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Planning and Management of Garbage Collection and Disposal: A Case study of Raipur, Chhattisgarh, India.

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Abstract

This research paper is based on Planning and management of Garbage collection and disposal at Raipur, Chhattisgarh. The study is undertaken covering all the aspects of Municipal Solid waste management within the municipal limits of Raipur city. Types of waste that are generated from the cities is also studied. This research is conducted to understand the process of managing the waste generated from all the wards from eight zone of Raipur city. In-depth study is conducted to understand the system of collection, transportation, and disposal of municipal waste. Transportation of Garbage is undertaken with the help of door-to-door collection with the help of vans which has provision of waste separation. The vehicle used for collection and transportation are tracked with the help of GPS system. Analysis of amount of waste collected from various garbage bins and from door-to-door collection is undertaken. Method of waste segregation at final disposal site is done with fully automated machine which is installed at disposal site located at Sakri on the outskirts of the city. It has been proposed to install waste to energy plant at disposal site so the energy can be produced from waste and also to used waste water collected form wet waste for various purpose including watering the garden at disposal site.

1. INTRODUCTION

1.1: Background

The universal truth is that wastage of anything is harmful for the society. The environment is surrounded with natural things but if any calamity or adversity occurs, it distracts the natural environment. The most affecting elements are the water, land, air and noise pollution. Despite laws requiring proper waste disposal and the protection and preservation of bodies of water, people stubbornly dump their garbage into drainage canals, creeks, rivers, streets, and other public places.

The fragmented and uncoordinated approach to waste handling methods as well as the insufficient resources to implement, has contributed largely to the unacceptably high levels of pollution and waste in Raipur.

Integrated waste management is a holistic and integrated system and process of management, aimed at prevention of the environment and minimization of waste at source, managing the impact of pollution and waste on the receiving environment and remediating damaged environments.

1.2: About Raipur district

Raipur being Geographically Located almost at the center of the Chhattisgarh state, was made its capital. District Raipur Extends from latitude 21° 23″ to longitude 81° 65".

Area – District Raipur was divided into three parts in the year 1998 resulting in the formation of Mahasamund and Dhamtari districts. Similarly, in the year 2011, Raipur was again divided forming two new districts namely Gariaband and Balodabazar-Bhatapara. Raipur district includes Dharsiwa, Arang, Abhanpur and Tilda plains. Raipur district is situated at 244 to 409 meters above sea level.

Neighboring Districts – District Raipur is surrounded by six neighboring districts viz Durg, Bemetara, Balodabazar-Bhatapara, Mahasamund, Raipur and Dhamtari.

Rivers – Mahanadi and Kharun are the major rivers of Raipur district. Mahanadi is the most important river of Chhattisgarh, originating from Shrungi mountains in Sihawa Tehsil of Dhamtari district. Kharun is another important river flowing in Raipur and Durg districts which originates in the hills of Petchuva in Durg district.

1.3: Climate and Rainfall – Raipur district has the maximum temperature of 44.3° C and minimum of 12.5° C The total average rainfall in the district is 1370 mm.

Soil – The area includes Kanhar, Dorsa, Matasi, Kachar and Bhatha lands with a PH average of 6.5 to 7.5 which is considered very useful for agriculture.

1.3.1: Climate

Raipur has a tropical wet and dry climate, temperatures remain moderate throughout the year, except from March to June, which can be extremely hot. The temperature in April–May sometimes rises above 48 °C (118 °F). These summer months also have dry and hot winds. In summers, the temperature can also go up to 50 °C. The city receives about 1,300 millimeters (51 in) of rain, mostly in the monsoon season from late June to early October. Winters last from November to January and are mild, although lows can fall to 5 °C (41 °F) making it reasonably cold.

1.3.2: Demographics

As of the 2011 census, Raipur Municipal Corporation had a population of 1,010,087, of which 519,286 are males and 490,801 are females —a sex ratio of 945 females per 1000 males, higher than the national average of 940 per 1000. 124,471 children are in the age group of 0–6 years, of which 64,522 are boys and 59,949 are girls —a ratio of 929 girls per 1000 boys. There are 769,593 literates (420,155 males, 349,438 females). The effective literacy was 86.90%; male literacy was 92.39% and female literacy was 81.10%, significantly higher than the national average of 73.00%.

The urban agglomeration had a population of 1,122,555, of which males constitute 578,339, females constitute 544,216 —a sex ratio of 941 females per 1000 males and 142,826 children are in the age group of 0–6 years. There are a total of 846,952 literates with an effective literacy rate of 86.45%.

1.3.3: Geographical feature

Raipur is located near the center of a large plain, sometimes referred as the "rice bowl of India", where hundreds of varieties of rice are grown. The Mahanadi River flows to the east of the city of Raipur, and the southern side has dense forests. The Maikal Hills rise on the north-west of Raipur; on the north, the land rises and merges with the Chota Nagpur Plateau, which extends north-east across Jharkhand state. On the south of Raipur lies the Deccan Plateau.

Fig: 1 Raipur city map
*Source: Google images

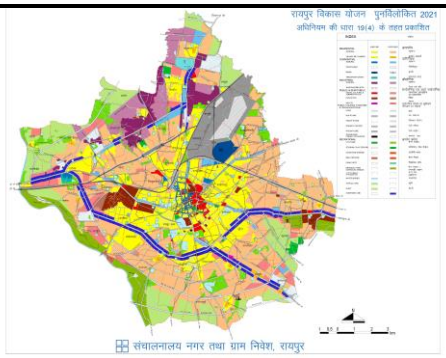


Fig: 2 Land use plan
*Source: Raipur vikas yojana punarvilokit 2021

1.4: Demographic features of Raipur

RMC has been divided into eight zones totally consisting of 70 wards, zone – I consists of wards 4 to 11, zone – II consists of wards 20 to 27,29, 35, zone – III consists of wards 28,30 to 34,42,44, zone – IV consists of wards 36,40,43,45 to 49, 55, zone – V consists of wards 16, 60,61, 65 to 69 and zone – VI consists of wards 50 to 54,56,62 to 64, zone – VII consists of wards 15,17,37 to 39,41,57 to 59, zone – VIII consists of wards 1 to 3,12 to 14,18,19,70. The basic infrastructure and facilities are provided across all the zones.

1.5: Urbanization in Chhattisgarh

Empowered Action Group states namely, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Uttrakhand, Odisha and Rajasthan are home to half of India's population as seen in its recent census, 2011.

Chhattisgarh one of the major states of India comprising of about 135 thousand sq. km. area and is home to over 25.5 million persons i.e. the population density for the state is 189 per sq. km. The population of the state grew by 22.6% during 2001-11, whereas the growth for urban population had been much higher at 41.8 percent during the period. Nearly one fourth (23%) of the population comprising 5.9 million persons live in 182 towns and cities. As in the rest of the country, the urbanization in Chhattisgarh is top heavy i.e., few large cities comprise a large proportion of the urban population.

1.6: Need for planning and management of municipal solid waste

Raipur, the capital city of Chhattisgarh, is located near the center of a large plain, referred as the "Rice Bowl of India" – where hundreds of varieties of rice are grown – and is also the biggest city of the region. With a population of over 1.2 million, the total quantum of municipal solid waste generated in Raipur is approx. 600 tons per day.

Raipur Municipal Corporation (RMC) seems to be struggling hard to maintain cleanliness and hygiene in city ever since it withdrew the sanitation contract from Kiwar Environment Company Ltd. Jaundice has come back to haunt residents, thanks to heaps of garbage that lies unattended on roads and stench emanating from drains that remain choked with filth.

1.7: Urbanization and the multifaceted challenge to manage waste

India is home to 1.21 billion people (based on 2011 Census) and the population has increased by almost 181.5 million (mn) since the last decade. The population growth in India has been high and it grew by 22% during 1991–2001 and 18% in the last decade. The beaming economy of the Indian sub-continent has also resulted in a rapid change in the demographics of the country from a rural to an urban society with a fast pace of urbanization, due to which an estimated 600 mn1 Indians will start living in urban areas by 2031.

Urbanization brings in a multifaceted challenge related to urban environment management due to population growth, growing economic activities, industrialization, changing lifestyles, as well as introduction of new technologies bringing in a completely different set of challenges to be faced (e.g., e-waste management). Urban waste management is one such burning issue which has emerged out of the said factors and has led

cities and towns to crumble under piles of garbage left in the open (to rot) as we fail to manage our waste due to a mismatch in the requirement and availability of services to deal with the same. Currently, we are not only limited to managing waste due our day-to-day activities (typical municipal waste) but are also forced to manage waste from the various industries located in the peripheral areas of our urban settlements. Our waste is both hazardous and non-hazardous, some of it is bio medical, while the remaining is from recent advances in the electronic and IT-related sectors. Poorly managed waste has direct implications to urban environment, leading to air, water, and soil pollution, and long-term health impacts and hence indirect implications to our economy and growth prospects. Hence, relooking into the present systems of waste management in the country is the need of the hour. The following sections provide an understanding of the various kinds of waste, and the required focus to improve our systems to enable the sustainability of the waste management sector with participation from both the government and private agencies.

1.8: Waste

Waste (or **wastes**) are unwanted or unusable materials. Waste is any substance which is discarded after primary use, or is worthless, defective and of no use. A by-product by contrast is a joint product of relatively minor economic value. A waste product may become a by-product, joint product or resource through an invention that raises a waste product's value above zero.

Examples include municipal solid waste (household trash/refuse), hazardous waste, wastewater (such as sewage, which contains bodily wastes (feces and urine) and surface runoff), radioactive waste, and others.

1.9: Waste types

The solid waste management sector is defined by the following kinds of waste based on their types and sources of generation. The waste types are governed by various rules laid down by the Ministry of Environment, Forest, and Climate Change Government of India.

Fig.3: Key waste types

*Source: Prepared by self

1.9.1: Municipal waste

- Commercial and residential wastes generated in a municipal or notified areas, excluding industrial hazardous wastes but including treated bio-medical wastes.
- Governed by the Municipal Solid Waste Management and Handling Rules, 2016

1.9.2: Industrial waste

- Attributes to waste material produced during the industrial activity. Waste either generated from residential, commercial, or industrial activity.
- Can be Hazardous as well Non-Hazardous in nature.
- Governed by various rules based on the type of waste

1.9.3: Hazardous waste

Waste either generated from residential, commercial, or industrial activity.

- Attributed to its qualities – ignitability, corrosively, reactivity, toxicity.
- Governed by the Hazardous and Other Wastes (Management and Trans-boundary Movement) Rules, 2016

1.9.4: Biomedical waste

- Any waste which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals.
- Governed by the Bio-Medical Waste Management Rules,2016

1.9.5: Plastic waste

- Waste generated from indiscriminate use and disposal of plastic into the physical environment leading to water, soil and air pollution
- Governed by the Plastic Waste Management Rules 2016

1.9.6: Plastic E-Waste

- e-waste' means electrical and electronic equipment, whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment and repair processes.
- Governed by the E-waste (Management), Rules 2016

Apart from the above waste categories, the construction and demolition waste generated from various means such as waste comprising building materials, debris and rubble resulting from construction, re-modeling, repair, and demolition of any civil structure, has also been defined with the regulatory framework under the Construction and Demolition Waste Management Rules, 2016, published by the Ministry of Environment, Forest, and Climate Change in 2016.

2.0 MUNICIPAL SOLID WASTE MANAGEMENT

Municipal solid waste management (MSWM) involves various activities associated with the generation, storage, collection, segregation, transfer and transport, processing, and disposal of solid waste in an environmentally compatible manner, adopting the principles of economy, aesthetics, and energy and conservation. This section focuses on the MSWM sector value chain, status of implementation of services in India and the role played by the government to improve situations.

2.1: Understanding the MSWM value chain in India

The typical MSWM value chain includes the stages of primary and secondary collection, transportation, intermediary storage in a transfer station, process and treatment and disposal in an environmentally sound and acceptable manner. The following figure illustrates a typical waste management value chain, though the waste management system varies from towns to towns depending on the quantum of waste to be handled.

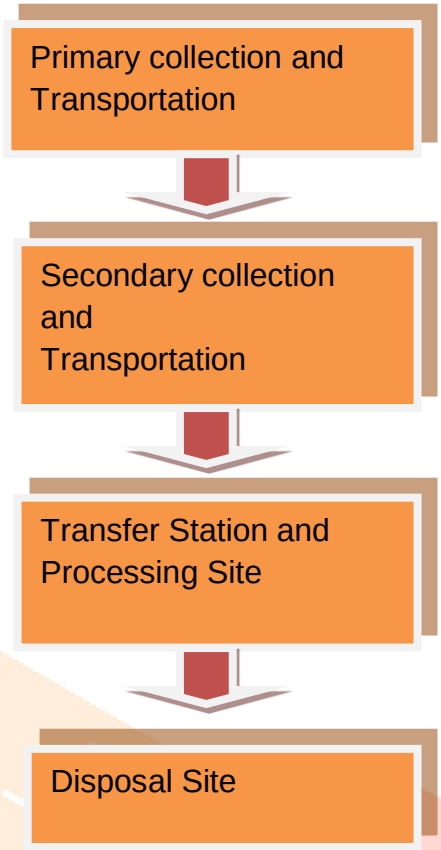


Fig.: 4 MSWM Value Chain
*Source: Prepared by self.

A recent World Bank paper estimates that ten years ago, there were 2.9 billion urban residents who generated about 0.64 kg of municipal solid waste per person per day (0.68 billion tonnes per year), which, as of today, is estimated at 3 billion residents generating 1.2 kg per person per day (1.3 billion tonnes per year). By 2025, this will likely increase to 4.3 billion urban residents generating about 1.42 kg/capita/day of municipal solid waste (2.2 billion tonnes per year).

The per capita generation of waste between the decades is a worrisome figure. India is no exception in its concern about the per capita waste generation rate, though the present per capita generation of waste is only 300–400 gm/capita for medium cities and between 400–600 gm/capita for large cities. However, this is going to increase with the present trend of urbanisation and consumption patterns. As per the Central Pollution Control Board (CPCB) report (2012–13), municipal areas in the country generate around 170,000 metric tonnes per day (TPD) of municipal solid waste (annual generation of 62 mn tonnes of waste). As per 2011 census, 31.16 % population (i.e. 377 mn people) of India live in 4,041 municipal authorities. It is estimated that by 2050, 50% of the population will be living in urban areas, and the volume of waste generation will grow by 5% per year. Accordingly, the expected waste quantity we are looking at for the year 2021, 2031, and 2050 are 101 mn metric tonnes per year, 164 mn metric tonnes, and 436 mn metric tonnes per year respectively. This will require significant land area to be put under landfilling. If the present scenario of waste management is considered, where most of the waste is dumped without treatment, we are looking at an estimated 88 square km (equivalent to the size of NDMC area) of precious land being brought under waste disposal through landfilling,2 which will eventually render the land unfit for any other use for as long as a half century before it can be stabilized for other uses. The following figure illustrates the comparatives for waste generation and land requirements.

Based on information available with the PwC team, the waste generation of Class I cities has been estimated to be around 80% of the total waste generation of the country. Having cited these figures, the Government of India (GoI) has hence been receptive to the municipal solid waste management issue and has initiated several flagship programmes such as the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in the past

and the Swachh Bharat Mission at present to strategize the implementation of waste management projects in India.

2.2: Role of government and private agencies in managing waste

According to the Indian Constitution, the responsibility for solid waste management is under the purview of the state government and the urban local bodies (ULBs). MSWM is governed by the Municipal Solid Waste Management and Handling Rules, 2016. The rules designate ULBs as solely responsible to manage solid waste in their area and direct that ULBS be responsible for the management of municipal solid waste within their territorial area and be responsible for the implementation of the provisions of these rules, and for any infrastructure development for collection, storage, segregation, transportation, processing, and disposal of municipal solid wastes. However, GoI, state governments and various institutions in the country, including the Planning Commission and the National Institute of Urban Affairs, have brought the requisite knowledge and advocacy to deal with this subject. Currently, waste management is one of the pressing issues that GoI is dealing with under its flagship programmes such as the Smart City Mission and the Swachh Bharat Mission. Currently, the waste management issue has been taken up through serious involvement of various ministries and institutions:

2.2.1 Involvement of various ministries and institutions in MSWM

Central
• Ministries involved:
• Ministry of Environment and Forest – Overall guidance through rules regulations and guidance materials.
• Ministry of Urban Development:
• Funding of projects through National Flagship Projects
• Technical Assistance through specialized teams imparting capacity to the state and ULBs.
• Ministry of New and Renewable Energy.
• Ministry of Finance through the Department of Economic Affairs.

State
• Responsible for implementation of funding through State Finance Commissions
• State Urban Development Departments as State Nodal body for channelizing Central Funds, Coordination between various ULBs for central schemes, and imparting capacity to laggard ULBs with knowledge and manpower.

ULB
•Implementation Responsibility.
• Implement through a set of byelaws
• Responsible for manpower and staffing
• Responsible for preparing and implementing the municipal rules
• Funding through ULB's own resource & Public Private Partnerships.

Private/NGOs
• Assist ULBs in implementation of waste management activity in the capacity of advisors, execution agencies. guided by a pre-defined contract between the public entity.
• Non-governmental organizations play an important role in collection and transportation and organizing the informal sector. In some cases, NGOs have done good work in end-to-end waste management.

Informal Sector
• Scavenging and rag picking.
• Informal waste recycling.

Table 1: Role of agencies in MSWM.

Institutions		
Government • Niti Ayog-Plans and Financial Support • DEA (Department of Economic Affairs)- Structure and Framework & Financial Support • NIUA - Capacity Building • BARC – Technology	Multi-Lateral/bilateral funding agencies: Capacity building and financing	Industry associations ASSOCHAM, CII, FICCI, NSWAI, etc.

*Source: Central Pollution Control Board (CPCB) report (2012–13)

While the above figure illustrates the role of government agencies, the following section specifically deals with the role of private agencies under various components of waste management.

Table 2: Role of Private agencies in MSWM.

S.No.	SWM Value Chain	Private Sector Involvement	Contractual Arrangements
1	Primary collection	Primary door-to-door collection of municipal solid waste.	Service/management contract
		Service/management contract	Service contract
2	Secondary collection & transportation	Construction and management of community bins	BOT and its variance and/or Separate EPC and O&M Contract
		Transportation of waste	Management contract/O&M contract
3	Transfer station management & processing site	Setting up and running transfer station	Concession and/or O&M contract built operate own (BOO)
		Processing using composting/ RDF / recoverable/ recycle projects	DBOT/ BOT (long term) EPC with 5–7 years O&M contract
		Waste to energy	Built operate transfer (BOT)
4	Waste disposal	Disposal in an engineered landfill site	Design build operate and transfer (DBOT), EPC with O&M Contract on renewal basis

*Source: Central Pollution Control Board (CPCB) report (2012–13)

While the private sector has been involved in waste management services on a regular basis, the sector has seen several issues and bottlenecks which have made it challenging to successfully implement projects. The following section deals with the inherent challenges that the sector faces with respect to the private sector participation.

2.3: Garbage management can be divided into two major areas

(i) Collection including storage, transfer, and transport, and

(ii) Disposal, including any accompanying treatment.

The collection operation can be sub-divided into two-unit operations- collection and haul. The collection operation consists of removing garbage from the storage point. The haul operation includes the total round trip travel time (for the vehicle) from the collection route to the (waste) disposal site.

Three alternatives are normally considered for solid waste disposal:

(1) Direct shipment from municipalities to a sanitary landfill.

(2) Direct shipment from municipalities to a transfer station where **municipal solid waste** is transferred to larger vehicles and then shipped for ultimate disposal.

(3) Direct shipment from municipalities to an incinerator where the **municipal solid waste** is burned, and the residue is shipped for ultimate disposal.

Municipal solid waste planning and management requires an assessment of many complex interactions among transportation systems, land use patterns, urban growth and development, and public health considera-tions.

Arising quality of life and high rates of resource consumption patterns have had a unintended and negative impact on the urban environment - generation of wastes far beyond the handling capacities of urban governments and agencies. Cities are now grappling with the problems of high volumes of waste, the costs involved, the disposal technologies and methodologies, and the impact of wastes on the local and global environment.

But these problems have also provided a window of opportunity for cities to find solutions - involving the community and the private sector; involving innovative technologies and disposal methods; and involving behavior changes and awareness raising. These issues have been amply demonstrated by good practices from many cities around the world.

There is a need for a complete rethinking of "waste" - to analyze if waste is indeed waste. A rethinking that calls for,

WASTE to become WEALTH
REFUSE to become RESOURCE
TRASH to become CASH

There is a clear need for the current approach of **waste disposal** that is focused on municipalities and uses high energy/high technology, to move more towards **waste processing** and **waste recycling** (that involves public-private partnerships, aiming for eventual **waste minimization** - driven at the community level, and using low energy/low technology resources. Some of the defining criteria for future waste minimization programs will include deeper community participation, understanding economic benefits/recovery of waste, focusing on life cycles (rather than end-of-pipe solutions), decentralized administration of waste, minimizing environmental impacts, reconciling investment costs with long-term goals.

2.4: Aim

To study the planning and management of garbage collection and disposal of Raipur.

2.4.1: Objective

Planning and management of garbage collection and disposal of Raipur is one of the important components of the Plan. The main objective of the detailed Planning and Management of garbage collection and disposal, Raipur shall be:

1. To overview literature on city solid waste management in India.

2. To understand the processes management of huge quality municipal garbage within the city limits of Raipur Municipal Corporation.

3. To analyze solid waste management rules 2016 by promoting public and private partnership and involvement of local stakeholders to successfully implement the management plan.

4. To suggest suitable planning measure for managing municipal garbage of Raipur Municipal Corporation.

2.4.2: Scope of work

Data Collection and Analysis for accurate quantification and characterization of garbage. Garbage quantification assessment and prediction. Analyze the existing garbage management situation. Assessing the institutional framework and resources available.

Stake holder's consultation comments and input. Understanding the role of different stakeholders at different levels of garbage management chain.

Formulate action plan and garbage management plan for the said area. And implement the action plan and monitor the results.

Preparation of plan for disposal on land i.e., environmentally safe and sustainable disposal in landfills.

All necessary works related to the job of preparation of plan and management of garbage collection and disposal. Preparation of plan for transportation of garbage.

2.4.3: Flow chart for municipal garbage management system

A) Problem definition and statement of objective

B) Inventory and data collection

C) Development of alternatives

D) System selection

E) Implementation methodology

2.5: Methodology

A comprehensive garbage management plan involves storage, collection,
Transportation, segregation, garbage characterization, processing and disposal
The detailed methodology proposed for the garbage management plan for Raipur
Municipal Corporation, Raipur.

2.5.1: Baseline information collection

Study of existing literature and information about generation of garbage and its impact assessment.

- Land use survey and current practices.
- Studying the area map of the study region regarding:
- Classification of the areas into residential, commercial and market etc.
- Location of nallahs and their characteristics
- Location of open points / dust bins
- Location of dumpsite (s)

Reconnaissance survey of the municipality will be conducted to assess the overall situation. The information would be a pre-requisite for finalizing location of waste collection bins, location of dustbins, and location of transfer station and route rationalization.

The analysis of all information/data from survey, field visits and discussions with various stakeholders would be analyzed.

2.6: Garbage Minimization

Waste minimization or reduction at source is the most desirable activity because the community does not incur expenditure for waste handling, recycling, and disposal of waste that is never created and delivered to the waste management system.

Estimation of Quantity of Garbage Generated and Future Projections

The quantity of Municipal Solid Waste (MSW) generated per day on an average would be carried out by the direct and indirect method. The methodology of estimation is as follows:

- Number of collection points with their spatial distribution in the town
- Transferring points (if any) with their spatial distribution in the town
- Market yards / Vegetable markets

Total amount of waste generated and collected (by indicating the date(s) of estimating the total quantity of waste) – 5 days average MSW quantities will be projected for the next 30 years by one of the most suited methods as 5 indicated in the 'Manual on MSWM prepared by CPHEEO, as this will help in suitable design of processing & disposal facilities.

2.6.1: Establish status/baseline of garbage management

A detailed survey shall be undertaken to establish the existing status of waste management in the locality. The existing resources such as manpower, equipment, vehicles, waste collection practices, transport facilities and disposal mechanisms will be evaluated. The results will be used to evaluate the adequacy of the existing resources. The technical adequacy as well as the resource adequacy shall be evaluated. A survey will also be conducted involving interviews with local inhabitants to understand the existing levels of waste management awareness among general public. Information will also be collected to assess the source segregation levels and community participation initiative for comprehensive waste management.

2.6.2: Assessment of garbage generation trend

After identification of the data sources and initiating the data collection and assessment of publicly available data, the Consultant shall carry out a survey in the city and conducts an assessment of the garbage generation trends in the city. The primary survey shall be performed to substantiate any shortfall in publicly available data. Additionally, a visit to the city and a survey shall be conducted. The study shall be carried out based on recent trends in **garbage** generation trends in the city. Best practices adopted for **garbage** management in the city shall thus be reviewed.

2.6.3: Assessment of primary and secondary collection mechanism

The objective of this task is to understand and assess the existing primary and secondary collection mechanisms of garbage generated in the Town. Under this task the following information would be collected and analyzed. Information on primary garbage collection arrangements such as number and spacing of dustbins information on house to house collection information on other primary collection mechanisms garbage collection scheduling and techniques, Street sweeping process and mechanism and organization of sweeping activities, Details of secondary garbage collection such as number and locations of transfer stations / collection points and other secondary collection arrangements, Identification of garbage generating sources like households, commercial establishments, hotels, institutions, etc. Details of bulk generators such as vegetable / fish / mutton markets, big hotels & restaurants, slaughterhouses, function halls, construction waste etc

2.6.4: Assessment of infrastructure – Collection and transportation equipment's and vehicles

Under this task the following information would be collected, Primary collection equipment such as push carts, wheelbarrows, container carts, tricycles, brooms, metal trays. Secondary collection and transportation equipment and vehicles like transfer station arrangements, tractor-trailer, dumper bins, dumper placers, etc. Information on daily recordings of vehicle movements as available from vehicle logbook, the infrastructure available would-be asses by their capacities and their condition and number, thus arrives at the adequacy. The suitability of present infrastructure and modification required would be assessed based on the characteristics of the town and the requirements. The performance would be assessed based on the number of trips made by each type of vehicles both to collection points and disposal points and user friendliness of the equipment.

2.6.5: Assessment of resource recovery through material recycling

Material recycling can occur through sorting of garbage into different streams at the source or at a centralized facility.

- Sorting at source
- Centralized sorting
- Sorting prior to garbage processing or land filling

Resource Recovery through Garbage Processing

Biological or thermal treatment of garbage can result in recovery of useful products such as compost or energy.

2.7: Theme of action plan

States and Union territories are required to prepare action plans for cities and towns based on the population and waste generation. Steps/action need to be taken could be indicated in a phased manner.

2.7.1: Action plan for cities generating waste >500Tonne per day

• Cities generating solid waste more than 500 t/d are suggested to formulate action plan which may include the following components: - Modernization/ mechanization of waste storage and transportation facilities; - Privatization/ contract with 'operators' for collection of waste from various sources and its transportation; and 12 - Seeking support of Private entrepreneurship in setting up of waste processing and disposal facility. • The cities with estimated waste generation of more than 500 t/d includes Ahmedabad, Agra, Bangalore, Bhopal, Chennai, Delhi, Hyderabad, Jaipur, Kanpur, Kolkata, Lucknow, Mumbai, Nagpur, Pune, Surat, and other cities.

2.7.2: Waste generation and composition

- Total quantity of waste generated in the country (based on weighment exercise by local bodies) is not reported. However, Ministry of Urban Development in its manual on solid waste management (year 2000) has estimated waste generation of 100,000 MT.
- 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)
- Quantities and waste generation rate in Raipur is as under.

Table:3: Quantities and waste generation in Raipur

S. No	Name of City	Area (Sq. Km)	Population (As per 2001 census)	Waste Quantity (TPD)	Waste Generation Rate (kg/c/day)
1	Raipur	6,05,747	56	184	0.30

*Source: www.cpcb.in

2.7.3: Solid waste generation in Raipur

Rank and Waste generation of Raipur as per Central pollution control board is as follows:

Table:4: Waste generation Rank, Raipur

Rank	City	Population (2011)	Waste Generation (TPD			
			1999- 2000	2004-05	2010-11	2015-16
45	Raipur (C.G)	1,010,087	-	184	224	230

*Source: www.cpcb.in

2.8 MANAGEMENT OF MUNICIPAL GARBAGE OF RAIPUR MUNICIPAL CORPORATION

2.8.1: Introduction

Raipur is the capital city of the Indian state of Chhattisgarh. It is also the largest city of the state. It was formerly a part of Madhya Pradesh before the state of Chhattisgarh was formed on 1 November 2000. It has a widely diverse population from all over the country. On the industrial prospects, it has seen an exponential growth over the years. With a strong presence of international brands and prominent global automobile companies, Raipur has emerged as a major business hub in the central India. It is ranked 7th in Ease of Living Index 2018 by Union Ministry of Housing and Urban Affairs (MoHUA)

For this the Administration of Raipur has taken right steps to implement proper solid waste management programme towards full compliance of MSW Rules 2000 (MOEF, GOI) in Raipur.

M/S DELHI MSW SOLUTIONS LTD-RAIPUR has been selected and appointed as consultant for preparation of DPR on SWM for the Raipur.

Delhi MSW Solutions Limited Delhi MSW Solutions Ltd., (DMSWSL) is a subsidiary of Hyderabad based Ramky Enviro Engineers Ltd. Ramky Enviro is South Asia's foremost waste management company providing services in the realm of scientific management of Municipal, Industrial and Biomedical, apart from E-Waste and wastewater treatment.

The total area is 226 Sq.km and the population as per 2011 census is Raipur district as per census 2011 is 10,27,264 this means a Density of 5707 persons/Sq.km. RMC has been divided into eight zones totally consisting of 70 wards.

RMC (Raipur Municipal Corporation) is conducting scientific processing and disposal of solid waste in the entire city. RMC is carrying out Collection & Transportation functions through contractual arrangements.

The need for proper MSW collection & transportation as well as processing & disposal has been realized by all the residents, shop keepers, service providers and the hospitality industry.

As per the field survey, total quantity of solid waste of the city is 920 MT/day, out of which about 70% is generated by Domestic Household, Commercial Establishments, and Hotels & Restaurants and Institutional waste.

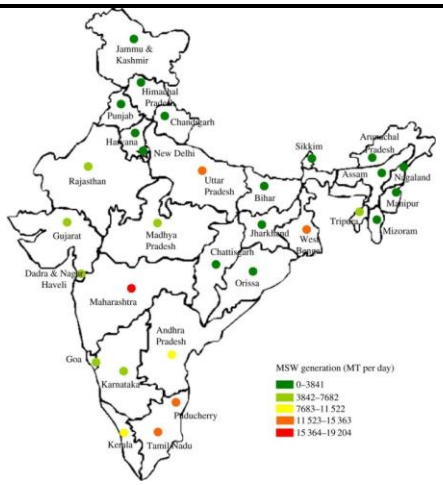


Fig.5: MSW generation (MT per day) in Indian States.
*Source: Google Image.

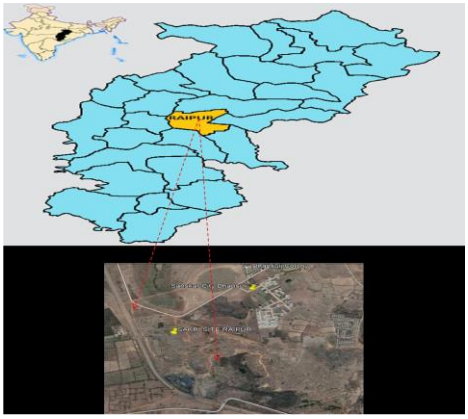


Fig.6: Study Area of Municipal Solid Waste Management – Raipur, Chhattisgarh
*Source: Google Image

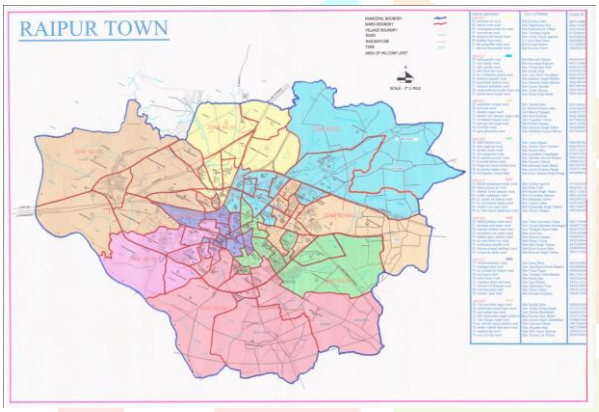


Fig.7: Map showing 8 Zones of Raipur Municipal Corporation
*Source: Raipur Municipal Corporation

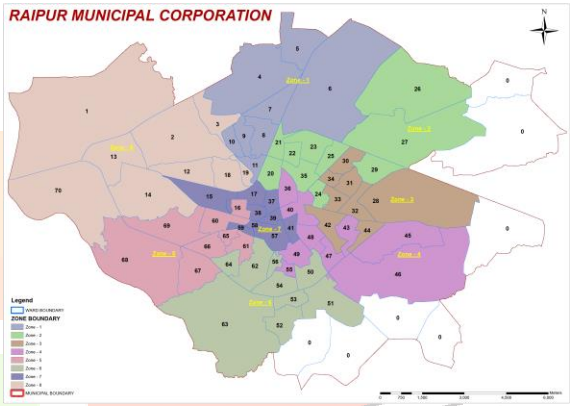


Fig.8 : Map showing 70 wards of Raipur Municipal Corporation
*Source: Raipur Municipal Corporation

2.8.2: Waste management hierarchy, Interrelationship of Functional element in SWM system inter-relation and eight zones of Raipur Municipal Corporation

These 8 zones have total number of 70 wards. Total number of vehicles allotted to collect the municipal solid waste is 211 and number of vehicles deployed is 217.Total trip record of these vehicles is 306 per day. The vehicles are parked at two parking station (Daldal seoni parking station and Gokul Nagar parking station). Municipal solid waste collected is then transferred at various transfer stations situated at various locations viz; Narayana transfer station, Kalimata transfer station, Purena transfer station, Dharnasthal transfer station, Gokul Nagar transfer station and Tarun talab transfer station. Total waste collected per day from all the 8 zones is 346128 metric ton, out of which waste of 302541 metric ton is house hold waste and 43587 metric ton is commercial waste.

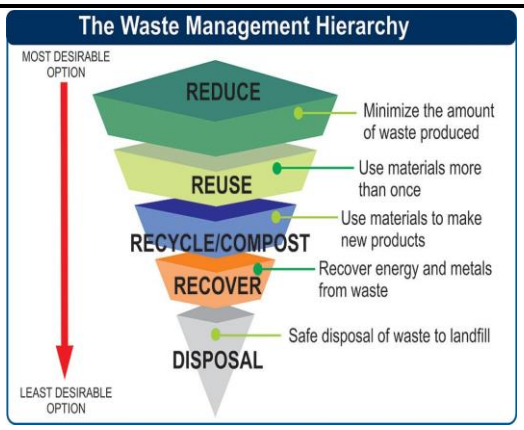


Fig.9 : Waste Management Hierarchy
*Source: Google images

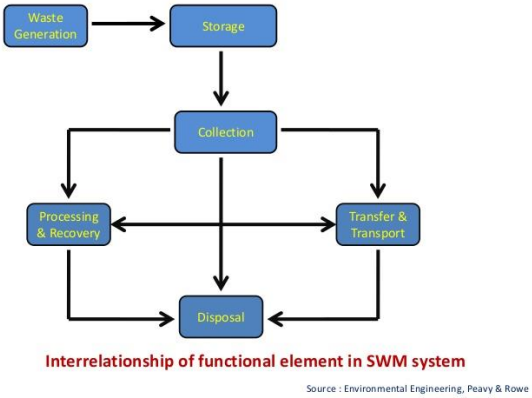


Fig.10 : Interrelationship of Functional element in SWM system
*Source: Google images

2.8.3 General Composition / Characteristics of MSW

Relative compositions of Household waste in Low-, Middle- and High-income countries are listed in the following table.

Table 5: Relative composition of household waste

Parameters	Unit	Low-income countries	Medium income countries	High income countries
Organics	%	40-70	20-40	20-30
Paper	%	01-10	10-30	15-40
Plastics	%	01-05	03-08	05-10
Metal	%	01-10	01-10	01-10
Glass	%	01-10	01-10	01-10
Rubber, leather, etc	%	05-10	05-10	05-10
Others	%	15-40	10-30	05-20
Moisture	%	40-80	40-60	5-20
Density	kg/m3	250-500	170-330	100-170
Low Calorific value	kcal/kg	800-1100	1000-1300	1500-2700

*Source: Report on Integrated solid waste management, Raipur.

Table 6: Physical Characteristics of MSW in Indian cities

Population Range (million)	Paper %	Rubber, Leather & Synthetic %	Glass and Metals %	Combustibles %	Inserts %
0.1 – 0.5	2.91	0.78	0.89	44.57	43.59
0.5 – 1.0	2.95	0.73	0.67	40.04	48.38
1.0 – 2.0	4.71	0.71	0.95	38.95	44.73
2.0 – 5.0	3.18	0.484	1.08	56.67	56.67
> 5.0	6.43	0.28	1.74	30.84	53.90

*Source: Report on Integrated solid waste management, Raipur.

Table 7: Chemical characteristics of MSW in Indian cities

Population Range (million)	Moisture %	Organic matter %	Total N2 %	P2O5 %	K2O %	C/N Ratio %	LCV (kcal/ kg) %
0.1 – 0.5	25.8	37.1	0.7	0.6	0.8	30.9	1010
0.5 – 1.0	19.5	25.1	0.7	0.6	0.7	21.1	901
1.0 – 2.0	27.0	26.9	0.6	0.8	0.7	23.7	980
2.0 – 5.0	21.0	25.6	0.6	0.7	0.8	22.4	907
> 5.0	38.7	39.1	0.6	0.5	0.5	30.1	801

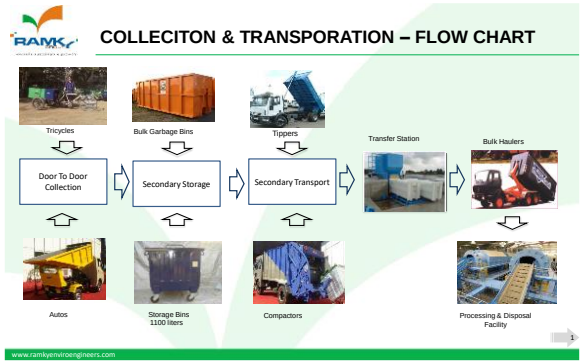
*Source: Report on Integrated solid waste management, Raipur.

During the last 10 years, life and consumption styles have remarkably modified the composition of MSW. The quantity of organic waste has decreased, while packaging related waste has increased (as of now it is about 40% of the total). Such a massive presence of packaging material, like plastic, paper, cardboard – all of which have high energy contents – has progressively raised the overall Heating Value of MSW.

Table 8 Quantity of MSW in urban centers

Population range (million)	Number of urban centers	Total population (million)	Average generation (per capita / day)	Quantity (tonnes / day)
< 0.1	328	68.300	0.21	14343
0.1 – 0.5	255	56.914	0.21	11952
0.5 – 1.0	31	21.729	0.25	5432
1.0 – 2.0	14	17.184	0.27	4640
2.0 – 5.0	6	20.597	0.35	7209
> 5.0	3	26.306	0.50	13153

*Source: Report on Integrated solid waste management, Raipur



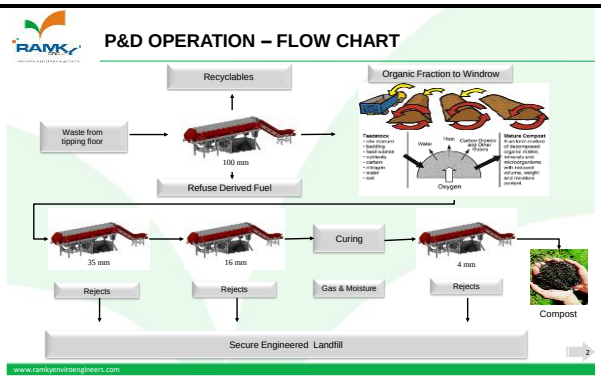


Fig.11: Collection & Transportation – Flow Chart

Fig 12: P & D Operation – Flow Chart

*Source: Delhi Solid Waste Management Solutions Ltd.

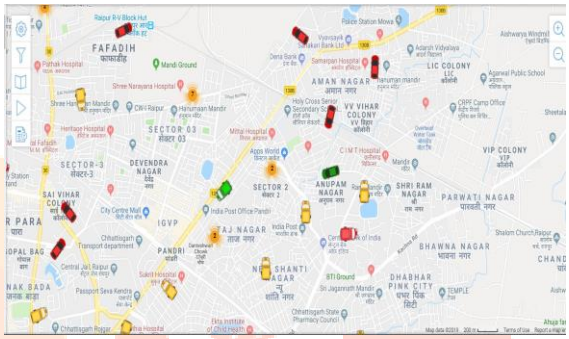
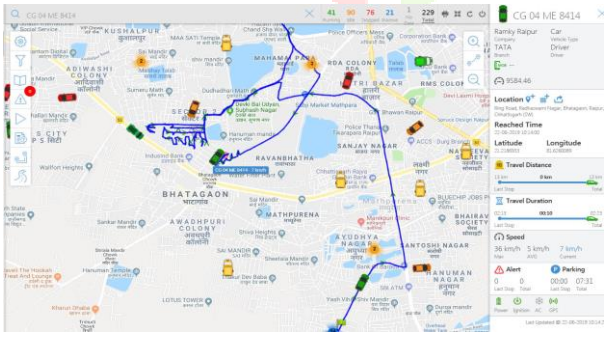


Fig.13: Live tracking of vehicles deployed for collection of Municipal solid waste

*Source: Delhi Solid Waste Management Solutions Ltd

- Vehicle is stationary with engine off.
- Vehicle is stationary with engine on.
- Vehicle is moving.



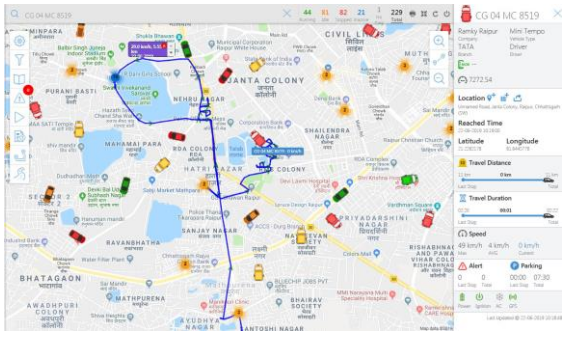


Fig.14: Route of vehicle deployed for collection of Municipal solid waste

*Source: Delhi Solid Waste Management Solutions Ltd.

Fig.15: Location of Garbage Bins and Transfer Stations at various places for Collection of Municipal solid waste
*Source: Prepared by self

Table 9: Location of garbage bins within Raipur municipal limits

S.no	Ward	Bin No.	latitude	longitude	Area
1	24	4	21.24722	81.64995	Ambedkar Chowk
2	24	15	21.25058	81.65136	Gulshan Appartment
3	24	24	21.24722	81.64995	Ambedkar Chowk
4	24	35	21.24767	81.64921	Behind B.P. Pujari
5	24	40	21.24823	81.65104	Amar Chowk
6	24	41	21.25058	81.65136	Gulshan Appartment
7	25	28	21.26019	81.65284	Merlin chowk
8	25	44	21.25676	81.65079	Sahu Hotel
9	25	58	21.25698	81.64988	Dulhan Saree road
10	35	34	21.25447	81.64881	Near LIC Office
11	35	37	21.25447	81.64881	Near LIC Office
12	35	53	21.25518	81.65068	Cloth Market Road, Gate No 1
13	35	138	21.25434	81.84013	Devendra Nagar Square
14	35	88	21.25582	81.64893	Pandri Gate No 1
15	35	73	21.25582	81.64893	Pandri Gate No 4
16	35	133	21.25567	81.64807	IDBI Bank ATM
17	35	101	21.25544	81.64261	Officer Colony
18	35	107	21.25477	81.64132	Officer Colony
19	35	115	21.25449	81.64433	Officer Colony
20	35	100	21.25486	81.64363	Officer Colony
21	35	106	21.25486	81.64363	Officer Colony
22	24	116	21.24996	81.64598	Shyam Plaza
23	24	117	21.26177	81.65151	Chabada House
24	24	79	21.25676	81.65079	Sahu Hotel, Prakash Hosiary
25	23	130	21.25884	81.64299	Guru Duwra (Hora House)
26	24	30	21.24092	81.64367	ST. Paul Church
27	24	31	21.24092	81.64367	ST. Paul Church
28	26	11	21.27536	81.67867	daldalsivini ward no 26
29	26	12	21.28641	81.73565	Genral Accountant Residence
30	26	16	21.28668	81.697	bajrang Basti Ward no 26
31	26	21	21.27795	81.66863	daldalsivini ward no 26
32	26	38	21.28116	81.69561	Ekta Chowk, Saddu
33	26	39	21.28114	81.6956	Ekta Chowk, Saddu
34	26	42	21.28648	81.68121	rajwada city ward no 26
35	26	45	21.29211	81.69726	VIP City
36	26	46	21.28737	81.72583	Genral Accountant Office
37	26	54	21.28706	81.73333	Genral Accountant Residence
38	26	57	21.29137	81.68825	VIP City
39	26	68	21.27614	81.67212	Shivaji Nagar Street No 1
40	26	74	21.27622	81.67085	Daldalsivini near Dubey Colony
41	26	77	21.27752	81.66935	Front of Counciler House
42	26	80	21.27406	81.66666	Near Gurudwara
43	27	3	21.2612	81.67471	VIP Estate, Ward 27
44	27	5	21.26368	81.67401	Ashoka Ratan, Ward 27

*Source: M/S DELHI MSW SOLUTIONS LTD-Raipur

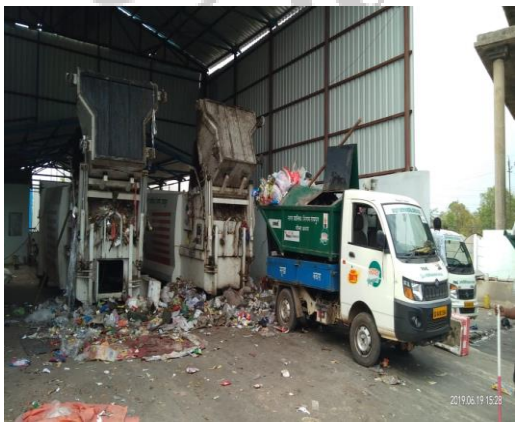
Transfer station – Devpuri, Raipur.

Transfer station – Haat Bazaar, Zone 3, Raipur.

Transfer station – Purena, Zone 4, Raipur.

Transfer station – Ram Nagar, Zone 8, Raipur.

Transfer station – Sanyasi Para, Sub-Station, Khamtarai, Zone 1, Raipur.



Transfer station – Shukyaari Bazaar, Zone 1, Raipur.

2.8.4: Ward wise data of household waste:

The monthly report of municipal waste collected every day is prepared every month, by weighing the total waste collected on daily basis. Further it is segregated in to dry waste, wet waste, inert waste, hazardous waste and recyclable waste.

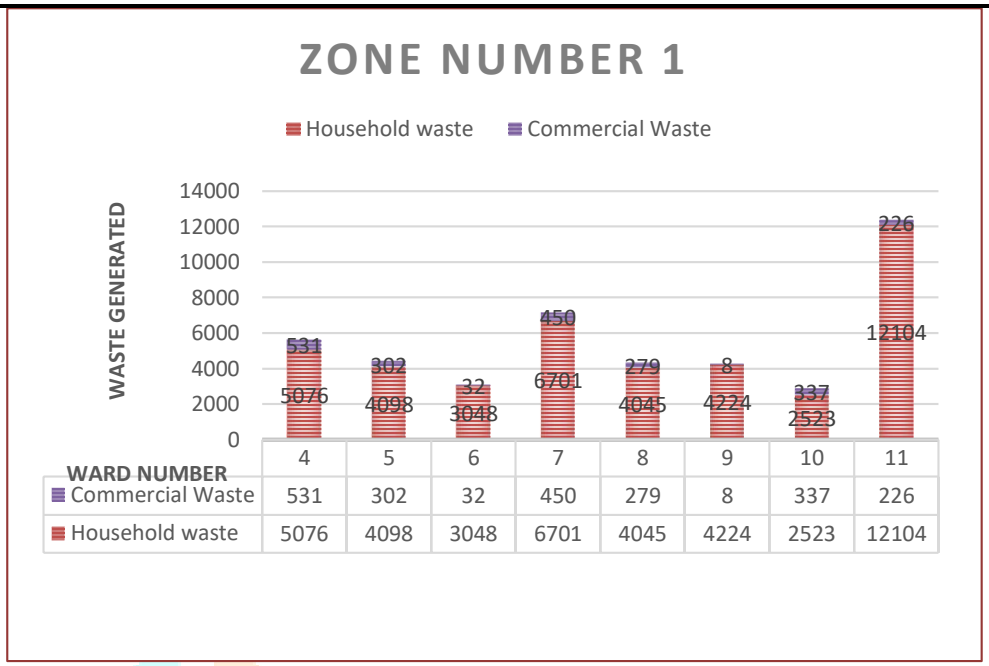


Fig 16 Garbage generated in zone No.1
*Source: Prepared by self

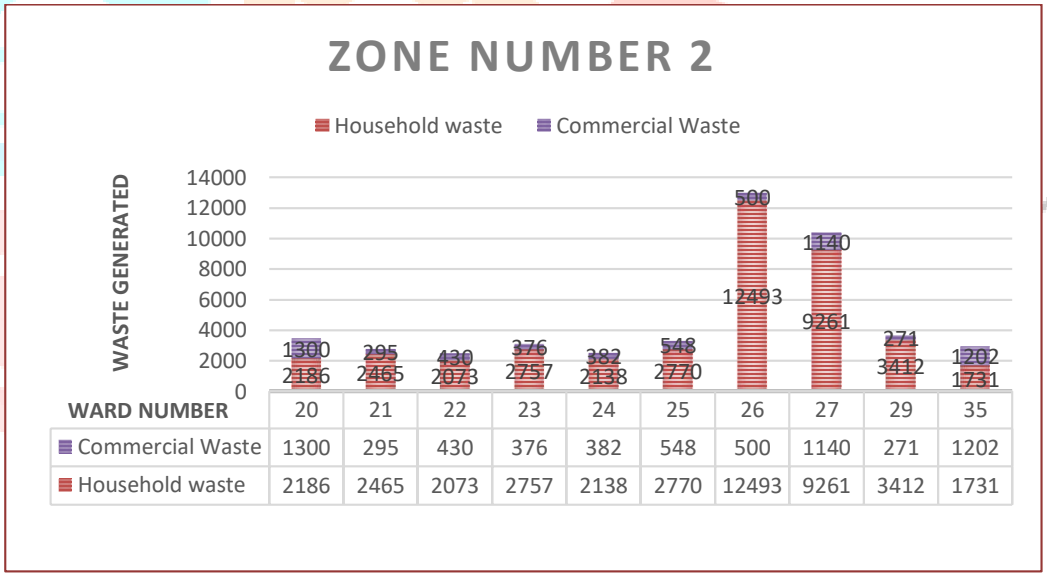


Fig 17 Garbage generated in zone No.2
*Source: Prepared by self

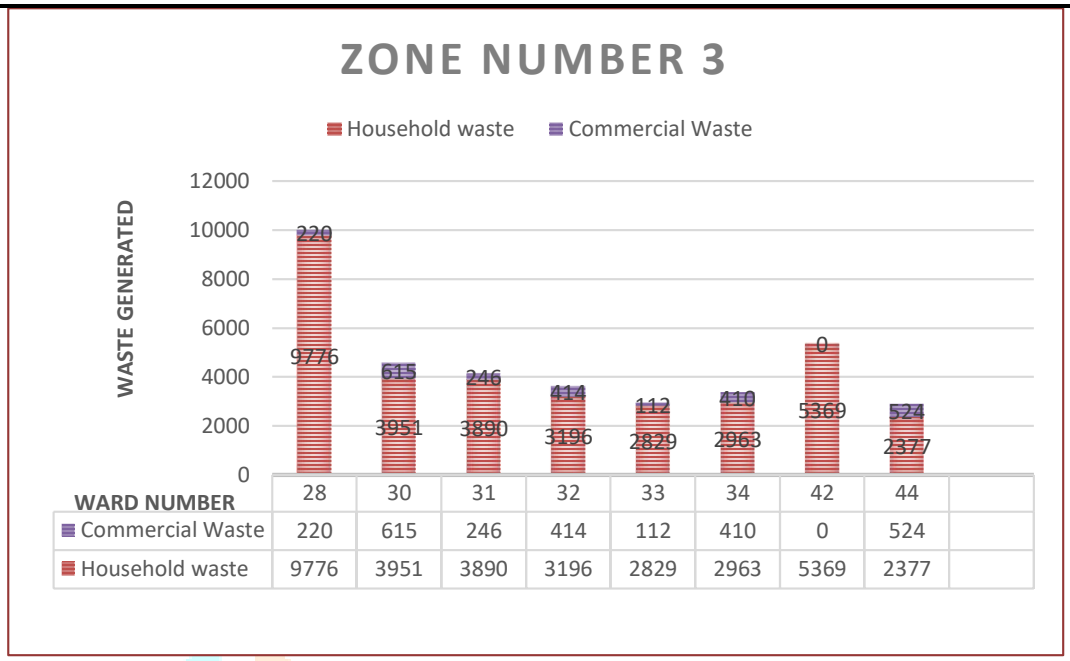


Fig 18 Garbage generated in zone No.3
*Source: Prepared by self

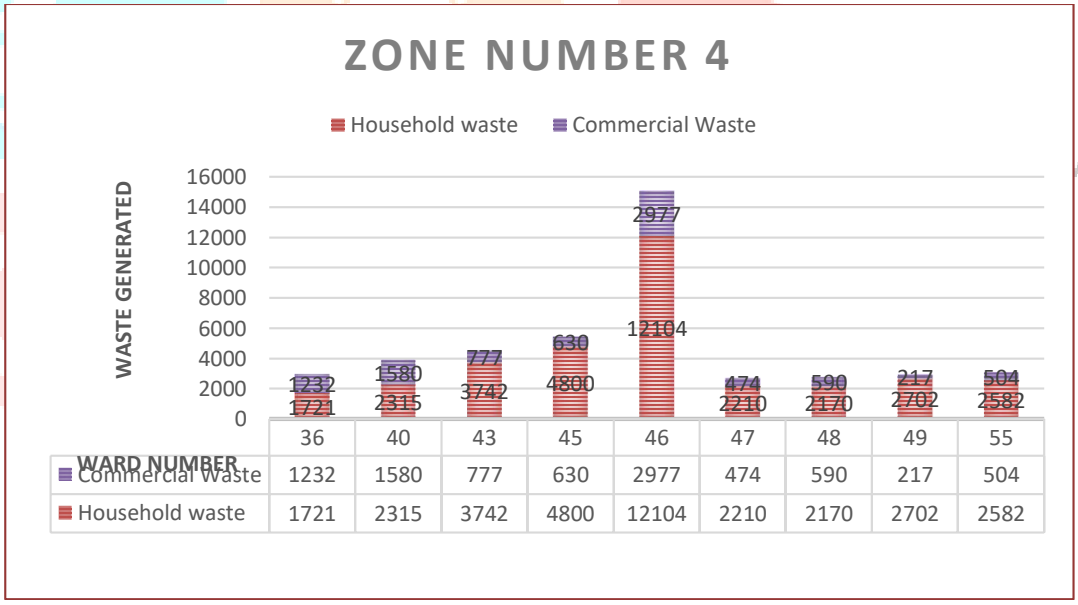
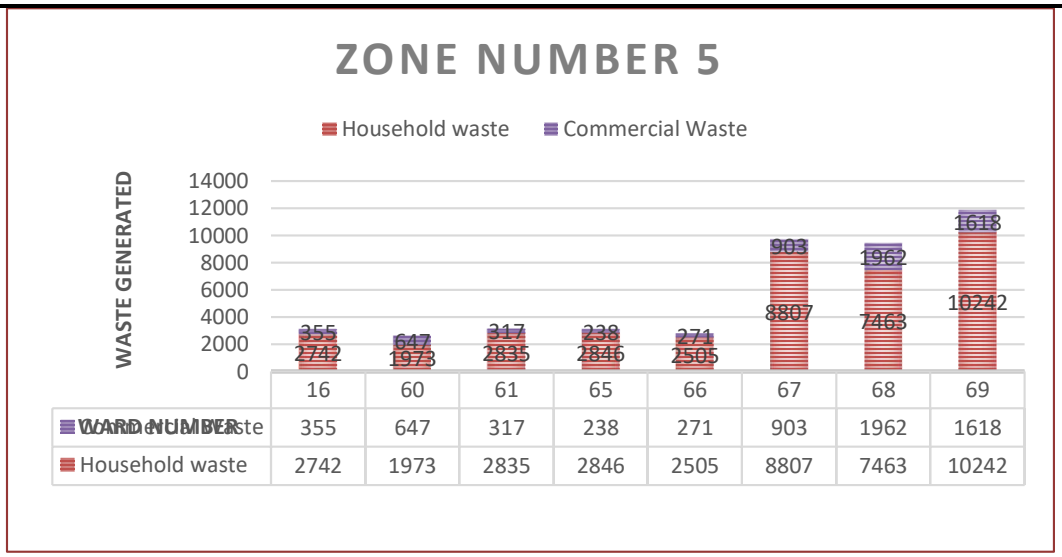
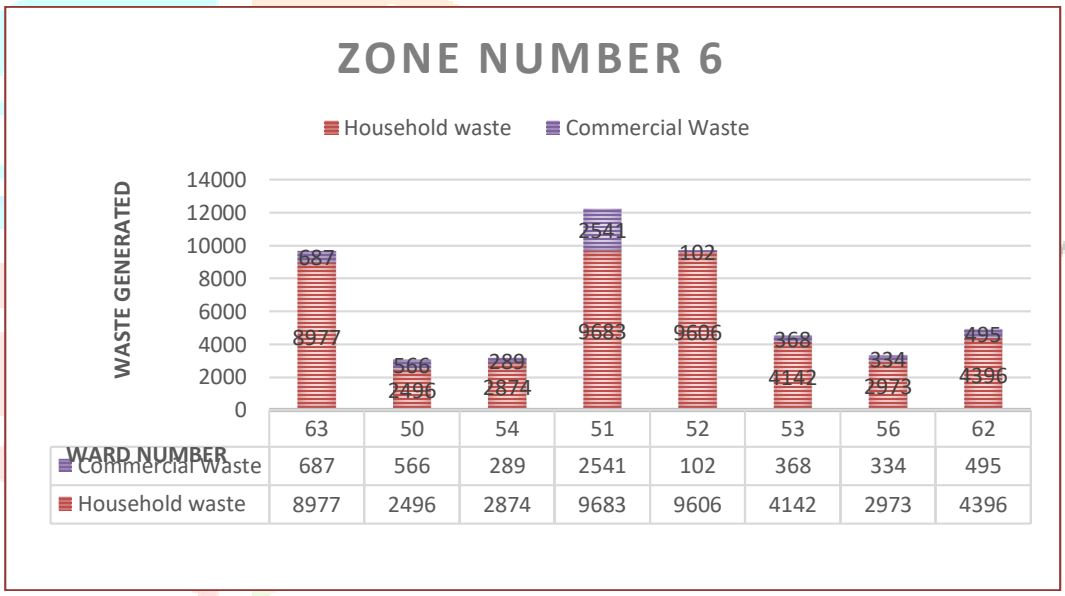


Fig 19 Garbage generated in zone No.4
*Source: Prepared by self



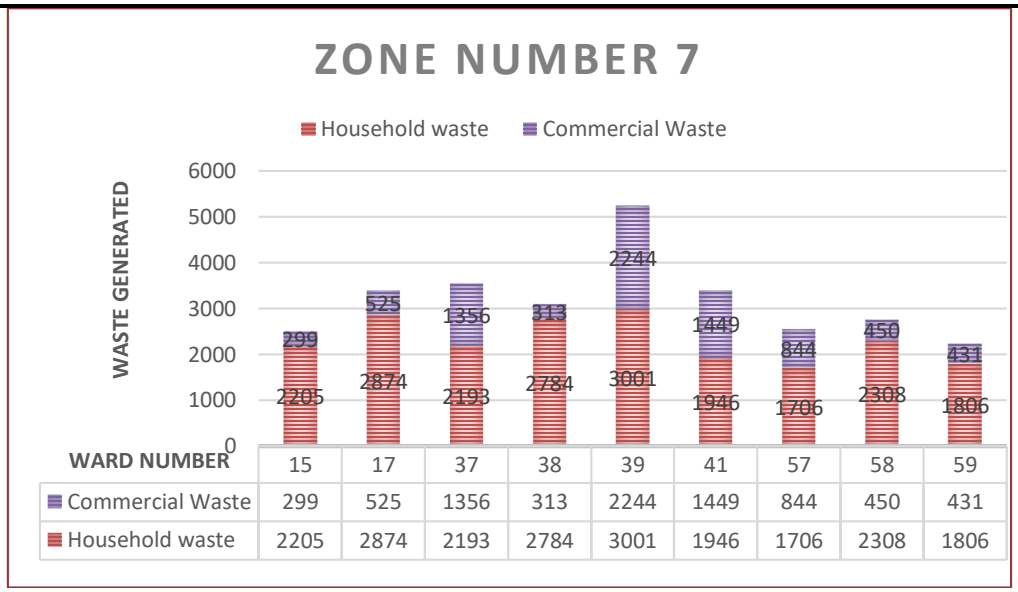
WARD NUMBER	16	60	61	65	66	67	68	69
Commercial Waste	355	647	317	238	271	903	1962	1618
Household waste	2742	1973	2835	2846	2505	8807	7463	10242

Fig 20 Garbage generated in zone No.5
*Source: Prepared by self



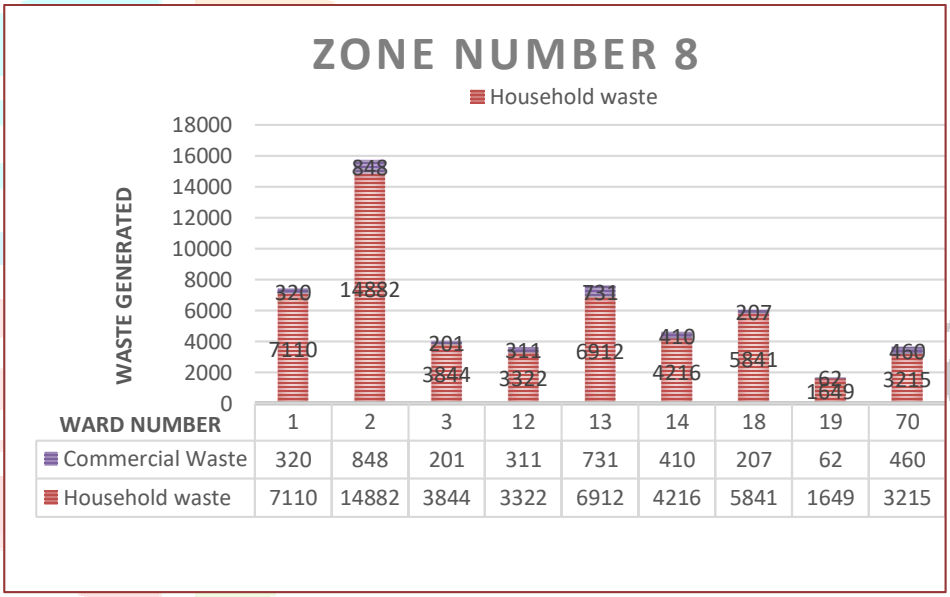
WARD NUMBER	63	50	54	51	52	53	56	62
Commercial Waste	687	566	289	2541	102	368	334	495
Household waste	8977	2496	2874	9683	9606	4142	2973	4396

Fig 21 Garbage generated in zone No.6
*Source: Prepared by self



WARD NUMBER	15	17	37	38	39	41	57	58	59
Commercial Waste	299	525	1356	313	2244	1449	844	450	431
Household waste	2205	2874	2193	2784	3001	1946	1706	2308	1806

Fig 22 Garbage generated in zone No.7
*Source: Prepared by self



WARD NUMBER	1	2	3	12	13	14	18	19	70
Commercial Waste	320	848	201	311	731	410	207	62	460
Household waste	7110	14882	3844	3322	6912	4216	5841	1649	3215

Fig 23 Garbage generated in zone No.8
*Source: Prepared by self

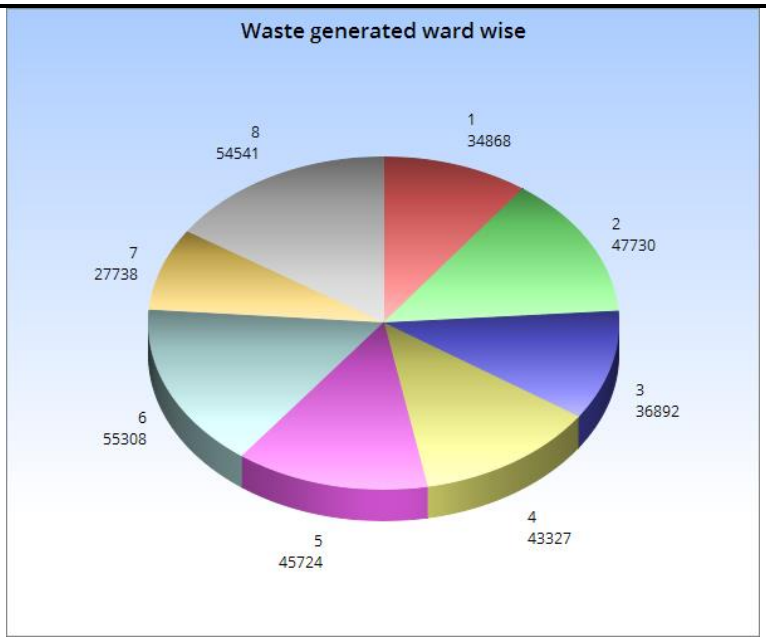


Fig 24 Garbage generated in 8 wards
*Source: Prepared by self

2.8.5 Dumping/Disposal of garbage at Sakri landfill

MSW is collected from various locations on daily basis, and transported to site by DMSWSL, in the mixed form, in an open / closed truck / Lorry, on "as is where is" condition.

The dumping of solid wastes from urban area has begun at Sakri Trenching Ground. Raipur Municipal Corporation is preparing landfill site through scientific method. Management and treatment of the garbage being dumped in this trenching ground will begin from November onwards.

Process of disposal of garbage will be carried out in waste recycling plant. M u n i c i p a l Commissioner Shiv Anant Tayal said that dumping of garbage at Sarona Trenching Ground had been stopped altogether. A solid waste from urban area is now being dumped on landfill site which has been created in Sakri, he said. About 51 vehicles of Municipal Corporation and 37 vehicles of garbage transport agency had transported nearly 400 ton wastes to Sakri site on last Wednesday.

Garbage collection is being done through scientific method at Sakri trenching ground which is sprawling over 68 acre area. Due to collection through scientific method, the harmful elements in waste materials cannot affect quality of underground water source. A cell has been created under scientific landfill for disposal of garbage. The liquid accumulating with the garbage can is experimented in gardening and irrigation.

He said that all zone commissioners were told not to send garbage transporting vehicles to Sarona. They were also told to make sure that waste materials do not fall on roads during transportation to Sakri site.

2.9: PROPOSAL – RDF BASED WASTE TO ENERGY

2.9.1 Introduction

Modern metropolitan cities and urban areas have grown large and wide with population in millions. Rapid urbanization, increasing population and Industrial diversification has led to the generation of enormous volumes of municipal and Industrial waste. This necessitates management of solid waste at generation, storage, collection, transfer and transport, processing, and disposal stages in accordance with the best principles of public health, economics, engineering, conservation, aesthetics, and environmental considerations.

Large population calls for the proper maintenance of the city in terms of infrastructure, traffic management, cleanliness, sanitation, and waste management. Under such circumstances, the twin problems to be addressed are efficient and effective management as well as a scientific approach to it.

Cities are considered as the growth engines, but growth benefit of environmental concern is self-defeating. Even though the urban local bodies utilize major part of its staff and resource for collection and disposal of

solid waste, most of the waste generated from households and commercial establishments is not collected and only a fraction of what is collected receives proper treatment / disposal. It is because these local bodies lack financial and administrative resources apart from inadequate institutional mechanisms. Furthermore, in all metropolitan cities and most large cities in India, about 50 to 60% of the municipal waste collected is dumped in open dumpsites. The rest keeps lying around in municipal bins and roadsides for several weeks to months, becoming an environmental/health hazard.

Waste management in any region includes the following four aspects. They include:

- Proper mechanisms for collection of waste regularly from residential as well as industrial areas.

- A scientific and eco-friendly system of segregation of waste into organic, inorganic, plastic and metal etc.

- Transportation of waste from the place of collection to the destination of disposal.

- A method of disposal of waste in appropriate places following a clean procedure.

Nowadays municipalities are forced to find new methods for waste disposal due to critical environmental problems from landfills and a lack of land availability caused by a fast-growing population and a higher rate of waste production.

Most of the developed countries have been successful in addressing this problem by evolving efficient MSW management system and by providing technological solutions to garbage disposal/treatment.

With the ever-increasing generation of garbage, it is time for immediate and concerted action. The proper disposal of urban waste is not only necessary for the preservation and improvement of public health, but it has an immense potential for resource recovery.

2.9.2 Role of Government for Management of Solid Waste

Government of India has taken several initiatives in the recent years to improve Solid Waste Management (SWM) practices. As per the constitution in India, SWM is a state subject and it is the primary responsibility of state government to ensure that, appropriate SWM practices are introduced in all the cities and towns in the state. The role of Government of India is broadly to formulate policy guidelines and provide technical assistance to the states / cities wherever needed.

2.9.3 Initiatives by Government Organizations

In the recent years, SWM system in India has received considerable initiatives from several Government organizations. Some of the key initiatives are discussed below:

a. The first initiative was taken by Supreme Court of India in 1998, to form a committee to study and provide report on the status of SWM in Indian cities. The report is highlighted with status of collection, storage, transportation, processing, and disposal of MSW.

b. As a 2nd initiative, the Ministry of Environment and Forests (MoEF), Government of India, published "Municipal Solid Waste Rules 2000 (MSW rules 2000). The rules dictate the duties and responsibilities of various government organizations, starting from Village Panchayats to all the ministries comes under Government of India.

c. Swachh Bharat Mission (SBM) was launched in the year of 2014, with a vision to achieve a clean India as a tribute to the father of the nation, Mahatma Gandhi, on his 150th birth anniversary, in 2019. Municipal Solid Waste Management is the main component of SBM.

d. The latest initiative is the concept of partnership between Solid Waste Management (SWM) and Swachh Bharat Mission (SBM). A draft SWM rules were published in the year of 2015, inviting public objections and suggestions. The suggestions / objections received were examined by the Working Group in the Ministry. Based on the recommendations of the Working Group, the Environment Ministry has revised the SWM rules in the year of 2016 i.e., MSW 2016 rules, which dictates a broad guideline for MSW handling and disposal.

2.9.4 Waste to Energy

Waste to Energy (WTE) is the sum of processes that produce electric energy from waste. Nowadays it has also become a safe and favorable form of energy recovery from the environmental point of view. As such, it is currently regarded as an essential element in the mechanism of integrated waste management, in all industrialized countries.

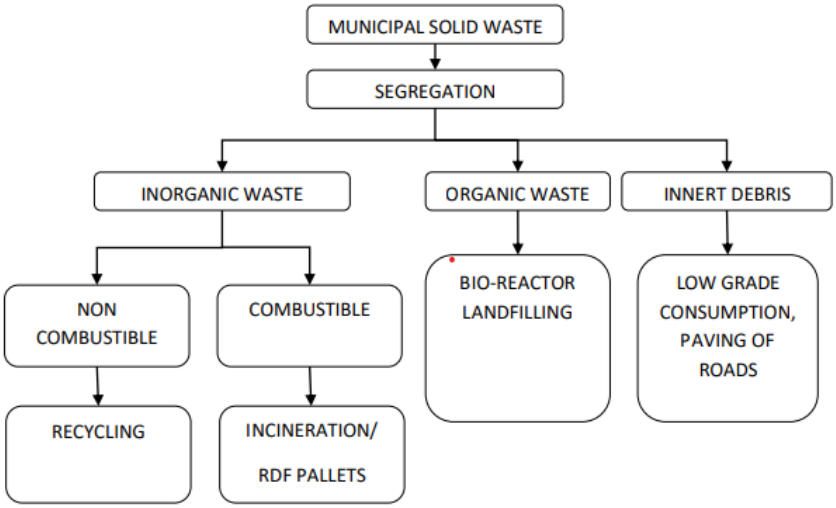


Fig 25: Hierarchy of municipal solid waste management
*Source: Google Image.

Waste-to-energy provides the fourth "R" in a comprehensive solid waste management program: Reduction, Reuse, Recycling, and energy Recovery.

3.0 Proposal by Raipur Municipal Corporation

After understanding all the details of garbage collection and disposal of municipal solid waste management of Raipur it is proposed to install an RDF based WTE plant at Sakri which will be a part of Integrated MSW Management Project which can be assigned by Raipur Municipal Corporation.

The main objective of the proposed Waste management Facility is to collect 100% of MSW generated in the city limits and to dispose-off the same through a most scientific, widely proven and productive disposal and install the RDF based Waste to Energy plant
which will be located at Sakri village, Raipur, Chhattisgarh. It is about 18km from Raipur city. The nearest airport is Swami Vivekananda Airport, Raipur located 20km from project site. The nearest railway station is Raipur Junction Railway Station located 15 km from the project site. The site is well accessible at radius of 3 km for NH – 130B highway which is starting from Raipur.

3.1 Space Availability

Fig 26: Proposed site for RDG base waste to energy plant
*Source: Google Image.

Adequate land is available in the identified area for locating the WTE plant. Considering various advantages like continuous vehicle movement for fuel, easy access to the fuel storage pit from the road without disturbance to the plant operation, adequate space for locating all the associated systems of the plant and

machinery, the proposed layout has been decided. Adequate space is available for construction activities during installation of the project.

3.2 Topographical and Geological Aspects

The land available is not flat thus varying levels will be adopted for the various equipment of the plant. Hence cutting and filling of land will be minimum. The soil bearing capacity is 20 t/m² at a depth of about 1.5 m will be considered for carrying out the foundation design of the power plant equipment.

3.3 Rail and Rail Facilities

The nearest railway station is Raipur Railway Station, which is at about 17 km from the site. The plant is well connected with the road network and nearest Airport is Raipur Airport.

3.4 Availability of RDF for Power Plant

Municipal solid waste collected from the collection points. It is proposed to get the MSW through trucks to the plant. MSW will also be collected from the surrounding areas. Hence there will not be any difficulty in the availability of the MSW to site and RDF for power plant operation.

3.5 Interconnection with Grid

The power plant will be interconnected with CSPDCL grid. The power plant will export the surplus power after meeting the power plant auxiliary consumption, to the CSPDCL sub-station at Kachana.