00,000. This is financed from funds provide by the Federal Ministry for Economic Corporation & Development (BMZ).

Some of the projects funded by KfW are:

- Financing for a solar project of Azure in 2011 in India
- Country wide mobile network for Myanmar
- Wind power in Latin America
- Water treatment plant in Namibia.

1.2.5. SUPPORT PROVIDED BY GIZ

For over 60 years, GIZ has been working jointly with partners in India for sustainable economic, ecological, and social development. The Government of India has launched several initiatives to address the country's environmental and social challenges.

Based on the initiatives of GoI, GIZ has been working in the urban environment sector with a focus on MSW since 2009 under various GIZ programmes. The project fosters technical cooperation under the Indo-German Environment Partnership (IGEP) programme, has been continued under the SNUSP II project with the aim of furthering the GIZ engagement in municipal solid waste. The objective of SNUSP II is providing technical support for improvements in sanitation with a focus on wastewater and municipal solid waste management at the national level and in selected Indian states and cities.

Support for Solid Waste Management has been envisaged at all the three tiers of the SNUSP II project. Following activities and interventions have either been undertaken or are foreseen at the national, state and city-level:

National Level:

- Supported MoUD and Central Public Health and Environmental Engineering Organization (CPHEEO) in the revision of the national level technical guidelines for Municipal Solid Waste Management namely the MSWM Manual under the aegis of an Expert Committee.
- Dissemination of the MSWM manual through trainings, training of trainers and e-modules based on the manual & SWM Rules, 2016.
- Support in creating mechanisms like guidelines/ advisories for proper implementation of the SWM Rules, 2016
- Preparation of model templates for tender documents

- Documentation of good practices in waste management.
- Support to national training institutes in conceptualizing and implementing necessary capacity development measures for state and city level officers and elected representatives.

State Level:

- Support to the state government in preparing State Policy and/ Strategy for MSW Management in Maharashtra, Uttarakhand and Kerala.
- Preparation of model templates for Detailed Project Report (DPR) preparation, baseline data collection, etc. including technical trainings on the subject for staff at state and city level.
- Trainings and Training of Trainers based on the manual developed for the stakeholders (ULBs, elected representatives, regional training institutes, state officers)

City Level:

- DPR preparation and implementation support to selected cities for municipal solid waste.
- Preparation and implementation of MSW plans in selected towns

2. SWM POLICIES AND FRAMEWORKS IN INDIA

2.1. KEY POLICIES AND PROGRAMMES IN THE SOLID WASTE SECTOR

In this section, a number of policies, programmes and initiatives in the solid waste management sector in India have been reviewed. The same are listed below.

- Revised MSW Rules 2016
- Swachh Bharat Abhiyan / Clean India Mission
- Service Level Benchmark
- Smart Cities Initiative
- National Mission on Sustainable Habitat (NMSH)
- MSW Manual (Revised) – Central Public Health and Environmental Engineering Organisation (CPHEEO)
- Ministry of New and Renewable Energy (MNRE) - WTE policies

These policies and programmes are detailed in the following section for their objectives and key goals, current status as well as key challenges faced. From the review, it becomes clear that there exists a strong policy framework for implementation of waste to energy project in India.

MSW Rules 2016

Initiated By: GoI

Introduction: Municipal Solid Waste (Management & Handling) Rules, 2000 (MSW Rules) **were applicable to every municipal authority** responsible for collection, segregation, storage, transportation, processing and disposal of municipal solids. The Government has revamped the Municipal Solid Wastes (Management and Handling) Rules 2000 and notified the new Solid Waste Management Rules, 2016 on April 8, 2016.

Key goals related to solid waste management:

- ULBs to identify and acquire land for processing and disposal of waste
- Achieving service level benchmarking for collection, transportation, treatment and disposal of waste in India
- Dept of Fertilisers will ensure promotion of co-marketing of compost with chemical fertilisers
- Phase out the use of chemical fertilizer in two years and use compost in all parks, gardens maintained by the local body
- Explore the existing operational dumpsites for their potential of bio-mining and bio-remediation
- All industrial units using fuel and located within one hundred km from a solid waste based refused derived fuel plant to replace at least 5% of their fuel requirement by refused derived fuel so produced
- Purchase of power by discoms from waste to energy facility at pre-determined tariff by state electricity regulatory authority.

Status:

- Compliance with MSW rules in terms of reporting and of technical standards etc. is still

very low which could mainly be due to inadequate funds and capacities at municipal level, however *Swachh Survekshan* under *Swachh Bharat Abhiyan* is encouraging municipalities to strive better and improve their ranks.

Limitations/challenges in its implementation:

- Lack of technical awareness among personnels with respect to waste processing technologies, selection of proper waste processing technology with respect to waste generation and development of landfill sites.
- Lack of public awareness/participation.
- Inadequate manpower with the Board for implementation and compliance verification with MSW Rules.

More details available at: http://www.moef.gov.in/sites/default/files/SWM%202016.pdf

Swachh Bharat Abhiyan / Clean India Mission

Initiated by: Government of India on 2 October 2014
Introduction: Swachh Bharat Abhiyan is a national level campaign by the GoI, covering 4,041 statutory towns with the ambitious target of complete sanitation which includes eliminating open defecation and smart management of both solid and liquid waste throughout the country. This campaign aims to accomplish the vision of 'Clean India' by 2 October 2019, 150th birthday of Mahatma Gandhi. The fund sharing between the Central Government and the State Government/ Urban Local Bodies (ULBs) is 75%:25%.

Key goals related to solid waste management:

- 100% collection and scientific processing/disposal/reuse/recycle of municipal solid waste
- 35% (updated from 20% earlier) VGF available for solid waste management
- States to provide VGF on sharing or additional basis
- Eradicate manual scavenging of waste
- Strengthen of urban local bodies to design, execute and operate systems
- Create an enabling environment for private sector participation in capital expenditure and operation & maintenance (O&M) costs
- Ensure solid & waste disposal systems and clean village
- 3% of the total allocation for the mission will be earmarked for the purpose of extensive capacity building activities which will be brought out separately in consultation with the States.

Status:

- The Swachh Bharat Mission is divided into two components – SBM Gramin (rural) and SBM Urban. The guidelines are available on the website of the Ministry of drinking water and sanitation and on Ministry of Urban Development website for rural and urban component, respectively.
- The Centre will soon develop an appropriate statistical framework to assess progress made on the ground in the Swachh Bharat Abhiyan.
- The government in order to assess the progress of the Mission will bring out a **Swachhta Status Report** (Sharma 2014) every year starting from 2016 after carrying out extensive surveys.

Limitations/challenges in its implementation:

- Just like Smart Cities, this new policy initiative is still unraveling. Logically, this initiative would be part of an overall smart city effort of GoI.

More details available at: http://moudulbs.nic.in/ISNAHome.aspx

Service Level Benchmark (SLB)

Initiated by: Ministry of Urban Development (MoUD), Government of India in 2009

Introduction: Benchmarking is a vital tool for introducing accountability in service delivery in all cities. Continuous benchmarking can help Urban Local Bodies (ULBs) and utilities in finding performance gaps and implementing improvements through the sharing of information and best practices and finally bringing better services to people. Recognising its importance, the MoUD has launched Service Level Benchmarking (SLB) covering water, sanitation, solid waste management and storm water drainage for all JNNURM mission cities.

Key goals related to solid waste management in cities:

- Household Level Coverage 100%
- Efficiency in Collection of Solid Waste 100%
- Extent of Segregation of MSW 100%
- Extent of MSW Recovered 80%
- Extent of Scientific Disposal of MSW 100%
- Extent of Cost Recovery 100%
- Efficiency in Collection of SWM Charges 90%
- Efficiency in Redressal of Customer Complaints 80%

Status:

- It is introduced in all states and across 4003 ULBs.
- Performance-related funds under the 13th Finance Commission have been linked to improvements in SLBs including SWM.

Limitations/challenges in its implementation:

- The data at city/ULB level can be credible and reasonably accurate only if, they have been captured on a regular basis at the lower levels, such as the ward level. However, systems for capturing key data elements identified for SLB are not present in many cases at the field level.
- Performance management will be sustainable only if disclosure, reporting, monitoring and performance management feedback, incentives and disincentives are also brought into the cycle. Else the system of measurement and disclosure of SLBs may not sustain itself.

More details available at: http://moud.gov.in/servicelevel

Smart Cities

Initiated by: Government of India (GoI) on 25 September 2014

Introduction: The Indian government has recently launched Smart Cities programme to build

100 smart cities across India. The aim is to integrate technology into the system to offer more structured and hospitable living conditions for residents. The concept of Smart cities has several verticals like smart transportation, smart waste management, smart energy, smart buildings etc.

Smart City plan is part of a larger agenda of creating industrial corridors between India's big metropolitan cities. These include the Delhi-Mumbai Industrial Corridor, the Chennai-Bangalore Industrial Corridor and the Bangalore-Mumbai Economic Corridor. Along these corridors, the hope is that several industrial and commercial centres will be reinvented as "Smart Cities". The Delhi-Mumbai Industrial Corridor (DMIC) is spread across six states and aims to create seven new smart cities as the nodes of the corridor in its initial phase.

Key goals related to solid waste management:

- 100% households are covered by daily door-step collection system
- 100% collection of municipal solid waste
- 100% segregation of waste at source, i.e. biodegradable and non-degradable waste
- 100% recycling of solid waste
- Segregation of recyclable and non-recyclable waste as well as wet and dry waste at the source so that there can be 100% recycling of solid waste
- Appropriate technology should be adopted for treatment of waste at decentralised locations
- Put in place an effective collection and disposal system
- Inspire use of products based on recycling of solid waste in particular – power, compost, building material (based on cycling of debris & construction materials)

Status:

GoI has allocated USD 1.2 billion (INR 70.6billion) (PRNewswire, 2015) for Smart Cities in Union Budget in 2014-15. However, it is anticipated that most of the infrastructure will developed either as full private investment or through PPPs. The contributions from the GoI and States/ULBs will be largely by way of Viability Gap Support (VGF).

India has also got into an agreement with Singapore to use its expertise in smart cities and urban planning for developing the 100 Smart Cities.

There already 60 cities shortlisted for the smart cities projects including Chandigarh, Ranchi, Nagpur & Visakhapatnam.

Limitations/challenges in its implementation:

- Smart city initiative is still at concept stage and is unfolding.
- There are no standard definitions or regulatory mechanisms for governing of smart cities.
- There are no clear appraisal mechanisms for selecting of suitable proposals.
- Mechanism/institutional structure for flow of funds is absent.

More details available at: http://indiansmartcities.in

National Mission on Sustainable Habitat (NMSH)

Initiated by: GoI in June 2010

Introduction: The NMSH is one of the eight missions under National Action Plan on Climate Change (NAPCC) which aims to which seeks to promote sustainability of habitats through

progress in energy efficiency in buildings, urban planning, enhanced management of solid and liquid waste, modal shift towards public transport and conservation through appropriate changes in legal and regulatory framework.

Key goals related to solid waste management:

- Same ambition as highlighted above under SLBs
  - Household Level Coverage 100%
  - Efficiency in Collection of Solid Waste 100%
  - Extent of Segregation of MSW 100%
  - Extent of MSW Recovered 80%
  - Extent of Scientific Disposal of MSW 100%
  - Extent of Cost Recovery 100%
  - Efficiency in Collection of SWM Charges 90%
  - Efficiency in Redressal of Customer Complaints 80%
- Recycling of material and urban waste management under which a special area of focus will be development of technology for producing power from waste. The mission will include a major R&D programme, focusing on bio-chemical conversion, waste water use, sewage utilisation and recycling options wherever possible.

Status:

- The total funding requirement assessed for the 12th five year plan period (2012-2017) is approx. USD 153 million (INR 9.50 billion) (MoEFCC, 2014), which is to be met from existing budget of the Jawaharlal Nehru National Urban Renewable Mission (JNNURM).
- More than 50 (ibid.) capacity building programmes in various stages of implementation.

Limitations/challenges in its implementation:

- Limited capacity of the officials involved in implementation to draw linkage between climate change and waste related issues.

More details available at: http://moud.gov.in/NMSH

MSW Manual – Central Public Health and Environmental Engineering Organisation (CPHEEO)

Initiated by: GoI in 2000

Introduction: Looking at the dismal situation of solid waste management practices being adopted by the ULBs in the country and having no action plan to solve the problem in future, CPHEEO - the technical wing of the MoUD and responsible for matters related to urban water supply and sanitation including solid waste management in the country - GoI prepared the Manual on "Municipal Solid Waste Management" so as to provide assistance to the user agencies in proper management of solid wastes in urban areas.

Key goals related to solid waste management:

- Step-wise guidance for MSW Plan
- Technical aspects related to collection, segregation, transportation, processing & treatment of MSW, municipal sanitary landfills
- MSWM Plan implementation (legal provisions etc.)
- Management aspects related to monitoring MSWM service provisions
- Management of special waste streams

Status:

- The manual is guiding document to ULBs for implementation of waste management projects.

More details available at: http://cpheeo.nic.in/

Ministry of New and Renewable Energy (MNRE) - WTE policies

Initiated by: MNRE, GoI on 12 September 2013

Introduction: The MNRE Scheme "**Programme on Energy from Urban, Industrial and Agricultural Wastes / Residues during 12th Plan period**" and with a total outlay of USD 6.3 million (INR 380 million) for the year 2013-14 (Ministry of New and Renewable Energy, 2013).

The main objectives of the programme are as follows:

To promote technology options for setting up of projects for recovery of energy from urban, industrial and agricultural wastes; and to create conducive conditions and environment, with fiscal and financial regime, to develop, demonstrate and disseminate utilisation of wastes and residues for recovery of energy

Key goals related to solid waste management:

- Setting up of five pilot projects based on MSW. In MSW to Power projects, any waste of renewable nature or biomass can be mixed to the extent of 25 % based on gross calorific value. Use of a maximum of 25 % conventional fuels would be allowed in biomass co-generation (non-bagasse) projects based on agricultural wastes and residues other than bagasse.
- Projects based on waste-to-energy conversion technologies, namely, biomethanation, combustion, gasification, pyrolysis or a combination thereof
- MSW based projects need to be developed in accordance with the decision of Hon'ble Supreme Court given during the hearing on 15 May 2007 and the recommendations of the Expert Committee referred therein.
- The projects based on biomethanation of MSW should be taken up only on segregated/uniform waste unless it is demonstrated that in Indian conditions, the waste segregation plant/process can separate waste suitable for biomethanation
- USD 0.3 million (INR 20 million) /MW (max. USD 1.5 million (INR 100 million/project) capital subsidy to be provided to the promoters generating power from municipal solid waste.
- Financial assistance would be provided for promotional activities - organising training courses, business meets, seminars/ workshops and publicity /awareness on case-to-case basis, subject to a maximum of USD 5,000 (INR 0.3million) per event/ activity.
- Financial support would be provided for R&D projects, including studies on resources assessment, technology upgradation, performance evaluation etc. to institutions/ industries. This will be governed by the procedures /guidelines issued by MNRE.

Limitations/challenges in its implementation:

- Low calorific value of waste
- Poor waste segregation and lower collection of waste than anticipated
- Inappropriate choice of technology and pricing of power
- Low financial flexibility
- Poorly structured PPP contracts and opposition from people living in the neighborhood.

More details available at: http://mnre.gov.in/schemes/offgrid/waste-to-energy/;

http://mnre.gov.in/file-manager/offgrid-wastetoenergy/programme_energy-urban

-industrial-agriculture-wastes-2013-14.pdf

3. WASTE TO ENERGY INCINERATION TECHNOLOGY

3.1. INTRODUCTION

For review of waste to energy incineration technology, we have selected Bengaluru based waste to energy project. This projects is being implemented by Bengaluru MSW Limited (BML is promoted by Essel Infraprojects Limited). This project has been awarded by Bruhat Bengaluru Mahanagara Palike (BBMP) based on the bidding process for the project.

This project is an integrated 11.5 MW Municipal Solid Waste Management facility consisting of waste segregation, material recovery, waste to energy and sanitary landfill for 600TPD MSW in enclosed facility at Giddenahall, Bengaluru. The proposed waste to energy project will get MSW as provided by BBMP, and while processing, it will generate electricity. The power generated shall be sold to obligated entities under Renewable Purchase Obligation (RPO) framework at tariff determined by the KERC.

For the development of MSW processing plant and SLF development, BBMP has provided a land of 25 acres for the MSW processing facility on lease basis at INR 1/acre per month.

Table 5: Project Information

Particulars	Details
Waste to be treated at plant facility	600 tons per day (TPD)
Waste to Energy Technology	Hitachi Zosen's Controlled Combustion Technology
Period of Agreement	20 years
Envisaged Plant Capacity/Output	11.5 MW (net) Power 1.34 TPH compost
Critical Plant Parameters (related to Power)	• Auxiliary consumption: 27% • Envisaged CUF of plant: 85.62%
Revenue	Levelized tariff: 7.78 INR/Unit Tipping fee: 279 INR/TPD Return on equity: 16% IRR
Calorific value of mixed waste	1650 kcal/kg
Expected commercial operation date	24 months

The proposed Hitachi Zosen's technology is mass-burn controlled combustion technology for power generation. This is based on highly engineered and reliable grate system with optimized secondary combustion chamber with tangential secondary air-injection and specifically chosen refractory result in low emissions. Following table provides a comparison of mass-burn incineration technology with other MSW processing technologies:

Table 6: Comparison of mass burn technology with other waste to energy technologies

Features	Composting	Landfill	Incineration	Gasification
Emission to Atmosphere	Low	Medium/ High	Low	Negligible
Recovery of energy	Low	NIL	High	Medium
Suitability for various kinds of wastes	Low	N/A	Medium	High
Rejects back to landfill	High (>60%)	N/A	Low	Low (<15%)
Seasonal variation	High	N/A	Low	Low
Land area for MSW disposal	Very high	Very high	Low	Low
Smell emitted	High	High	Medium	Low

Process time	High (>30 days)	N/A	Low	Low
Construction time	High	Very High	Low	Low

3.2. TECHNOLOGY

Incineration is the process of control and complete combustion, for burning solid wastes. It leads to energy recovery and destruction of toxic wastes. The temperature in incinerators varies between 980 & 2000°C. One of the most attractive features of the incineration process is that it can be used to reduce the original volume of combustible solid waste by 80-90%.

Mass burn waste to energy plant requires almost no pre-treatment of waste and is tolerant of variations in the MSW characteristics. Modern mass-burn combustion incinerators use sophisticated flue gas cleaning system to meet stringent emission norms globally. Combustion of MSW is the dominant waste processing & disposal technology globally and is a mature and proven process and adopted in most of the developed and developing countries where they follow the full segregation principal of wastes.

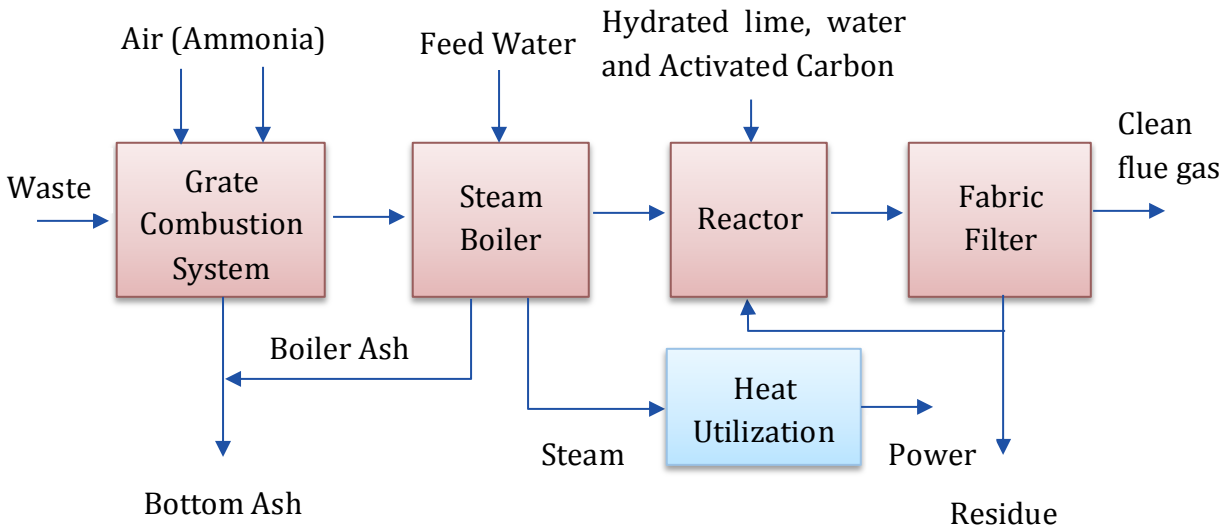


Figure 3 : Process overview: Block Diagram

This technology has following advantages:

- Suitable for mixed MSW and No manual handling of waste
- Continuous processing and disposal of waste with green energy recovery
- Reduces volume of MSW by 90%
- Eliminates pathogens/ bacteria
- Proven and mature technology globally
- Proven measures are available to restrict emissions
- Eliminates odour and smell nuisance

3.3. CAPITAL COST AND O&M COST OF THE PROJECT

For a single boiler, single turbine generator with air cooled condenser, the technical profile will be as follows:

Table 7: Capital cost

Particulars	Cost (in INR Lakhs)
Plant & Machinery	12,874
Building & Civil cost	3,000
Engineering expenses	700
Ash disposal plant	200
Transmission cost	780
Landfill	1,500
Total hard cost	**19,054**
Contingency expenses	571.62
Other soft cost (including PMC, consultancy and financing expenses)	1,116.89
Interest During Construction	2,373.53
Pre-operative expenses	190.54
Total Capital Cost	**23,306.58**

The capital cost is INR. 23,306 Lakhs, with per MW cost of INR. 2,027 lakhs including charges for construction of transmission lines, transfer stations and landfill.

BML has considered an O&M cost of 14.47 INR Crores for its waste to energy project with an annual escalation of 5.72%. This includes operation of the plant and maintenance of sanitary landfill site.

The calorific value and composition of MSW is highly variable as it will have heterogeneous mix and it cannot be predicted. Further during monsoon season, there will be higher moisture content in the MSW that will reduce the calorific value and therefore the power production of plant. The plant is anticipated to operate at 60% for first year of stabilization period and 85.6% afterwards. BML has also considered auxiliary consumption of 16% for tariff determination.

4. WASTE GENERATION RATE AND WASTE CHARACTERISTICS OF CITIES WITH OVER ONE MILLION POPULATION

CPCB with the assistance of NEERI has conducted survey of solid waste management in 59 cities (35 metro cities and 24 state Capitals: 2004-05) (NEERI, 2005). Waste generation rate of cities above one million population is provided in the table below:

Table 8: Waste Generation Rate

S. No	Name of City	Population (As per 2001 census)	Area (Sq. Km)	Waste Generation Rate (kg/c/day)
1	Faridabad	10,55,938	216	0.42
2	Meerut	10,68,772	142	0.46
3	Nashik	10,77,236	269	0.19
4	Varanasi	10,91,918	80	0.39
5	Jamshedpur	11,04,713	64	0.31
6	Agra	12,75,135	140	0.51
7	Vadodara	13,06,227	240	0.27
8	Patna	13,66,444	107	0.37
9	Ludhiana	13,98,467	159	0.53
10	Bhopal	14,37,354	286	0.40
11	Indore	14,74,968	130	0.38
12	Nagpur	20,52,066	218	0.25
13	Lucknow	21,85,927	310	0.22
14	Jaipur	23,22,575	518	0.39
15	Surat	24,33,835	112	0.41
16	Pune	25,38,473	244	0.46
17	Kanpur	25,51,337	267	0.43
18	Ahmedabad	35,20,085	191	0.37
19	Hyderabad	38,43,585	169	0.57
20	Bangalore	43,01,326	226	0.39
21	Chennai	43,43,645	174	0.62
22	Kolkata	45,72,876	187	0.58
23	Delhi	1,03,06,452	1483	0.57
24	Greater Mumbai	1,19,78,450	437	0.45

Waste characteristics of cities with more than one million population is provided in the table below:

Table 9: Waste Characteristics

S. No	Name of City	Compostable (%)	Recyclable (%)	C/N Ratio	HCV (Kcal/Kg)	Moisture (%)
1	Faridabad	42.06	23.31	18.58	1319	34
2	Meerut	54.54	10.96	19.24	1089	32
3	Nashik	39.52	25.11	37.20	2762	62
4	Varanasi	45.18	17.23	19.40	804	44
5	Jamshedpur	43.36	15.69	19.69	1009	48
6	Agra	46.38	15.79	21.56	520	28
7	Vadodara	47.43	14.5	40.34	1781	25
8	Patna	51.96	12.57	18.62	819	36
9	Ludhiana	49.8	19.32	52.17	2559	65
10	Bhopal	52.44	22.33	21.58	1421	43
11	Indore	48.97	12.57	29.30	1437	31
12	Nagpur	47.41	15.53	26.37	2632	41
13	Lucknow	47.41	15.53	21.41	1557	60

14	Jaipur	45.5	12.1	43.29	834	21
15	Surat	56.87	11.21	42.16	990	51
16	Pune	62.44	16.66	35.54	2531	63
17	Kanpur	47.52	11.93	27.64	1571	46
18	Ahmedabad	40.81	11.65	29.64	1180	32
19	Hyderabad	54.2	21.6	25.90	1969	46
20	Bangalore	51.84	22.43	35.12	2386	55
21	Chennai	41.34	16.34	29.25	2594	47
22	Kolkata	50.56	11.48	31.81	1201	46
23	Delhi	54.42	15.52	34.87	1802	49
24	Greater Mumbai	62.44	16.66	39.04	1786	54

5. FOUR CASE STUDY REPORT

Four cities in consultation with client has been selected for case study considering their population size (over one million population), Political and administrative support, present status of waste collection and segregation at/near source etc.

Case study is focused on following factors:

- Number of hotels, residences and industries
- Value chain of waste management and associated stakeholders
- Estimated volume of Municipal Solid Waste generated from hotels, residences, market area, institutes, slums etc.
- Very IMPORTANT are the overall waste characteristics in terms
  - Biodegradables: Food waste, fruit/vegetable market waste, garden waste, paper, wood, etc.
  - Combustibles: Relatively dry materials with high calorific values such as plastic, rubber, leather, wood, cardboards, synthetic materials, etc.
  - Inert: Dust, sand, grit, concrete/debris, ceramics, etc.

This report is primarily based on secondary data (like DPR) however team has conducted 1-2 days site visit to confirm the data collected from secondary sources. Team visited existing dump sites, processing plants (if any) and all other places for better understanding of present way of waste management in respective cities.

Team has conducted interviews with Municipal Authorities, Staffs engaged in waste management, waste collectors, private players, Government institutions and other responsible bodies. List of stakeholders interviewed is provided below:

Activity	Ranchi	Nagpur	Chandigarh	Visakhapatnam
Visit Date	16/12/2016	21-22 Dec 2016	27-28 Dec 2016	27-28 Dec 2016
Meeting with	**JUIDCO:** Dr D K Singh (Project Director) Dr Ranvijay Singh (SWM specialist) Prabhjot Singh (Dy Project Manager) **SUDA:** Rajesh Sharma (Director) **RMC:** Sandeep (Sanitary Inspector) **Essel Infra:** Pranay Vidyarthi	**NMC:** Dr R Sonawane (Add Commissioner) R J Dufare (Project cell) Dr Pradeep Dasarwar (Medical Officer) **NEERI:** Dr Rakesh (Director) Dr Sunil (SHWM expert) **Essel Infra:** Brijesh Kumar (AGM)	**MCC:** B Purusartha (Commissioner) P S Bhatti (Medical Officer) Vijay Premi (Technical expert) Megha (SWM expert) **PMIDC:** Rajinder Sahota (Director- SBM) **M/s Jai Prakash:** Sharma (Plant in charge)	**SAC:** Prabhakar (COO) **APUIDFCO:** Ganesh Babu (Procurement manager) **CDMA:** Puranchander (Jt Director) **JITF:** M V Chary (President)
Document collected	DPR, Visit snaps	DPR, Visit snaps	Visit snaps	DPR, Visit snaps

6. CASE STUDY: RANCHI CITY

6.1. BACKGROUND

Jharkhand state was formed on 15 November 2000 by carving out the Bihar divisions of Chhota Nagpur and Santhal Parganas. Ranchi is the capital of Jharkhand, and its third most populous city of the state. The Ranchi city is divided into 55 wards for which elections are held every 5 years. The Ranchi Municipal Corporation has population of 1,073,427 of which 558,872 are males while 514,555 are females as per report released by Census India 2011. Ranchi Municipal Corporation has total administration over 207,636 houses to which it supplies basic amenities like water and sewerage (Census Ranchi, 2011). Ranchi ULB has received a credit rating of '**BB-**' by CRISIL in 2012.

The city is located 1305 km east of Delhi, 412 km from Kolkata and 1,668 km from Mumbai. Ranchi is well-connected with a number of major cities of India via Air, Trains and Roads.

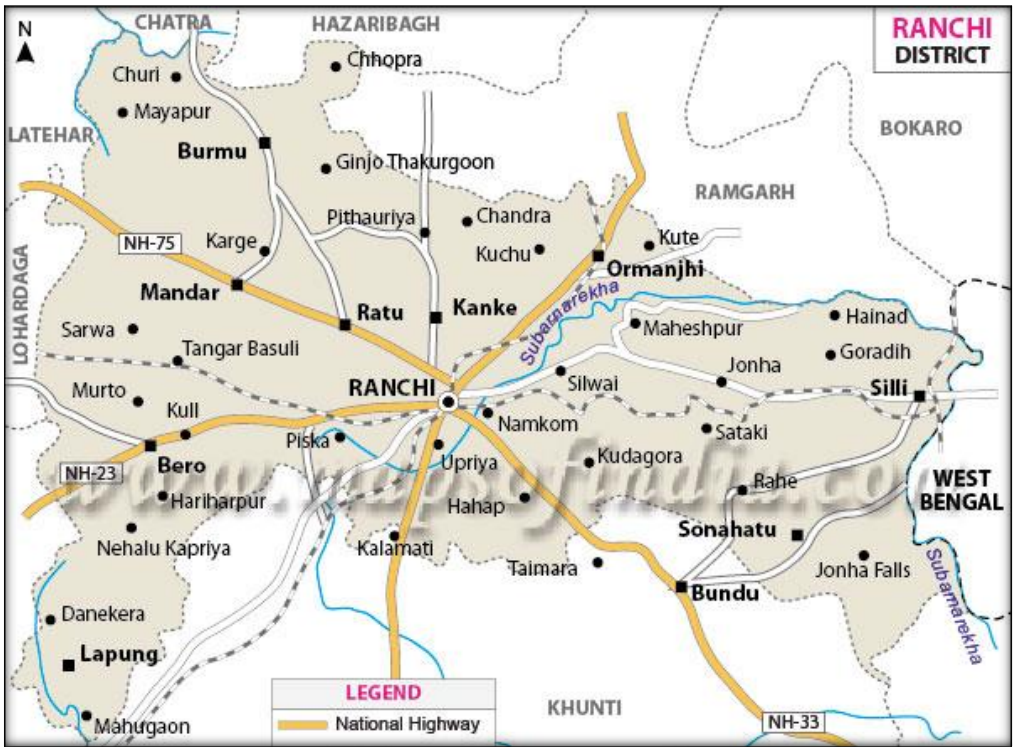


Figure 4: Ranchi city map

The city has witnessed a sudden surge in population after the declaration of the new state of Jharkhand in 2000. Owing to the rising employment opportunities and opening of numerous regional and state level offices, banks, and FMCG companies, the city witnessed a rapid influx of employment seeking migrants.

Ranchi has a hilly topography and its dense tropical forests a combination that produces a relatively moderate climate compared to the rest of the state. Summer temperatures range from 20 °C to 42 degrees, winter temperatures from 0 °C to 25 degrees. December and January are the coolest months, with temperatures dipping to the freezing point in some areas. The annual rainfall is about 1430 mm (56.34 inches). From June to September the rainfall is about 1,100 mm.

Ranchi has been selected as one of the hundred Indian cities to be developed as a smart city under PM Narendra Modi's flagship Smart Cities Mission.

6.2. WASTE MANAGEMENT VALUE CHAIN

Ranchi Municipal Corporation (RMC) is responsible for providing municipal and civic services, which includes but not limited to the collection, segregation, transportation, treatment and disposal of Municipal solid waste (MSW) generated in the Ranchi city of Jharkhand. There are total 55 wards in Ranchi. Out of which Essel Infra is collecting and transporting the MSW (no sewerage) from 13 wards and remaining wards are served by Municipal Corporation. Essel Infra will gradually exercise the collection & transportation for 55 wards. The scope of Essel infra also includes waste processing.

At present, city generates approximately 600 TPD of waste which is dumped at Jhiri without any treatment. The MSW treatment project (waste to energy) is awarded to Essel Infra and the construction work is likely to begin by March of this year. City is planning to come up with EOI on bio-mining to reclaim the land under dump yard.

Table 10 : Number of hotels, residents and other waste generation sources

S No	Category	Number
1	Number of Flats in Apartments	54,975
2	Number of household	137,428
3	Number of Shops	54,971
4	Number of religious establishments	26,661
5	Number of nursing homes/ hospitals	165
6	Number of Hotels/Banquet/Halls/Restaurants/malls	769

Source: DPR title- Ranchi MSW Private Limited, Ranchi (DPR C & T, MSW) Ranchi city prepared by C.P. Consultants Pvt. Ltd., 2016

Door to door collection

Dustbins in city

Dustbins in city

Transportation of waste

Dumpsite

Disposal of waste

Burning of waste Dumpsite

Waste at dumpsite

Waste pickers at dumpsite

Non-function trommel

Equipments for compacting

Civil structure

Figure 5: Waste Management Value Chain: Ranchi

The existing scenario of waste management is detailed below:

6.2.1. WASTE GENERATION

As per the DPR prepared for Municipal Corporation Ranchi, there is waste generation availability to the tune of 500-600 TPD which will be further used as raw material for suitable processing. There is no practice of segregating the waste at source. There are 2,07,636 households (Census Ranchi, 2011) and 4066 industrial units (Ranchi Industry, 2016) in Ranchi.

6.2.2. WASTE COLLECTION & TRANSPORTATION

Presently, all the solid waste generated throughout the city is dumped in the open spaces in an unclean manner. These include road side dumps, clogged *nallahs* & open spaces close to houses. There is rampant practice of unhygienic collection of waste by the rag pickers without any personal protective equipment or gear. The distance travelled for the dumping of the waste is more because of the unscientific and unhygienic method. Solid waste is transported without any cover or maintenance over large distances by tractor trolleys. The primary collection & secondary storage of solid waste is unorganized & inefficient. Secondary storage is practically non-existent in the city with dumping of waste in open areas.

Recently, Essel Infra has signed the concessionaire agreement in June 2016; Essel Infra will gradually exercise the collection & transportation for 55 wards. The scope of Essel infra also includes waste processing.

From residential customers, fixed charges of INR 30 per households are collected monthly.

There are 114 trucks/ cars for transportation purposes, with each making 2 trips per day. The fuel for these trucks is provided free by municipal corporations. For cost towards driver salary and truck rent, INR 333/trip is reimbursed to the transportation contractor. Each truck can have upto 1.5-2 ton MSW, which can be even 5 ton if sewerage or naali waste is there.

6.2.3. WASTE PROCESSING

Presently, waste is collected in un-scientific manner is small tractor trolleys and dumped in the existing landfill. There is no mechanism for treatment/ processing of the collected MSW for the city. The waste is disposed in the open landfill as a heap. There are some 30-40 rag pickers who pick & collect Upto 10kg of plastic daily and sell it further at rate of INR 10-12/kg of plastic.

6.2.4. WASTE DISPOSAL

The waste is dumped at Jhiri dumping ground with no processing facility or segregation. The dumping site is located some 15km from the city and is spread across an area of 30 acres (Telegraph, 2015). There were sieving machine at site which were rusting for no use. There is no road inside the dumping yard to enable the tractors/ trucks/ dumpers to drive the waste inside the dumpyard and often these trucks get stuck in the garbage.

6.3. WASTE COMPOSITION

The DPR for Ranchi indicates that there is a high percentage of bio-degradable matter (60%) in the wastes sampled from wards with an average moisture content of nearly 30%, while the recyclables are marginally above 30%. The ash content of the waste is more than 10% in average. Considering highest values, biodegradable wastes were observed to be nearly 75% in one ward with 80% as moisture.

The observations indicated in the DPR after physical and chemical analysis is:

1. The study analysis found no flower waste while fruit waste was only found in 1 out of 6 wards in study area (18.17%)
2. Combustible waste did not contain any dry tree waste and very meager percentage of cotton/textiles waste. Wooden furniture was found in 2 out of 6 wards
3. Plastic and paper formed the majority of recyclables. There were no rubber wastes detected in waste characterization study. E-waste was only found in 1 out of 6 wards (8.45%).

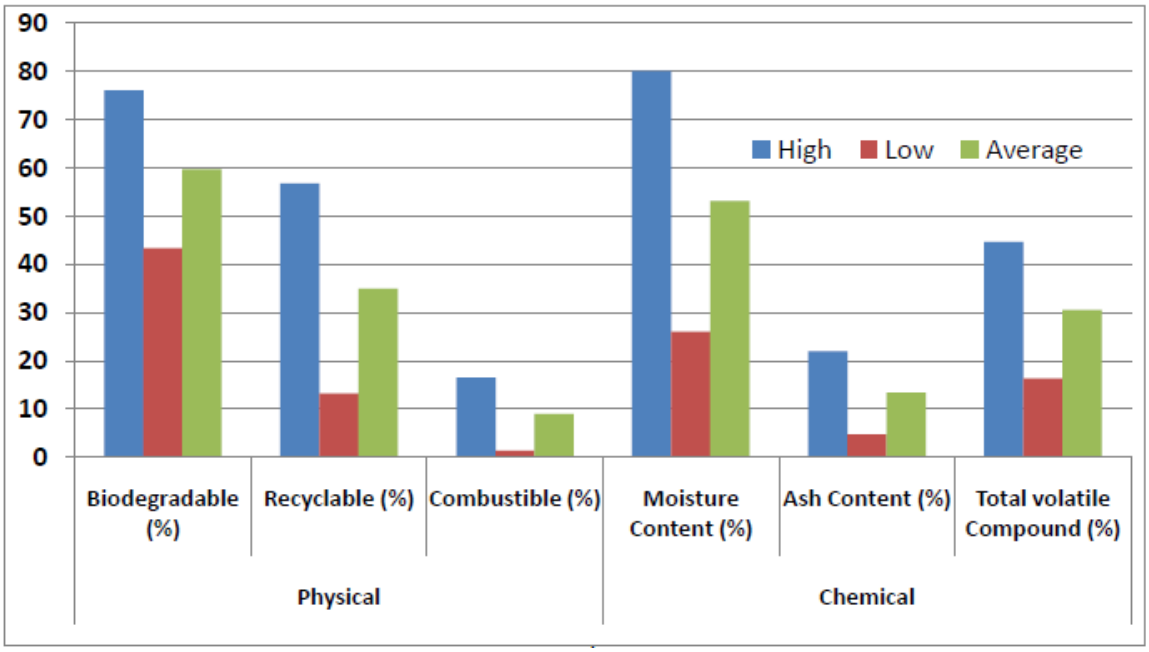


Figure 6 Waste Characterization summary

4. Inert waste in the form of coal was found in 2 out of 6 wards studied with no presence of bricks and construction debris.
5. Chemical Analysis is provided below with major parameters. Calorific value varies from 1313 to 3374 kcal/kg while moisture content varies from 45.31% till 80.01%. The lowest ash recorded is 4.77% while the highest is 21.93%. Bulk density recorded is around 0.5.

Table 11: Waste characterization

Locations	Ward 29	Ward 8	Ward 11	Ward 26	Ward 25	Ward 47
Moisture Content	56.27	78.75	80.01	45.31	53.47	43.75
Ash content (%)	10.57	16.03	11.27	21.93	4.94	4.77
Fixed Carbon	24.48	39.10	3.56	15.62	5.91	11.61
Carbon (%)	11.24	9.6	21.69	18.62	21.16	20.69
Bulk density	0.58	0.40	0.40	0.65	0.57	0.42
Calorific Value (Kcal/kg)	1803	1313	3374	2699	2616	2187

7. CASE STUDY: NAGPUR CITY

7.1. BACKGROUND

Nagpur is the winter capital and the third largest city of Maharashtra and largest city of central India. It has one of the highest literacy rates of 91.92% among all the urban agglomerations in India. NMC divides city in 10 zones and each zone is divided into several wards. As per provisional reports of Census India, population of Nagpur in 2011 was 2,405,665; of which male and female are 1,225,405 and 1,180,260 respectively (Census Nagpur, 2011). Nagpur ULB has received a credit rating of '**A**' by CRISIL in 2012.

The city is located in centre of India at a distance of 1065 km from Delhi and 825 km from Mumbai. Nagpur is well-connected with a number of major cities of India via Air, Trains and Roads.

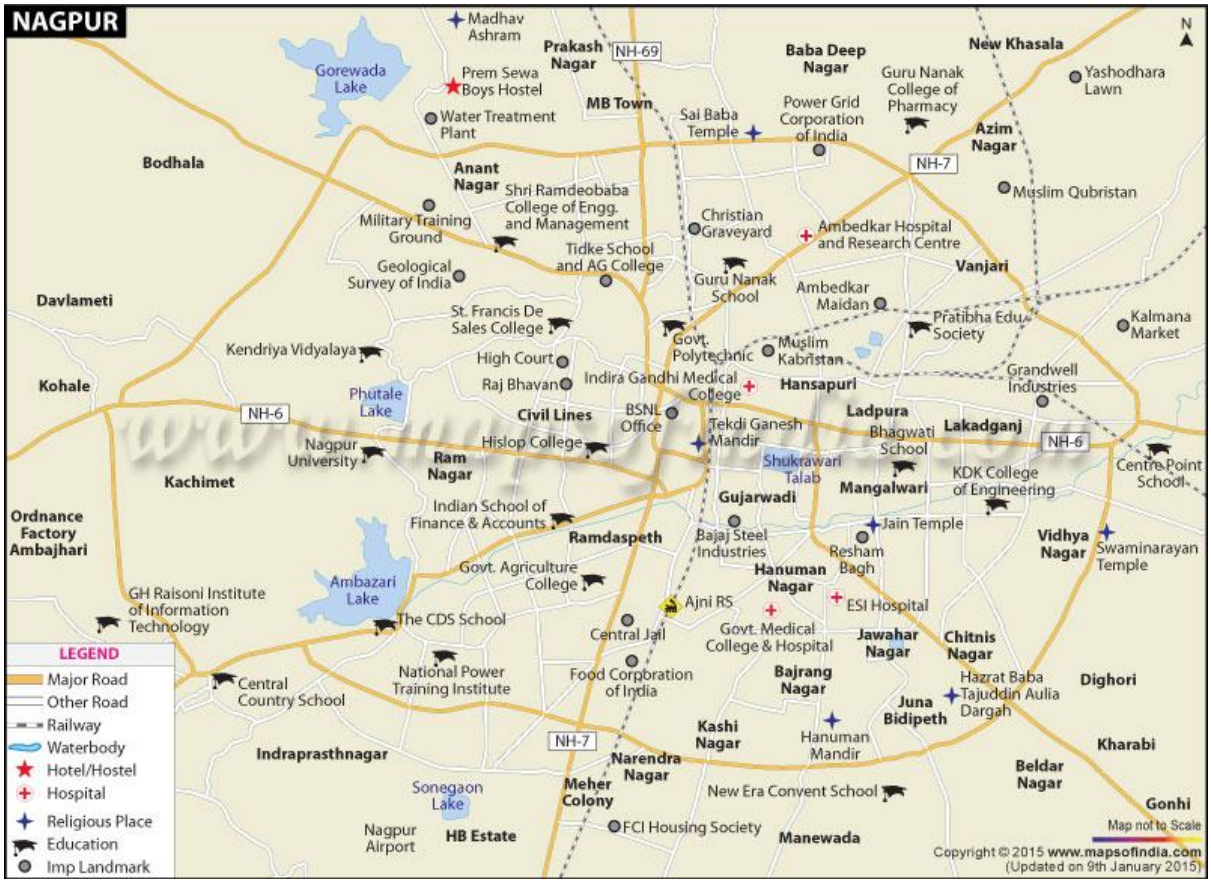


Figure 7: Nagpur city map

Nagpur has tropical savannah climate with dry conditions prevailing for most of the year. It receives about 163 mm of rainfall in June. The amount of rainfall is increased in July to 294 mm. Gradual decrease of rainfall has been observed from July to August (278

mm) and September (160 mm). The highest recorded daily rainfall was 304 mm on 14 July 1994. Summers are extremely hot, lasting from March to June, with May being the hottest month. Winter lasts from November to January, during which temperatures drop below 10 °C (50 °F). The highest recorded temperature in the city was 48 °C on May 19, 2015, while the lowest was 3.9 °C.

Nagpur is known for its greenery and was adjudged the cleanest and second greenest in India after Chandigarh in 2010 (Economic Times, 2008). The city has been adjudged as the 20th cleanest city in India and the top mover in the western zone as per Swachh Sarvekshan (Hitvada, 2016) 2016. Nagpur is also one of the proposed Smart Cities from Maharashtra.

7.2. WASTE MANAGEMENT VALUE CHAIN

Nagpur Municipal Corporation is responsible for providing municipal and civic services, which includes but not limited to the collection, segregation, transportation, treatment and disposal of Municipal solid waste (MSW) generated in the Nagpur city of Maharashtra. Since 2008, Kanak Resources Management Ltd (KRML), in collaboration with Nagpur Municipal Corporation is endeavoring house to house collection, transportation of waste to Bhandelwadi dump site. It covers 95% of total households with door to door collection of waste with 611 vehicles.

Sewerage Treatment Plant, water treatment plant, Bio-medical waste treatment plant, waste processing plant are all co-located adjacent to each other in the vicinity of dump site. There is a 200 TPD of waste to compost processing plant located near to dump site. NMC is on the verge of awarding waste processing facility of 800TPD to Essel Infra. Dr R J Dufare (Pench Project Cell, NMC) informed that the Corporation is also evaluating the possibility of reclaiming the land from the landfill site and is expected to come up with an Request for EOI in a month or two regarding Bio-mining. The idea is to deploy 3 sieving machines with capacity of 200TPD each and in 3 years the entire land can be reclaimed.

The Service level benchmarks for Solid Waste Management work in Nagpur in comparison to benchmark set by MoUD are as follows:

Table 12 : Comparison of service level benchmarking

S. No.	Indicator	Value	MoUD Benchmark
1	Household level coverage of SWM services (5.04 Lakhs properties covered with door-to-door collection out of 5.31 Lakhs total properties)	95%	100%
2	Efficiency of collection of MSW (950TPD waste collected in out of 1000TPD generated)	95%	100%
3	Extent of segregation of MSW	28%	100%

4	Extent of MSW recovered	9%	80%
5	Extent of scientific disposal of MSW	0%	100%
6	Efficiency in redressal of consumer complaints	97%	100%
7	Extent of cost recovery in SWM services (No use charges in place, recovered from only commercial & industrial development)	75%	100%
8	Efficiency in collection of SWM related user related charges	-	90%

Collection of waste

Waste dump site

Waste dump site

Open dumping

Equipments for compacting

Hanjer plant

Figure 8: Waste Management Value Chain: Nagpur

7.2.1. WASTE GENERATION

At present Nagpur city generates about 1000 to 1100 TPD of heterogeneous solid waste material. The Nagpur City Profile is given below:

Table 13 : Waste generation source

Parameter	Value
Area	227.29 km²
Household	5,25,000
Shops & Offices	75,193
Zones	10
Wards	145

Waste Generation	1000

7.2.2. WASTE COLLECTION & TRANSPORTATION

At present, M/S Kanak Resources Management Ltd. is responsible for door-to-door collection of solid waste in the Nagpur city. Some 300+ different size vehicles, ranging from Tata Ace to dumper truck, transport the city waste to Bhandelwadi site.

NMC claims that the waste is broadly segregated, collected and transported into two categories: MSW and street sweeping waste. Even the trucks/ transport cars have separate chamber for both the types. However the same wasn't observed at weigh bridge station where trucks are weighed and directed for next step.

Dr Pradeep Dasarwar, Medical Officer at Municipal Corporation, informed that Corporation has engaged 7000+ employees for purpose of street sweeping alone. Municipal Corporation pays to Kanak Resources at INR 1033/tonne for collection and transportation of waste.

7.2.3. WASTE PROCESSING

The city waste to the tune of 1000TPD+, arrives at the weighing bridge. Based upon the broad classification of waste as MSW or street sweeping waste, the truck is directed at Hanjer MSW processing unit or to the landfill site respectively. However Hanjer MSW plant is able to manage 150 to 200 TPD of waste only and remaining waste is dumped at Bhandelwadi dump site. Waste at Bhandelwadi dump site is processed by windrow composting method.

7.2.4. WASTE DISPOSAL

The MSW site at Bhandelwadi in operation since 1969 and spread across more than 50 acres. 6,00,000 Metric Tonne of solid waste was disposed at this site during 1969 to 2008.

Since 2009, the MSW processing and disposal facility was executed in two phases. In the first phase, the entire waste spread across the site was compacted and consolidated in north-eastern part of the site prior to the commissioning of MSW processing and disposal facility. The second phase comprise of commissioning of MSW processing and disposal facility on the cleared land.

Mr Sanjay, Zonal Officer, informed that around 800TPD of MSW is dumped at Bhandelwadi site. Inside landfill facility, the waste heaps are well maintained and there was an also fire brigade stationed to douse off any fire at initial stage itself. Many times rag pickers put *angaare* or fire into waste to burn off the combustible waste so that they

can explore and search for useful metals with magnets. Some 200 photo ID cards have also been issued to the rag pickers who are allowed to pick the waste inside landfill site.

7.3. WASTE COMPOSITION

As per the DPR for Nagpur city, the composition of MSW collected in the city is as follows:

Table 14: Waste characterization

S. No.	Constituent	%	Product
1	Wet Organic Material	30%	Compost
2	Dry Organic Material	30%	Refused Derived Fuel
3	Recyclables	5%	Plastic, Ingots
4	Refuse	17%	Mainly soil, sand, debris
5	Residue	18%	Inert to landfill

8. CASE STUDY: CHANDIGARH CITY

8.1. BACKGROUND

Chandigarh is a city and a union territory of India that serves as the capital of the Indian states of Haryana and Punjab. As a union territory, the city is governed directly by the Union Government and is not part of either state.

The city tops the list of Indian States and Union Territories by per capita income followed by Haryana and Delhi respectively in the country. The city was reported to be the cleanest in India in 2010, based on a national government study (Rediff, 2010). In 2016, Chandigarh was declared as the second cleanest city of India under Swachh Bharat Survekshan (Chandigarh, 2016). In 2015, a survey by LG Electronics (Business Standard, 2015), ranked Chandigarh as the happiest city in India over the happiness index. As per provisional reports of Census India, population of Chandigarh in 2011 is 961,587; of which male and female are 525,629 and 435,958 respectively (Census Chandigarh, 2011).

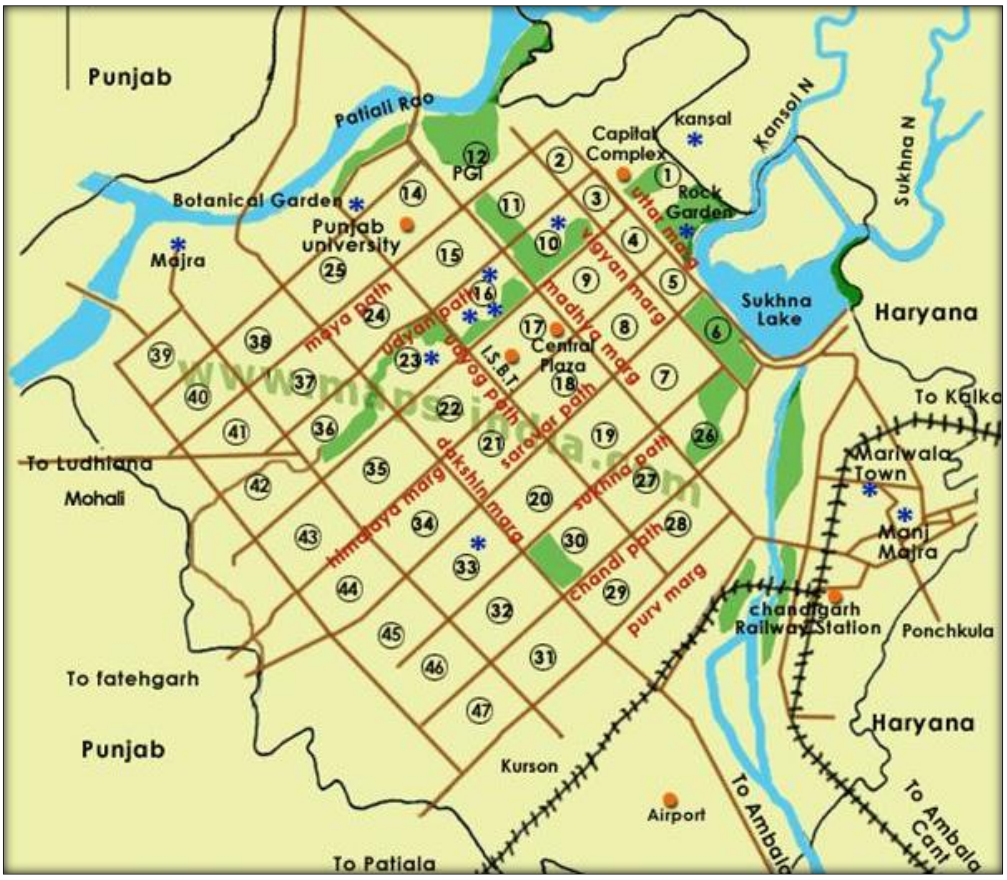


Figure 9: Chandigarh city map

The city is located 250 km north of Delhi and well-connected with a number of major cities of India via Air, Trains and Roads.

Chandigarh has a humid subtropical climate characterised by a seasonal rhythm: very hot summers, mild winters, unreliable rainfall and great variation in temperature (−1 °C to 46 °C OR 30.2 °F to 114 °F). The average annual rainfall is 1110.7 mm. The city also receives occasional winter rains from the Western Disturbance originating over the Mediterranean Sea.

Chandigarh has been selected as one of the hundred Indian cities to be developed as a smart city under PM Narendra Modi's flagship Smart Cities Mission. Chandigarh is also known to be the first (WHO, 2011) smoke-free city in India. Chandigarh Municipal Corporation has a credit rating of '**A+**' issued by ICRA in 2012 (JnNURM, 2012).

8.2. WASTE MANAGEMENT VALUE CHAIN

Chandigarh city has 20 wards (61 sectors) which generates 380 TPD (CPCB, 2016) of municipal solid waste. The waste collection, transportation & disposal is carried out by Municipal Corporation of Chandigarh. Waste collected from households is transferred to trucks at transfer stations.

There is a waste processing plant by M/s Jai Prakash Associate Ltd. which produces RDF for further industrial application. Corporation has provided free land to the company for waste processing instead of any provision of tipping fee. However this plant, at present, is not running at full capacity and processing only 80-90 TPD of waste. Remaining waste is dumped at nearby dumping ground without any treatment. As a result, Municipal Corporation is finding it difficult to manage its waste. At the time of site visit, Municipal Corporation was in process of inviting tenders for setting up new waste processing plant in Chandigarh.

Dustbin

Transfer stations

Transportation of waste

Dump site

Segregation of recyclable

Waste pickers at dump site

RDF plant

Weigh bridge

RDF produced

Loading of RDF

Leveling of dump site

Boundary wall of dump site

Figure 10: Waste Management Value Chain: Chandigarh

8.2.1. WASTE GENERATION

Chandigarh city has 20 wards (61 sectors) (CPCB, 2011) which generates 380 TPD of municipal solid waste from 1 million population.

There are about 2950 (Chandigarh, 2016) Small Scale and 15 Large and Medium Scale Units in existence in Chandigarh as on date. Growth of industry for the last few years has been limited in Chandigarh as it is not an industry led city because of the limited space envisaged for industrial development at the time of original planning of the city. However, still keeping in view the fact that industry would provide crucial resource base in the city, a limited area of about 1450 acres was planned for development as industrial area mainly for the development of small scale and pollution free industries.

Sector 26 also houses a wholesale market for grains, fruits & vegetables (Market committee Chandigarh, 2016). The waste generated in *mandi* is disposed at dumping ground. The garbage generated in the city is as under:

Table 15 : Status of waste management

Waste	Quantity
Total garbage	~380 TPD
To garbage processing plant	~90 TPD
To dumping ground	~290 TPD
Inerts & rejects from Garbage processing plant to dumping ground	~35 TPD

8.2.2. WASTE COLLECTION & TRANSPORTATION

The first step in Management of Solid Waste is collection of garbage and its depositing in the waste bins/collection at collection point/Collection into Tractor Trolleys. The system of collection is as follows

Table 16 : Locality wise waste collection and transportation

Locality	Waste Collection and Transportation
Sector 2,3,4,5,7,8,9,10,11, 39	Collected by 10 No. of tractor/ trolleys & one tipper of MCC, as due to large size of houses and large amount of waste/Horticulture waste. It is not remunerative for privately employed collectors.
Other residential Sectors	By 675 No. of door to door collectors but employee privately/by residents/by RWA's/ NGO's
11 Villages	Tractor trolleys
Manimajra	By 1 tampoo & 2 trolleys
Commercial establishments, Big Hotels	By tractor trolleys and dumper placers
Apni Mandi Waste	By Tractor trolleys of market committee
Horticulture Waste	By tractor trolleys
Gaushala & cattle pond	Cow dung taken by residents own transport

The waste is collected by waste collectors going from door-to-door and dustbins. This door-to-door collection is done in all the residential sectors and covers about 70-80% of the registered households. Chandigarh Municipal Corporation have set up various community *Sehaj Safai Kendra's* (transfer stations) in 35 out 56 sectors where the waste after collection is stored primarily before getting transported to the disposal site.

After temporary storage at Sehaj Safai Kendra, waste is transported to dump site.

8.2.3. WASTE PROCESSING

In Chandigarh city there exists an agreement between government and private company functioning under the name of Green Tech Fuel Processing Plant (A subsidiary of M/s Jai Prakash Associate Ltd). The company is responsible for complete processing of the municipal solid waste and it derives the refused fuel from it. It has no role in collection and transportation of the waste.

The state-of-the-art European technology customized to Indian MSW (of high moisture content and varying calorific value) involves conversion of waste (mainly horticulture) into densely packed fluff/pallets free from any harmful by-products and effluents. It is the first plant to have dryer and hot air generator (HAG) installed to process the waste. The refuse-derived fuel (RDF) obtained from the plant has calorific value of 3100 Kcal/Kg and moisture content less than 15% (Jaypee Group, 2015). The plant has a processing capacity about 500 tons of garbage daily. With the help of this technology the volume of municipal solid waste gets substantially reduced. However this plant, at present, is not running at full capacity and processing only 80-90 TPD of waste. Remaining waste is dumped at nearby dumping ground without any treatment.

8.2.4. WASTE DISPOSAL

There is only one designated dump yard consisting of 45.11 acres of land which is situated in sector 38 near Dadu Majra labor colony. The total area of the dumping ground is 45.11 acres, out of which 25 acres has been reclaimed by capping 17 acres and creating a land fill site on 8 acres. The remaining 20 acres is being used for dumping the rejects or inert from the waste processing plant and waste coming from sabzi mandies, apni mandies, big hotels, and villages under the Chandigarh administration.

Waste processing plant processes only 20% of waste generated from city and remaining waste is dumped at this disposal site. Waste dumped at site undergoes the following process: dumping, EM solution and levelling.

A heavy chained Buldozer is used for compacting, pushing and levelling the garbage in low lying areas al landfill site. One JCB has been provided for digging fresh soil for spreading soil cover on landfilling daily basis. Leachate collection and treatment facilities have been provided. Also gas venting system is provided at the landfill site.

EM solution is helpful in acceleration of decomposition process of the garbage, reduction in the volume of gas discharge with the result that foul smell has substantially minimized minimization of larva of flies & mosquitoes, reduction in suspended dust particles, reduction in the volume of waste and fermentation period.

8.3. WASTE COMPOSITION

The municipal solid waste from Chandigarh city comprises of following constituents:

Component	Percentage
Plastics and polythene	7%
Clothes	4%
Paper	6%
Organic/vegetables	52%
Glass	1%
Inerts	21%
Miscellaneous waste	3.8%

The densities of solid waste in Indian cities range from 280 to 1000 Kg/ m3 (Hazra and Goel, 2009) and it is estimated to be 550 kg/m3 for Chandigarh. Chemical properties of waste indicate that it contains high moisture content (60%) and calorific value (800-1000 Kcal/Kg). Heavy metals like lead, cadmium, copper and nickel were present in solid waste samples.

9. CASE STUDY: VISAKHAPATNAM CITY

9.1. BACKGROUND

Visakhapatnam, popularly known as Vizag, is a fast developing port city in India. Visakhapatnam is the second largest urban agglomeration in Andhra Pradesh state. On account of rapid industrialization, there has been significant migration into the city. As per provisional reports of Census India, population of Visakhapatnam in 2011 is 1,728,128; of which male and female are 873,599 and 854,529 respectively (Census Visakhapatnam, 2011).

The city was originally a small fishing village but due to its natural harbour, it developed into a major port. It has experienced rapid industrialization with the growth of major industries, including steel, petroleum re-fining and fertilizer. With the formation of "Greater Visakhapatnam" in 2005 the city's development is set for a quantum leap. The city of Visakhapatnam has implemented a number of reforms including e-governance and citizen-friendly initiatives. Visakhapatnam has been the first city in the country to implement e-governance and still leads in offering a variety of services to its residents online.

Figure 11: Visakhapatnam city map

The city is located at east coast of India at a distance of 1,776 km from Delhi, 884 km from Kolkata, 800 km from Chennai and 1,352 km from Mumbai. City is well-connected with a number of major cities of India via Air, Trains and Roads.

Visakhapatnam has been selected as one of the smart city under Smart Cities Mission. Visakhapatnam was ranked as the fifth cleanest city in India according to the government's Swachhta Sarvekshan rankings (Hindustan Times, 2016).

Fishing is one of the major activities in the Visakhapatnam. The export of the 70% fishing products in India is from Andhra Pradesh and major portion of this is from Visakhapatnam. It is estimated that around 6 lakh people of the state depend on fishing activity of which one fourth are in Visakhapatnam.

Climate: The temperature range in Visakhapatnam is 17.5°C to 34°C with average annual rainfall of 95 cm.

9.2. WASTE MANAGEMENT VALUE CHAIN

In Andhra Pradesh, 110 Municipalities and 15 corporations are generating 11,500 TPD of MSW. In the above figure it appears that AP is treating almost all the waste it is generating. But as per APPCB only 1595 TPD is being processed (Source, APPCB Website). This indicates a huge gap in the generation and treatment of solid waste which is matter of great concern.

Table 17 : Number of hotels, residents and other waste generation sources

Sl. No	Type of Waste	Number	Waste generated (Tons/day)
1	Domestic Household waste	3,50,000 (Approx.)	635.00
2	Commercial Establishments waste **(Shops/office/institutions etc.)**	80,000	42.00
3	Hotels & Restaurants	600-650	21.00
4	Institutional waste	180 Primary schools, 45 secondary schools and 15 colleges	5.00
5	Hospitals	664 Clinics, 50 hospitals and 66 nursing homes	3.00
6	Slaughter houses	3	3.00
7	Cinema halls	35	1.00
8	Function halls	160	14.00

Source: DPR title- Detailed Project Report on Municipal Solid Waste Management for Visakhapatnam, prepared by Feedback Infra Private Limited, 2016

Door to door collection

Dust bin

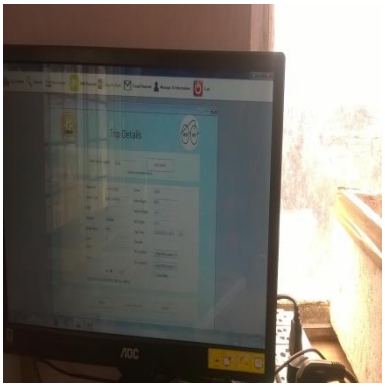
Primary collection

Primary collection

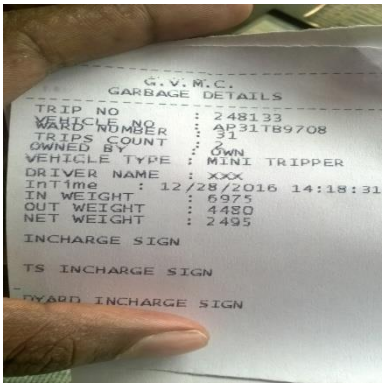
Street sweeping

Dustbins

Transportation



Computerized weighbridge



Weigh bridge slip

Dumping site

Dumping site

Dumping site

Figure 12: Waste Management Value Chain: Visakhapatnam

9.2.1. WASTE GENERATION

GVMC has been divided into six zones totally consisting of 72 wards, zone – I consists of wards 1 to 6, zone – II consists of wards 7 to 18, zone – III consists of wards 19 to 30, zone – IV consists of wards 31 to 49, zone – V consists of wards 50 to 65 and zone – VI consists of wards 66 to 72.

Based on the average per capita generation of municipal solid waste, it can be estimated that the waste generation from the households is about 635 MT. The average per capita waste generation of solid waste in Visakhapatnam was observed to be 0.45-0.47 kg/per capita/day. It is noticed that the waste genera-tion from High-income groups was found to be 0.40 – 0.45 kg/day and from the low-income groups between 0.35-0.40 kg/day. The commercial and the street sweepings also contribute for increase of the per capita waste generation for the city of Visakhapatnam.

The DPR for city has found the per capita waste generation at 0.48 kg/capita/day. The reason for the higher per capita waste generation is due to the packing food material in Visakhapatnam and due to commercial establishments. The ratio of residential, commercial and street sweeping is found to be around 32:57:11 which indicate the higher commercial waste generation.

9.2.2. WASTE COLLECTION & TRANSPORTATION

Waste is collected from the Households by waste collectors. Manual Push Carts (Total 800 Nos) are used for primary collection of waste. Recyclables segregated near source by waste collectors is sold to market. Waste collected from households or other establishments are stored in open spaces is either loaded manually or with the help of loaders (in case of huge accumulations) in trucks. The vehicles involved in the solid waste transportation in Visakhapatnam include dumper placers, tractors, mini vans,

tippers (big & small). Waste from commercial establishments, Mainly Dry Organic Waste like paper, Rubbish, Package Material, etc, are collected into the dumper bins by staffs.

City has approximately 75 Dumper placers, 132 TATA Acres, 64 Small Tippers Transport the Garbage from storage point to transfer station and dump site. There are 1313 permanent workers, 3919 Out Sourcing workers, 30 Permanent Drivers, and 200 Out Sourcing Drivers are working.

The collection and transportation of waste is practiced on all the days of the year including the public holidays by GVMC.

9.2.3. WASTE PROCESSING

There is a small compost plant in the Visakhapatnam city which is located in ward no. 10 behind Eenadu office. It was established on pilot basis in the year 2001 with coordination of NGO Exnora. Total area of the compost plant is 1.5 acres and is receiving a total solid waste of 5 to 6 Tons per day. There are 27 members working for this compost plant to segregate the recyclables and bio-degradable, and compost plant maintenance. There are 3 dumper bins provided in this compost plant to carry the inert material and disposes it in the Kapuluppada disposal site. Composting is done in the aerobic process which is in presence of oxygen.

M/s. Maridi Eco Industries Pvt. Ltd is operating a biomedical waste treatment plant in 5 acres within the Kapuluppada disposal site.

9.2.4. WASTE DISPOSAL

The waste collected from all the wards are disposed at the dump site located near Kapuluppada. This site is operating for the last 7 years with about 80 acres. Three JCBs and one bulldozer are employed by GVMC for solid waste disposal management, including the operation of the waste disposal site.

The existing waste disposal site where crude open dumping is practiced with no leachate collection and treatment system and does not meet the current requirements of the MSW 2000 Rules. Open burning of waste, indiscriminate disposal, presence of stray animals & rag pickers at the disposal site and leachate migration into the subsurface are common occurrences. The total waste dumped at Kapuluppada dump site is about 600-650 TPD, whereas the total waste generation is about 920 TPD.

City has planned to set up 15 MW waste to energy plant and this project has been awarded to M/s JITF Urban Infrastructure Ltd at a preferential tariff of 6.226 INR/kwh. Construction work is expected to begin by March 2017.

9.3. WASTE COMPOSITION

The DPR for the Visakhapatnam city has provided the following break up of waste generation in the city:

Table 18: Waste characterization - Physical

Type	Percentage
Organic Waste Comprising of Leaves , Fruits, Vege-tables, Food Waste, Fine organic Matter, Hay and Straw etc	52%
Recyclables Comprising of Rubber and leather, Plastics, Rags, Paper, Wooden Matter, Coconuts, Bones, Straw, fibers	23%
Inert Matter Comprising of ash, Crockery, Earthen ware (pots), Stones and Bricks, Metals, Glass, sand, silt from drains etc.	25%
Total	**100%**

The chemical composition if the waste is as per following table:

Table 19: Waste characterization - Chemical

Sl No	Parameter	Unit	Value
01	pH (5% solution)	-	8.01
02	EC(5% solution)	µsiemens/cm	1108
03	Total Waste Soluble	mg/gm	3.4
04	Moisture content	%	38.9
05	Total organic Carbon	%	18.4
06	C/N Ratio (Dry)	-	25.5
07	Calorific Value	kCal/kg	1220
08	Total Phosphorus	%	0.76
09	Total Potassium as K	mg/gm	0.92
10	Total Nitrogen as N	%	0.72
11	Arsenic as As2O3	mg/kg	BDL
12	Cadmium as Cd	mg/kg	2.3
13	Chromium as Cr	mg/kg	16.4
14	Nickel as Ni	mg/kg	8.6
15	Lead as Pb	mg/kg	17.2
16	Zinc as Zn	mg/kg	36.8
17	Copper as Cu	mg/kg	91.6

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