# PLANNING PROPOSALS FOR SOLID WASTE MANAGEMENT OF BHOPAL CITY

**A DISSERTATION**

***Submitted in partial fulfillment of the requirements for the award of the degree of***

**MASTER OF URBAN AND RURAL PLANNING**

***By***

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## CANDIDATE'S DECLARATION

I hereby declare that the work, which is presented by me in the dissertation entitled **"Planning Proposals for Solid Waste Management of Bhopal city"**, in partial fulfillment of the requirements for the award of the degree of **Master In Urban and Rural Planning** submitted to the Department of Architecture and Planning , Indian Institute of Technology Roorkee, Roorkee, is an authentic record of my own work carried out during the period from August 2006 to June 2007 under the supervision of **Dr. Nalini Singh** and **Dr. Ashutosh Joshi**, Department of Architecture and Planning, IIT Roorkee, Roorkee.

The matter embodied in this dissertation has not been submitted by me for the award of any other degree.

Date: June, 2007
Place: Roorkee

**(Jitendra Singh Saharwar)**

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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# ABSTRACT

In Bhopal, the collection, transportation and disposal of MSW are unscientific and chaotic. Uncontrolled dumping of wastes on outskirts of city has created overflowing landfills that are not possible to reclaim because of the haphazard manner of dumping. It has created serious environmental implications in terms of ground water pollution and contributed to global warming. Solid Waste Management is one of the important areas which is neglected during the years. Municipal Authority is unable to provide a fool-proof system to tackle these problems.

The main objectives of this dissertation are the investigation of current solid waste management practices and give proposals for efficient solid waste management for the Bhopal city area. Literature on solid waste management in Bhopal has been reviewed and data analysed. The results show a rapid increase in the total amount of municipal solid wastes and significant changes in their composition. Increasing population is one of the major factor for it. The total solid waste generation has reached 0.43 kg per capita per day.

Waste analysis indicated a high percentage of food wastes and other compositeable products. Different waste treatment options for municipal solid waste have been studied and the factors affecting the important management issues in the operation of Bhopal's solid waste management system are discussed. Key design data and other useful information selected from a variety of reliable sources are presented.

Two new sites are proposed for municipal solid waste disposal and treatment. The adoption of modern waste management practices should be emphasized in order to achieve greater efficiency. Composting, both aerobic and anaerobic options, are available to the city for

scientific disposal of waste in future. Finally, recommendations have been given to enable the municipal corporations to run the waste services efficiently.

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*Jitendra Singh Saharwar*

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# CHAPTER 1

# INTRODUCTION

# CHAPTER 1: INTRODUCTION

## 1.1 BACKGROUND

Waste production is an inevitable phenomenon of all cities. When waste is produced more then it has to be managed more efficiently. The large city produces more waste. So in larger city management of solid waste is more desired. The production of waste is directly proportional to population. So in dense area where large numbers of people live in small area the waste will be produced more in comparison to same area having lesser population.

Due to rapid growth in population cities are growing larger and denser. Cities are getting polluted due to the production of various type of wastes produced in the city. Among the pollutants solid waste has its major role.

Unfortunately in India, the issue of solid waste management has not attained its due attention. Corrupt, inefficient municipal bodies don't pay much attention to this problem. Sometimes infectious diseases spread rapidly claming number of lives. In the spread of the infectious diseases the dirt in the city acts as catalyst. Solid waste is in the residential areas act as birth place of harmful virus and bacteria. The health and environment of city depends on cleanliness of the city.

## 1.2 AREA OF STUDY

Municipal Area of Bhopal, it's also called the city of lakes, is the capital of the state of Madhya Pradesh. BMC has total no. of wards 66 having population 14, 23,602 (Census 2001) its area is 285 Sq. Km

## 1.3 *PROBLEM IDENTIFICATION*

Healthy city is a living, breathing, growing, changing complex organism. It is a place where its citizens recognize the physical, mental, social and spiritual nature of health and work together to create conditions that promote healthy living. The exact quantity and characteristic of waste produce in Bhopal is not known, but the BMC reports that 600T/day of solid waste is generated in the urban area. Most waste dumped on open land or outside the containers. The BMC reports that 60% of the city area is cleaned and swept daily, 30% twice per week and 10% fortnightly. At present municipal waste is crudely dumped at the Bhanpur village trenching ground, at about road and during the rainy season 16 km from the city. There is no proper access and most of the refuse vehicles do not reach the disposal site.

## 1.4 SOLID WASTE MANAGEMENT ISSUES OF BHOPAL

Generation of waste is inevitable but an effective, efficient and sustainable waste management system is rare in our society. Solid Waste Management is an obligatory function of local bodies. Unfortunately this function of municipal body is accorded low priority resulting in lack of inter-sectoral coordination within the agencies and low output of employees engaged in this activity. Household and commercial waste is often referred together as Municipal Solid Waste (MSW). Clean air, water and land are clearly essential to civilized society, but this begs the question how clean; is clean at what cost and who pays? Similarly we need to ask who- makes our city dirty and who pays for it and who suffers? Integrated Waste Management (IWM) system combines, waste collection, treatment and disposal methods with the objectives of achieving environmental benefits, economic optimization and societal acceptability. An integrated approach to solid waste management can deliver environmental, social and economic sustainability.

In view of the notification of the Ministry of Environment and Forests Government of India, it is mandatory for all municipal bodies to ensure environment friendly methods of waste management.

| | |
|---|---|
| MSW Generated | 600mt/day |
| MSW Collected | 450mt/day (around 75%) |
| Compost Plant | 120mt/day (run @ 60% cap) |

## 1.5 AIM

To provide an efficient solid waste management system for Bhopal city

## 1.6 OBJECTIVES

1. To study the existing solid waste scenario of Bhopal City
    i. Existing function of Municipal Corporation
    ii. Solid waste generation data
    iii. Sources of solid waste
    iv. Existing practices of collection and disposal
2. To study and analyze the best practices already adopted for the management of the Solid Waste in other cities in India and abroad.
3. Impact of solid waste on environment.
4. Problem in existing practices for solid waste disposal in Bhopal.
5. Providing solution for existing practices.

## 1.7 SCOPE

The thesis will provide guideline and proposal which will help to evolve an efficient, environmentally viable Solid Waste Management system that could be functional in the existing fabric of the city of Bhopal.

## 1.8 LIMITATION

1. The study would be within the municipal boundaries of Bhopal Municipal Corporation.
2. The study would be limited to disposal of solid waste.

3. The study is based on the information obtained from Bhopal Municipal Corporation and other sources.

## 1.9 METHODOLOGY

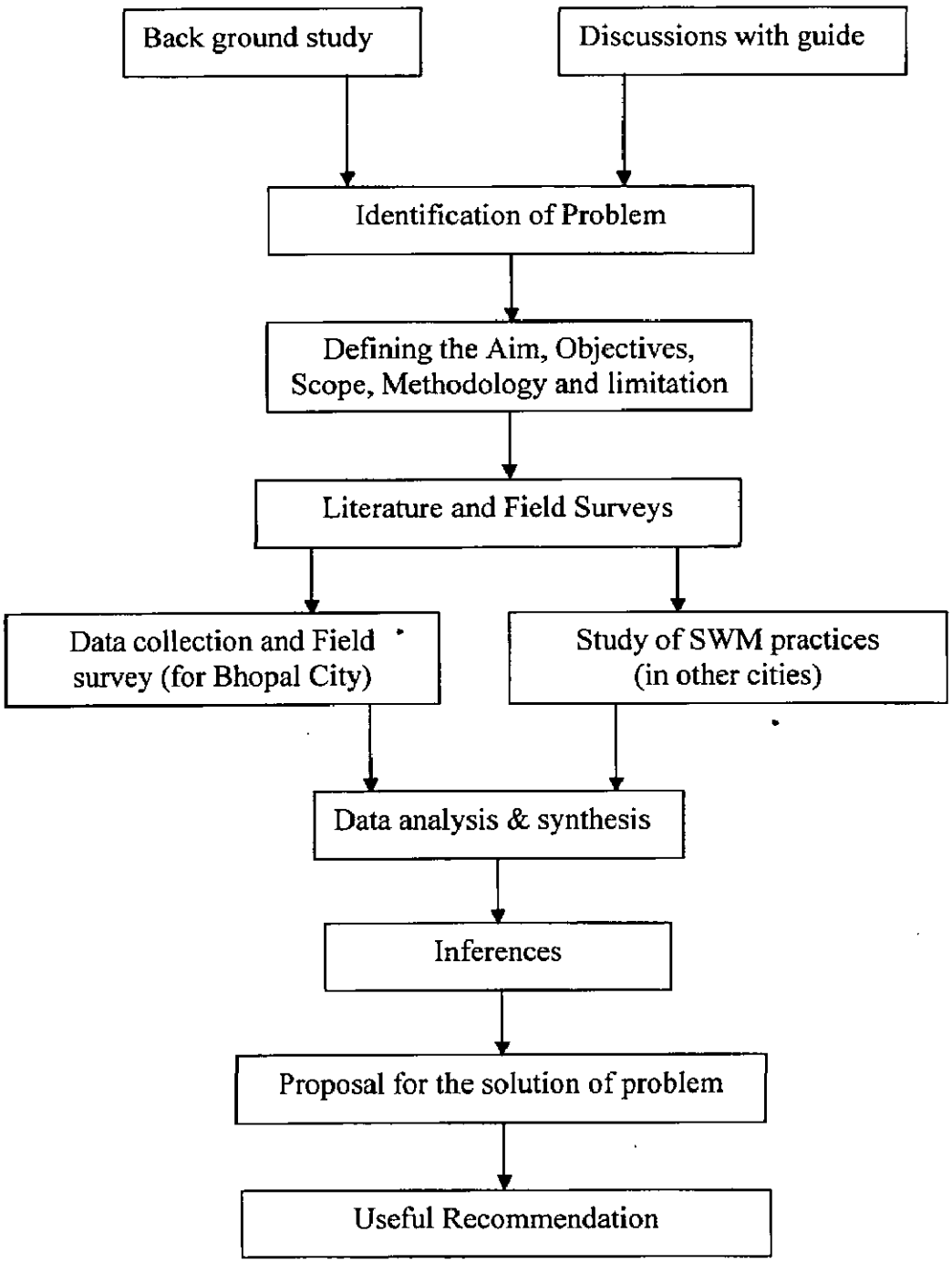



Figure 1.1 Methodology

# CHAPTER 2

# LITERATURE STUDY

# CHAPTER 2: LITERATURE STUDY

## 2.1. WHAT IS WASTE?

**"Waste"** includes-

(a) any substance which constitutes a scrap material or an effluent or other unwanted surplus substance arising from the application of any process; and

(b) any substance or article which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled;

## 2.2. CATEGORIES OF WASTE

### 2.2.1. Waste Category 1

Waste which will not decompose or will decompose only very slowly Subsoil – Topsoil – Clay – Concrete – Hard core – Brickwork – Stone – Sand – Silica (Excluding Finely Powdered Waste : Category 3) – Excavated Road Metal – Glass – Pottery – China – Enamels – Ceramics – Mica and Abrasives – Mineral Processing Waste.

### 2.2.2. Waste Category 2

Materials, which can be decompose and may consist of soluble matter, which could cause pollution if allowed to enter water systems. Ferrous Metals – Non Hazardous Nonferrous Metals – Plastic – Leather – Natural Man-made Fibers – Wood and Wood Products – Paper Plasterboard – Ash – Clinker – Cement – Calcium Carbonate – Gypsum – Silicate Slag – Boiler Scale – Cardboard. Vegetable Matter and Food – Processing Waste – Animal Carcasses – Cellulose Waste – Household Waste and similar Waste from Commercial and Industrial Premises – Floor Sweepings – Rubber and Latex – Soap – Dry Sewage and Sludge – Shot Blasting Residues .

### 2.2.3. Waste Category 3

This category includes chemicals and chemical compounds which is not Special Waste but which may require specialist control measures in order to prevent harm to the environment or risk to human health.

### 2.2.4. Waste Category 4

This category includes chemicals and chemical compounds which are Special Wastes. This includes chemicals, which may cause death or serious tissue damage, chemicals with a flash point of less than 21°C, and prescription only medicines.

### 2.2.5. Clinical Waste 5

This waste including human tissue – body fluids – swabs – dressings – needles – sharp instruments

## 2.3. DEFINITIONS OF SOLID WASTES

There are many terms, which relate to the types and sources of wastes and these too must defined. Based on the source, origin and type of waste a comprehensive classification is describe below:

### 2.3.1. Municipal Waste

Municipal waste includes wastes resulting from municipal activities and services such as street waste, dead animals, market waste and abandoned vehicles. However, the term commonly applied in a wider sense to incorporate domestic wastes, institutional wastes and commercial wastes.

There are five broad categories of MSW:

a. Biodegradable waste: food & kitchen waste, green waste, paper (can also be recycled)
b. Recyclable material: paper, glass, bottles, cans, metals, certain plastics, etc
c. Inert waste: construction and demolition waste, dirt, rocks, debris
d. Composite wastes: Waste clothing, Tetra Pak, Waste plastics such as toys
e. Domestic hazardous waste & toxic waste: medication, paints, chemicals, light bulbs, tubes, spray, fertilizer and pesticide containers, batteries, shoe polish, etc.

### 2.3.2. Domestic/Residential Waste

This category of waste comprises the solid wastes that originate from single and multi-family household units. These wastes are generate as a consequence of household activities such as cooking, cleaning, repairs, hobbies, redecoration, empty containers, packaging, clothing, old books, writing/new paper, and old furnishings. Households also discard bulky wastes such as furniture and large appliance, which cannot be repair and used.

### 2.3.3. Commercial Waste

Included in this category are solid wastes that originate in offices, wholesale and retail stores, restaurants, hotels, markets, warehouses and other commercial establishments. Some of these wastes are further classifies as garbage and others as rubbish.

### 2.3.4. Institutional Waste

Institutional wastes are those arising from institutions such as schools, universities, hospitals and research institutes. It includes wastes, which classified as garbage and rubbish, as well as wastes, which considered hazardous to public health and to the environment.

### 2.3.5. Garbage

Garbage is the term applied to animal and vegetable wastes resulting from the handling, storage, and sale, preparation, cooking and serving of food. Such wastes contain putrescible organic matter, which produces strong odours and therefore attracts rats, flies and other vermin. It requires immediate attention in its storage, handling and disposal.

### 2.3.6. Rubbish

Rubbish is a general term applied to solid wastes originating in households, commercial establishments and institutions, excluding garbage and ashes.

### 2.3.7. Ashes

Ashes are the residues from the burning of wood, coal, charcoal, coke and other combustible materials, for cooking and heating in houses, institutions and small industrial establishments. When produced in large quantities at power generating plants and factories these wastes classified as industrial wastes. Ashes consist of a fine powdery residue, cinders and clinker often mixed with small pieces of metal and glass.

### 2.3.8. Bulky Wastes

In this category are bulky household wastes, which cannot be accommodate in the normal storage containers of households. For this reason, they require special collection. In developed countries, bulky wastes are large household appliances such as cookers, refrigerators and washing machines as well as furniture, crates, vehicle parts, wood, trees and branches. Metallic bulky wastes sold as scrap metal but some portion is disposed of at sanitary landfills.

### 2.3.9. Street Sweeping

This term applies to wastes that collected from streets, walkways, alleys, parks and vacant lots. In the more affluent countries manual street sweeping has virtually disappeared but it still commonly takes place in developing countries, where littering of public places is a far more widespread and acute problem. Mechanized street sweeping is the dominant practice in the developed countries. Street wastes include paper, cardboard, plastic, dirt, dust, leaves and other vegetable matter.

### 2.3.10. Dead Animals

This term applied dead animals, which die naturally or accidentally killed. This category does not include carcass and animal parts from slaughterhouses, which regarded as industrial wastes. Dead animals divided into two groups, large and small. Among the large animals are horses, cows, goats, sheep, hogs and the like. Small animals include dogs, cats, rabbits and rats. The reason for this differentiation is that large animals require special equipment for lifting and handling during their removal. If not collected promptly, dead animals are a threat to public health because they attract flies and other vermin as they putrefy. Their presence in public places is particularly offensive and emits foul smell from the aesthetic point of view.

### 2.3.11. Construction and Demolition Wastes

Construction and demolition wastes are the waste materials generated by the construction, refurbishment, repair and demolition of houses, commercial buildings and other structures. It mainly consists of earth, stones, concrete, bricks, lumber, roofing materials, plumbing materials, heating systems and electrical wires and parts of the general municipal waste stream, but when generated in large amounts at building and demolition sites, it generally

removed by contractors for filling low-lying areas and by urban local bodies for disposal at landfills.

### 2.3.12. Industrial Wastes

In the category are the discarded solid material of manufacturing processes and industrial operations. They cover a vast range of substances, which are unique to each industry. For this reason, they considered separately from municipal wastes. It should be note, however, that solid wastes from small industrial plants and ash from power plants are frequently disposed of at municipal landfills.

### 2.3.13. Hazardous Wastes

Hazardous wastes defined as wastes of industrial, institutional or consumer origin, which, because of their physical, chemical or biological characteristics are potentially dangerous to human and the environment. In some cases although the active agents may be liquid or gaseous, they classified as solid wastes because they are confine in solid containers. Typical examples are solvents, paints and pesticides whose spent containers frequently mixed with municipal wastes and become part of the urban waste stream. Certain hazardous wastes cause explosions in incinerators and fires at landfill sites. Others, such as pathological wastes from hospitals and radioactive wastes, require special handling at all time. Good management practice should ensure that hazardous wastes are stored, collected, transported and disposed off separately, preferably after suitable treatment to render them innocuous.

### 2.3.14. Sewage Wastes

The solid by-products of sewage treatment classified as sewage wastes. They are mostly organic and derive from the treatment of organic sludge from both the raw and treated

sewage. The inorganic fraction of raw sewage such as grit is separate at the preliminary stage of treatment, but because it entrains putrescible organic matter, which may contain pathogens, must be buried/disposed off immediately. The bulk of treated, dewatered sludge is useful as a soil conditioner but invariably its use for this purpose is uneconomical. The solid sludge therefore enters the stream of municipal wastes unless special arrangements are make for its disposal.

**Table: 2.1 The type of waste we generate and the approximate time it takes to degenerate**

| Type of litter | Approximate time it takes to degenerate the litter |
|---|---|
| Organic waste such as vegetable and fruit peels, leftover foodstuff, etc. | a week or two |
| Paper | 10–30 days |
| Cotton cloth | 2–5 months |
| Wood | 10–15 years |
| Woolen items | 1 year |
| Tin, aluminum, and other metal items such as cans | 100–500 years |
| Plastic bags | One million years? |
| Glass bottles | undetermined |

Source: India infrastructure report

**Table: 2.2 Pollution from Solid Waste**

| WASTE TYPES | AIR | WATER | LAND |
|---|---|---|---|
| **AGRICULTURE** | Dust<br>Open burning<br>Odour | Run-off | Manure<br>Pruning<br>Harvest residue |
| **MINING** | Fine dust<br>burning | Mine aids<br>Salts | Tailings<br>Strip-mining<br>Overburden |

| | | | |
|---|---|---|---|
| **INDUSTRY** | Incineration<br>Open burning<br>Odour | Coastal and other<br>water pollution<br>Landfill pollution | Dumps<br>Junkyards |
| **MUNICIPAL** | Incineration<br>Open burning<br>Odour | Incineration<br>Land fills<br>Sea dumps | Land fills<br>Open dumps |

Source: India infrastructure report

## 2.4. SOLID WASTE MANAGEMENT

Rotting organic refuse is not only aesthetically unpleasant but attracts predators, and carried by these, bacteria thrive in warm, moist, rotting garbage spreading malaria, viral fever (dengue), plague etc. The incident of plague in Oct 1994 in Surat city pressed everyone to think over SW problem. If this problem not tackled within preventive time, it may create other dreadful, hazardous and incurable problems.

The proper disposal of SW derived from any source is dependent on management practices. A management system must be developed and described that incorporates many diverse factors. Those factors considered may include economics, engineering, land use ordinances, environmental regulations, geography and sociology. A Solid Waste Management (SWM) system that could optimize these parameters would be design based on figure 2.1

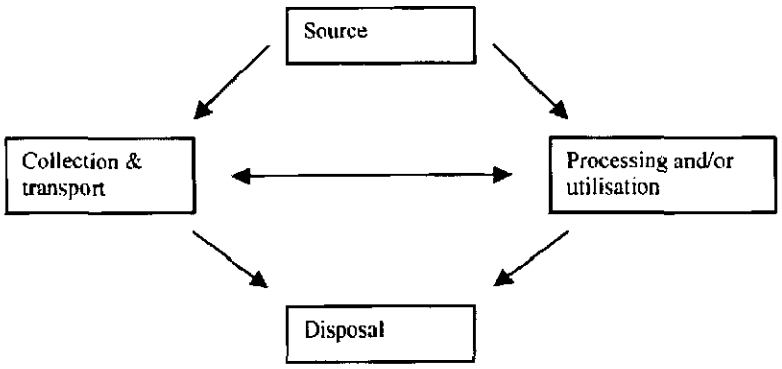



Figure 2.1 Solid Waste Management Systems

SWM involves interplay of six functional elements- generation of wastes, storage, collection, transfer and transport, processing, recovery and disposal in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics and other environment considerations and, that also is responsive to public attitude.

## 2.5. SOLID WASTE MANAGEMENT PRACTICES IN INDIA

### 2.5.1. General

Urbanization is now becoming a global phenomenon, but its ramifications are more pronounce in developing countries. Natural growth of population, reclassifications of habitation and migration trends are important in urban population in India. The population of urban India was 285.35 million as per 2001 census, which accounts for 27 per percent of the total population. Global experience shows that when a country is urban population reached almost 25% of the overall population (as in the case of India), the pace of urbanization accelerates.

Due to rapid urbanization and uncontrolled growth rate of population, SWM has become acute in India. Municipal bodies in India render SWM services. However, it is an essential service, it is not attaining proper priority, which it deserves and services are poor. NEERI has provided extensive services to municipal bodies in India to improve their MSWM system.

Solid waste management is one among the basic essential services provided by municipal authorities in the country to keep urban centers clean. However, it is among the most poorly rendered services in the basket the systems applied are unscientific, outdated and inefficient; population coverage is low; and the poor marginalized. Waste is litter all over leading to in sanitary living conditions. Municipal laws governing the urban local bodies do

not have adequate provisions to deal effectively with the ever-growing problem of solid waste management.

The present system of MSWM in India can be depicting by Figure. Waste generated at households is generally accumulated in small containers (often-plastic buckets) until such time, that there is sufficient quantity to warrant disposal into community bins Containers used for household storage of solid wastes are of many shapes and sizes, and are fabricated from a variety of materials. The type of the container generally reflects the economic status of its user (i.e. the waste generator). Waste segregation at source is not practice.

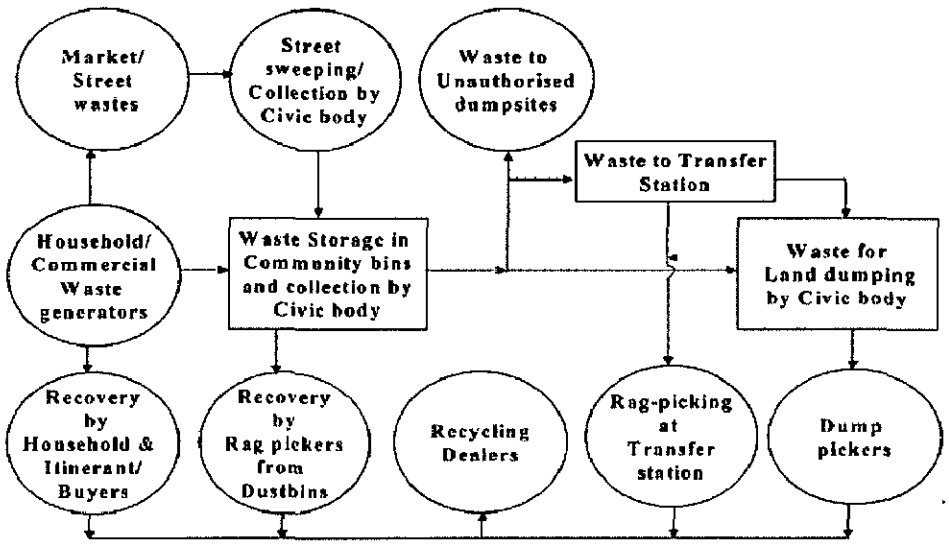



Figure 2.2 Schematic of Solid Waste Management Practice in India

### 2.5.2. Quantum and Nature of Solid Waste

Per capita waste generation ranges between 0.2 kg and 0.6 kg per day in the Indian cities amounting to about 1.15 lakh MT of waste per day and 42 million MT annually. In addition, as the city expands, average per capita waste generation increases (Tables 2.3 and 2.4).

**Table 2.3 Waste Generation per Capita in Indian Cities**

| Population range(in million) | Average per capita waste generation gms/capita/day |
|---|---|
| 0.1 to 0.5 | 210 |
| 0.5 to 1.0 | 250 |
| 1.0 to 2.0 | 270 |
| 2.0 to 5.0 | 350 |
| 5.0 plus | 500 |

Source: India infrastructure report

**Table 2.4 Waste Quantities and Waste Generation Rates in 1 million plus Cities and State Capitals**

| CITY | Waste quantity generated (MT/d) | Waste generation rate(kg/c/d) |
|---|---|---|
| Vadodara | 157.33 | 0.12 |
| Kohima | 12.48 | 0.16 |
| Nashik | 200 | 0.19 |
| Lucknow | 474.59 | 0.21 |
| Guwahati | 166.25 | 0.21 |
| Gandhinagar | 43.62 | 0.225 |
| Jabalpur | 216.19 | 0.23 |
| Ranchi | 208.27 | 0.246 |
| Nagpur | 503.85 | 0.25 |
| Dehradun | 131 | 0.29 |
| Raipur | 184.27 | 0.3 |
| Indore | 556.51 | 0.35 |
| Bhubaneshwar | 234.46 | 0.36 |
| Patna | 510.94 | 0.37 |
| Ahmedabad | 1302 | 0.37 |
| Faridabad | 448.01 | 0.38 |
| Dhanbad | 77.12 | 0.387 |
| Bangalore | 1669 | 0.39 |
| Bhopal | 574.07 | 0.4 |
| Agartala | 77.36 | 0.4 |
| Asansol | 206.65 | 0.425 |

| | | |
|---|---|---|
| Daman | 15.2 | 0.43 |
| Meerut | 490 | 0.46 |
| Agra | 653.57 | 0.49 |
| Allahabad | 509.24 | 0.51 |
| Ludhiana | 734.37 | 0.53 |
| Jamshedpur | 387.98 | 0.59 |
| Visakhapatanam | 600 | 0.62 |

Source: India infrastructure report

**Notes:** MT/d metric tonnes per day, kg/c/d: kilograms per capita per day.

The waste generation rates in India are lower than the low-income countries in other parts of the world and much lower compared to developed countries. However, lifestyle changes, especially in the larger cities, are leading to the use of more packaging material and per capita waste generation is increasing by about 1.3 per cent per year. With the urban population growing at 2.7 per cent to 3.5 per cent per annum, the yearly increase in the overall quantity of solid waste in the cities will be more than 5 per cent. The Energy and Resources Institute (TERI) has estimated that waste generation will exceed 260 million tones per year by 2047 more than five times the present level. Cities with 100,000 plus population contribute 72.5 per cent of the waste generated in the country as compared to other 3955 urban centers that produce only 17.5 per cent of the total waste.

**Table 2.5 Waste Generation in Class 1 Cities with Population above 100,000**

| **Type of cities** | **Tones/day** | **% of total garbage** |
|---|---|---|
| The 7 mega cities | 21,100 | 18.35 |
| The 28 metro cities | 19,643 | 17.08 |
| The 388 class 1 town | 42,635 | 37.07 |
| Total | 83,378 | 72.50 |

Source: MOUD (2005)

Physical and chemical characteristics of solid waste in Indian cities vary depending on population size and geographical location (Annexes Tables: A 1, A 2, A 3 and A 4).

## 2.6. REASONS FOR INADEQUACY AND INEFFICIENCY IN SERVICES

### 2.6.1. Apathy of Municipal Authorities

Though municipal authorities have held the responsibility of managing solid waste from their inception over three centuries ago, the issue seldom got the attention it deserved. Elected representatives as well as the municipal authorities generally relegate the responsibility of managing municipal solid waste (MSW) to junior officials such as sanitary inspectors. Systems and practices continue to be outdated and inefficient. No serious efforts are make to adapt latest methods and technologies of waste management, treatment and disposal. Though a large portion of the municipal budget allotted for solid waste management, most of it spent on the wages of sanitation workers whose productivity is very low. There are no clear plans to enhance their efficiency or improve working conditions through the provision of modern equipment and protective gear. Unionization of the workers, politicization of labour unions and the consequent indiscipline among the workforce are all results of bad working conditions and inept handling of labour issues.

Almost all the 3955 towns with population below 100,000 run SWM services rather unprofessionally. They depend on sanitary inspectors to manage solid waste with the help of sanitation workers. In many small towns, even qualified sanitary inspectors are not post and services lifted in the hands of unqualified supervisors.

The situation of cities with 100,000 plus population is somewhat better, though far from satisfactory. In these cities, generally there are health officers who head the SWM

department. In some of the larger cities qualified engineers, supervise SWM seeking technical inputs from doctors as well.

### 2.6.2. Absence of Community Participation

Community participation has a direct bearing on efficient SWM. Yet, the municipal authorities have failed to mobilize the community and educate citizens on the rudiments of handling waste and proper practices of storing it in their own bins at the household, shop and establishment level. In the absence of a basic facility of collection of waste from source, citizens are prone to dumping waste on the streets, open spaces, drains, and water bodies in the vicinity creating in sanitary conditions. Citizens assume that waste throw on the streets would be picked up by the municipality through street sweeping.

For the public, which is quite indifferent towards garbage disposal etiquette, the onus of keeping the city clean is entirely on the ULB's. This mind set is primarily responsible for the unscientific systems of waste management in the country.

## 2.7. PRESENT SWM SERVICES AND IT'S DRAWBACKS

### 2.7.1. Storage of Waste at Source

There is no practice of storing the waste at source in a scientifically segregated way. Citizens have not been educated to keep domestic, trade, and institutional bins for storage of waste at source and stop littering on the streets.

### 2.7.2. System of Primary Collection from the Doorstep

There is no public system of primary collection from the source of waste generation. The wastes discharge here and there later collected by municipal sanitary workers through street

sweeping, drain cleaning, etc. Street sweeping has, thus become the principal method of primary collection.

### 2.7.3. Street Sweeping

Even street sweeping not carried out on a day-to-day basis in most cities and towns in India. Generally, commercial roads, important streets prioritized, and rest of the streets swept occasionally or not swept at all. Generally, no sweeping done on Sundays and public holidays and a backlog created on the next working day.

The tools used for street sweeping are generally inefficient and out-dated. For instance, the broom with a short handle is still in use forcing sweepers to bend for hours resulting in fatigue and loss of productivity. Traditional handcarts/tricycles are use for collection, which do not synchronize with the secondary storage systems. Waste deposited on the ground necessitating multiple handling.

There are no uniform yardsticks adopted for street sweeping. However, some states/cities has prescribed work-norms, these are not very scientific. Most of the cities allocate work to sanitation workers on ad hoc basis.

### 2.7.4. Waste Storage Depots

As waste collected through traditional handcarts/tricycles that can carry only a small quantity of waste at a time, there is a practice to set up depots for temporary storage of waste to facilitate transportation through motorized vehicles. Generally, open sites or round cement concrete bins, masonry bins or concrete structures are use for temporary bulk storage, which necessitates multiple handling of waste. Waste often spilt in residential areas, which are both unsightly as well as unhygienic.

### 2.7.5. Transportation of Waste

Transportation of waste from the waste storage depots to the disposal site is donning through a variety of vehicles such as bullock carts, three-wheelers, tractors, and trucks. A few cities use modern hydraulic vehicles as well. Most of the transport vehicles are old and open. They are usually loaded manually. The fleet is generally inadequate and utilization in optimal. Inefficient workshop facilities do not do much to support this old and rumbling squad of squalid vehicles. The traditional transportation system does not synchronize with the system of primary collection and secondary waste storage facilities and multiple manual handling of waste results.

### 2.7.6. Processing of Waste

Generally, no processing of municipal solid waste is donning in the country. Only a few cities have been practicing decentralized or centralized composting on a limited scale using aerobic or anaerobic systems of composting. In some town, un-segregated wastes is put into the pit and allow to decay for more than six months and the semi-decomposed material is sold out as compost. In some large cities, aerobic compost plants of 100 MT to 700 MT capacities are set up but they are functioning much below installed capacity. A few towns are practicing vermi-composting on a limited scale.

### 2.7.7. Disposal of Waste

Disposal of waste is the most neglected area of SWM services and the current practices are grossly unscientific. Almost all-municipal authorities deposit solid waste at a dump-yard situated within or outside the city haphazardly and do not bother to spread and cover the waste with inert material. These sites emanate foul smell and become breeding grounds for

flies, rodent, and pests. Liquid seeping through the rotting organic waste called leachate pollutes underground water and poses a serious threat to health and environment.

## 2.8. TECHNOLOGIES AVAILABLE FOR PROCESSING, TREATMENT, AND DISPOSAL OF SOLID WASTE

The main technological options available for processing/ treatment and disposal of MSW are composting, vermicomposting, anaerobic digestion/biomethanation, incineration, gasification and pyrolysis, plasma pyrolysis, production of Refuse Derived Fuel (RDF), also known as pelletization and sanitary land filling/landfill gas recovery. Not all technologies are equally good. Each one of them has advantages and limitations.

### 2.8.1. Composting

Composting is the decomposition of organic matter by microorganism in warm, moist, aerobic and anaerobic environment. Farmers have been using compost made out of cow dung and other agro-waste. The compost made out of urban heterogeneous waste found to be of higher nutrient value as compared to the compost made out of cow dung and agro-waste. Composting of MSW is, therefore, the most simple and cost effective technology for treating the organic fraction of MSW.

Main advantages of composting include improvement in soil texture and augmenting of micronutrient deficiencies. It also increases moisture-holding capacity of the soil and helps in maintaining soil health.

Composting is suitable for organic biodegradable fraction of MSW, yard (or garden) waste/waste containing high proportion of lignocelluloses materials, which do not readily degrade under anaerobic conditions, waste from slaughterhouse and dairy waste.

### 2.8.2. Vermi Composting

Vermi-compost is the natural organic manure produced from the excreta of earthworms fed on scientifically semi-decomposed organic waste. Normally, vermi-composting is preferred to microbial composting in small towns as it requires less mechanization and it is easy to operate. It is, however, to be ensured that toxic material does not enter the chain which if present could kill the earthworms.

### 2.8.3. Waste to Energy

Even though the technology of waste to energy (WTE) projects has been proving worldwide, its viability and sustainability is yet to demonstrated and established in the country. The main factors that determine the techno-economic viability of WTE projects are quantum of investment, scale of operation, availability of quality waste, statutory requirements and project risks.

### 2.8.4. Anaerobic Digestion and Biomethanation

Biomethanation is a comparatively well established technology for disinfections, deodorization and stabilization of sewage sludge, farmyard manures, animal slurries, and industrial sludge. Its application to the organic fraction of MSW is more recent and less extensive. It leads to bio-gas/power generation in addition to production of compost (residual sludge).

This method is suitable for kitchen wastes and, other putrescible wastes, which may be too wet and lacking in structure for aerobic composting. It is a net energy-producing process (100–150 kWh per tonne of waste input).

However, this method is suitable for only the organic biodegradable fraction of MSW; it does not degrade any complex organics or oils, grease, or lignocelluloses materials such as yard waste. Similar to the aerobic composting process input waste needs to be segregate for improving digestion efficiency (biogas yield) and the quality of residual sludge.

### 2.8.5. Semi-Aerobic Landfill

Semi Aerobic Landfill Site works as a leachate treatment facility. Inside of this landfill site, leachate is treated and quality improved by itself at the same time of decomposition process. Therefore, the operation cost is also the least.

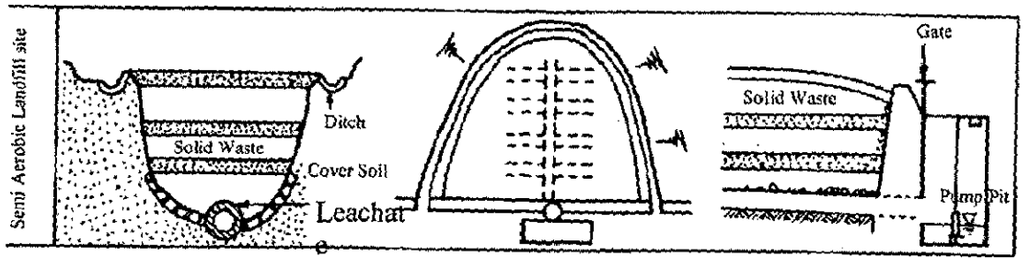



Figure 2.3 Semi-Aerobic Landfill Site Method

This method is already introduced or tested in Japan, Malaysia, Iran, and Indonesia

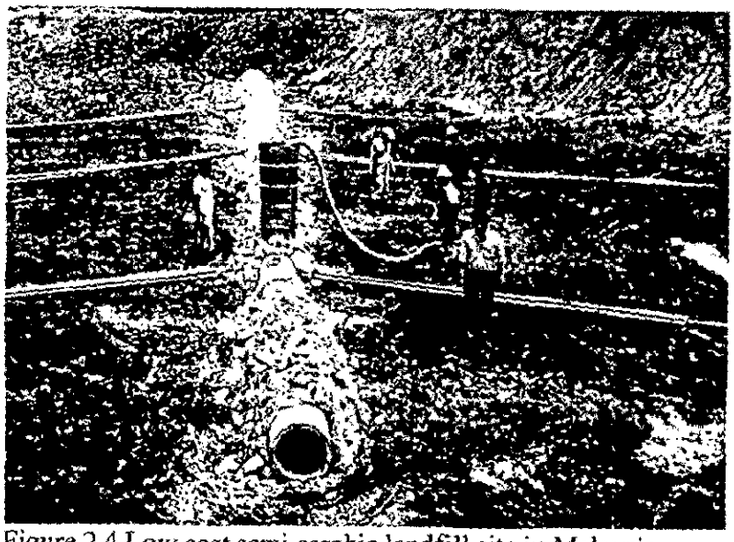


Figure 2.4 Low cost semi aerobic landfill site in Malaysia

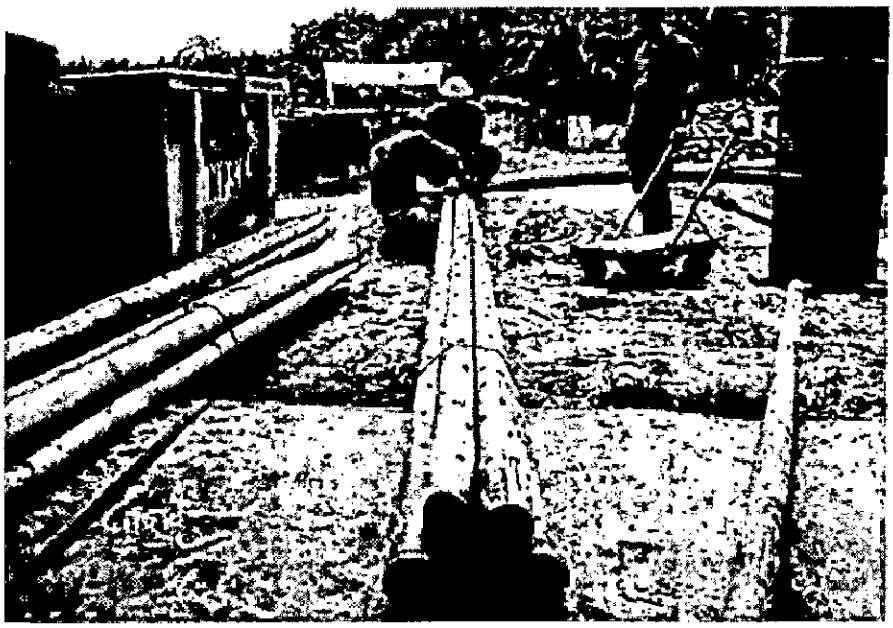


Figure 2.5 Leachate collection pipes made of bamboos

Figure 2.6 Gas venting cage made of bamboo in Indonesia

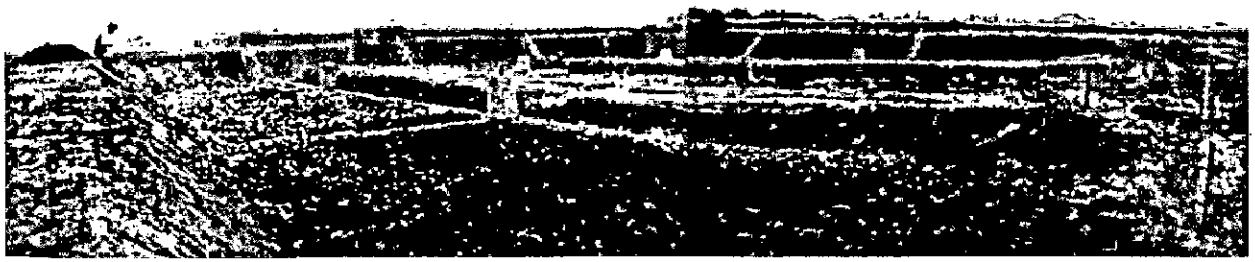


Figure 2.7 Semi - aerobic landfill site in Indonesia

Pipe materials using local product, such as bamboo, oil drums etc

It is better that a landfill site would be rather shown to the citizens eyes than trying to hidden from them. Generally, inadequate operation of Landfill site causes an objection by citizens to construct the final disposal site. In order to avoid the complain of citizens by occurring unsuitable living circumstance such as offensive odor, dust, crow, good operation should be needed such as

i. To make daily cover wastes by soil
ii. To check the carried garbage to landfill site
iii. To make a plan for operation of landfill site
iv. Moreover to make clean the periphery of Landfill site
v. To construct the boundary fence
vi. To plant the forest surrounded the space
vii. To make a clear access road inside of the landfill site is necessary
viii. To introduce stepwise approach to sanitary landfill, selecting subsequent operation area, the area is to construct by a sanitary landfill.

Production of Refuse Derived Fuel (RDF)

It is a processing method for mixed MSW, which can be very effective in preparing an enriched fuel feed for thermal processes like incineration or industrial furnaces.

The process, however, is energy intensive and not suitable for wet MSW during rainy season. If RDF fluff/pellets are contaminating by toxic/hazardous material, the pellets are not safe for burning in the open or for domestic use.

### 2.8.6. Incineration

This method, commonly used in developed countries is most suitable for high calorific value waste with a large component of paper, plastic, packaging material, pathological wastes, etc. It can reduce waste volumes by over 90 per cent and convert waste to innocuous material, with energy recovery. The method is relatively hygienic, noiseless, and odourless, and land requirements are minimal. The plant can be located within city limits, reducing the cost of waste transportation.

This method, however, is least suitable for disposal of chlorinated waste and aqueous/high moisture content/low calorific value waste as supplementary fuel may be needed to sustain combustion, adversely affecting net energy recovery.

The most important merit of incineration technology is the size reduction that eases the problem of waste dumping. About 75% of weight reduction and 90% of volume reduction is achieving through burning. All the organic matters, whether putrescible or not, are reduced to ash. MSW can be use even without much fuel preparation. A complete sterilization achieved due to burning of even biologically hazardous waste, thus avoiding epidemics. MSW can also be co fired as an additional source in coal-based power plants.

The demerit of such plants is the air pollution that can never be avoid even in highly sophisticated power plants. The additional cost of the complete pollution control systems is about 30% of the power plant cost, which makes it financially unattractive to the already high investment system. The pollution is caused mainly due to particulate matter, CO2, SO2 (sulphur dioxide), NOX (oxides of nitrogen), dioxin, and furan. The last two are supposed to be hazardous to health. Dioxin and furan are the generic terms referring to a special family of chlorinated benzene ring compounds

1. Polychlorinated dibenzo-p-dioxins and
2. Polychlorinated dibenzo-p-furans

Totally 210 different types of toxins and furans exist but the tetra series (containing four chlorine atoms) are believed to be the most toxic. In addition, the ash contains toxic elements such as arsenic, cadmium, lead, and mercury and treating the ash for the pollutants beyond limit is another costly affair. Another operational problem found in such plants is the additional maintenance cost to solve the problems of fouling and slagging in the furnace.

### 2.8.7. Pyrolysis/Gasification, Plasma Pyrolysis Vitrification (PPV)/Plasma Arc Process

Pyrolysis gasification processes are establish for homogenous organic matter like wood, pulp, etc., while plasma pyrolysis vitrification is a relatively new technology for disposal of particularly hazardous wastes, radioactive wastes, etc. Toxic materials get encapsulate in vitreous mass, which is relatively much safer to handle than incinerator/gasifier ash. These are now being offer as an attractive option for disposal of MSW also. In all these processes, besides net energy recovery, proper destruction of the waste is also ensuring. These processes, therefore, have an edge over incineration.

This process produces fuel gas/fuel oil, which replace fossil fuels and compared to incineration, atmospheric pollution can controlled at the plant level. NO and SO gas emissions do not occur in normal operations due to the lack of oxygen in the system.

It is a capital and energy intensive process and net energy recovery may suffer in case of wastes with excessive moisture and inert content. High viscosity of Pyrolysis oil may be

problematic for its transportation and burning. Concentration of toxic/hazardous matter in gasifier ash needs care in handling and disposal.

No commercial plant has come up in India or else where for the disposal of MSW. It is an emerging technology for MSW, yet to be successful demonstrated for large-scale application.

### 2.8.8. Sanitary Landfills and Landfill Gas Recovery

Sanitary landfills are the ultimate means of disposal of all types of residual, residential, commercial and institutional waste as well as unutilized municipal solid waste from waste processing facilities and other types of inorganic waste and inert that cannot be reuse or recycled in the near future.

There are mainly three types of sanitary landfills namely

1. Area method,
2. Ramp method, and
3. Trench method

In all the methods, the site first selected considering the following factors.

1. It should be at least 10 000 ft (3048 metres) away from the airport.
2. It should not be located in wetlands.
3. It should not be in flood- or earthquake-prone areas.
4. It should have a stable soil structure.

Its main advantage is that it is the least cost option for waste disposal and has the potential for the recovery of landfill gas as a source of energy, with net environmental gains if organic wastes are land filled. The gas after necessary cleaning can utilized for power

generation or as domestic fuel for direct thermal applications. Highly skilled personnel are not required to operate a sanitary landfill.

The merits of sanitary landfill are many as compared those of the conventional ones. It reduces emission of CH4, non-CH4 organic compounds, and toxicants (e.g. vinyl chloride, toluene, benzene, etc.) into the atmosphere. Land and water contamination due to leachate migration is minimizing. The main advantage is the protection of public health and environment. The menace of birds and rodents is reducing. Fire hazard is minimizing due to regular extraction of gas. The problem of smelly odour wafting to the nearby locality is comparative reduced.

The major objections to sanitary landfills are high initial costs for design and construction, public opposition when selecting the site, and increasingly, the concern for recovery of materials instead of disposal. The general tendency is 'dump yard not in my backyard'. Even after precautions, the obnoxious gas emission to the atmosphere can never checked completely and hence some odour is bound to be there. The efficiency of leachate and gas extraction is also doubtful. The problems of pests and rodents are minimizing but never complete eliminated. Even after keeping the sanitary landfill area aesthetically presentable, the real estate value of the nearby area is, reduced.

In India disposal of organic waste at the landfill prohibited and it made mandatory to treat the organic. Fraction of municipal solid waste before disposal of waste, the scope of landfill gas recovery is therefore, minimized in the Indian situation.

## 2.9. FACTORS GOVERNING CHOICE OF TECHNOLOGY

The decision to implement any particular technology needs to be base on its techno-economic viability, sustainability, as well as environmental implications, keeping in view the local conditions and the available physical and financial resources.

The key factors are:

a. The origin and quality of the waste;
b. Presence of hazardous or toxic waste;
c. Availability of outlets for the energy produced;
d. Market for the compost/anaerobic digestion sludge;
e. Energy prices/buyback tariff for energy purchase;
f. Cost of alternatives, land price and capital and labour cost;
g. Capabilities and experience of the technology provider
h. Low quality of municipal solid waste;
i. Delay in clearance of disposal sites.

## 2.10. PRIVATE SECTOR PARTICIPATION IN SWM AT URBAN LOCAL BODY LEVEL

Experience the world over has shown that private sector participation (PSP) results in cost savings and improvement in efficiency and effectiveness in service delivery mainly due to financial and managerial autonomy and accountability in private sector operations. Besides, it brings in new investment and better technologies. In developed countries, the private sector manages most of the SWM services.

In India, largely, municipal authorities are providing solid waste management services departmentally. Resistance from labour unions and interpretations of labour laws has

discouraged city administrations from contracting out services to private operators. Of late, some experiments to privatize certain SWM services have demonstrated improvement in the level of services in a cost-effective manner.

The present capacity of municipalities in India to manage the privatization process is, however, extremely limited. There is a need for developing in-house financial and managerial capability to award contracts to private sector and monitoring the services provided since the onus of ensuring proper service delivery and compliance of standards, remains with the local body.

### 2.10.1. Privatization of Disposal of Waste

In case of disposal of waste, there are no examples of private sector participation in India, as no such plants existed thus far. However, the concept of paying tipping fees is gaining acceptance with a beginning made by the Municipal Corporation of Bangalore. The BMP (Bangalore Mahanagar Palika) is using an integrated treatment and disposal facility for the treatment and disposal of 1000 tonnes of waste per day. Here, the contractor are paid a tipping fee of Rs 195/tonne only for the disposal of rejects not exceeding 30 per cent of the total quantity of waste delivered.

Based upon technology and investment requirements, various profiles of contracting with private firms are emerging. Mega cities namely Delhi, Mumbai, Bangalore, Kolkata, Chennai, Hyderabad, and Ahmedabad have gone in for large contracts and have attracted national and international firms. In some cases, cities have strategically gone in for small waste collection and transportation contracts promoting local firms with modest financial resources. Cities must ensure that such service responsibility is distribute amongst multiple firms or between private firms and ULB staff so that in case one firm fails others can take over without disrupting the service.

### 2.10.2. Secondary storage and transportation

Municipal authorities enter into secondary storage and/or transportation contracts to avoid investing in vehicles and equipment and to avail of a more efficient system. In such an arrangement, the private firms provide containers and/or vehicles with drivers as well as fuel. The onus of maintaining the fleet of vehicles also lies with them. Such contractors are either paid per trip to the treatment/disposal site or per tonne of waste transported (examples can be found in Ahmedabad, Surat, and Mumbai)

## 2.11. ROLE OF RESIDENT WELFARE ASSOCIATIONS (RWAS), NGOs, AND COMMUNITY BASED ORGANIZATIONS (CBO)

There is enormous potential to involve RWAs, NGOs and CBOs in SWM services in a cost-effective manner without getting into contracts with private operators. With some support from the ULB in the form of grant or subsidy, the community is keen to manage its own waste. There are NGOs/ CBOs, which also promote the welfare of rag pickers. They are willing to come forward to involve the rag pickers in door-to- door collection and source segregation of waste. In this model, followed in Ahmedabad and Ludhiana, there is no contractual relationship between the ULBs and RWAs/NGOs as they only get grants to support their activity carried out through their own labour and grants can be discontinue if purpose is not serve.

## 2.12. OBSTACLES TO PRIVATE CONTRACTING IN SWM

### 2.12.1. Absence of user charges

Provision of doorstep waste collection service under MSW Rules 2000 adds to the cost of SWM service and thus affects the finances of ULBs unless they introduce recovery of user fees from the beneficiaries. This is lacking in most of the cities and the contractors paid out

of the general revenue of the local body. This requires the local body to have a sound revenue base from which to allocate resources for SWM. The privatization effort currently underway in North Dumdum and New Barrack pore in West Bengal and Gandhinagar in Gujarat are good examples of user charges levied to sustain door-to-door collection on a long-term basis without additional burden on the ULBs.

### 2.12.2. Absence of a Labour Rationalization Policy

In some cities, as much as 20 to 50 per cent of the ULB staff is engaged in waste collection and transportation. Quite often, the staff is more than adequate but underutilized. Private contracting to improve the same service renders the existing staff redundant. It therefore becomes imperative that an adequate staffing plan be draw up in consultation with the unions to arrive at a judicious combination of labour retrenching, and redeployment.

## 2.13. NATIONAL PLAN FOR MSWM

Considering the status of MSWM of the country, the committee constituted by The Supreme court of India has summarized in a flow chart as depicted in Figure, the elements of MSWM for India.

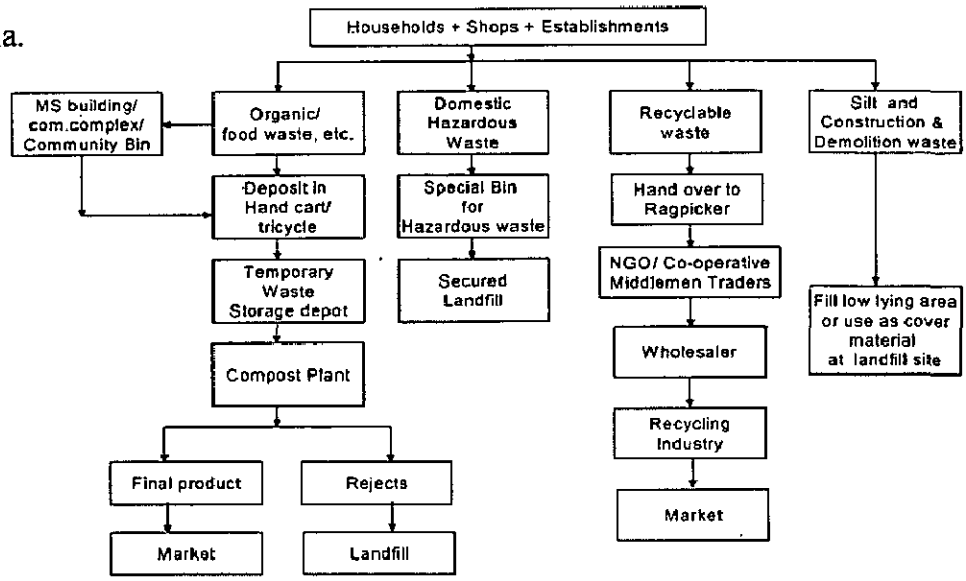



Figure 2.8 Recommended Flow Chart of Municipal Solid Waste in India

(Source: Supreme Court Committee Report)

# CHAPTER 3

# CASE STUDY

# CHAPTER 3: CASE STUDY

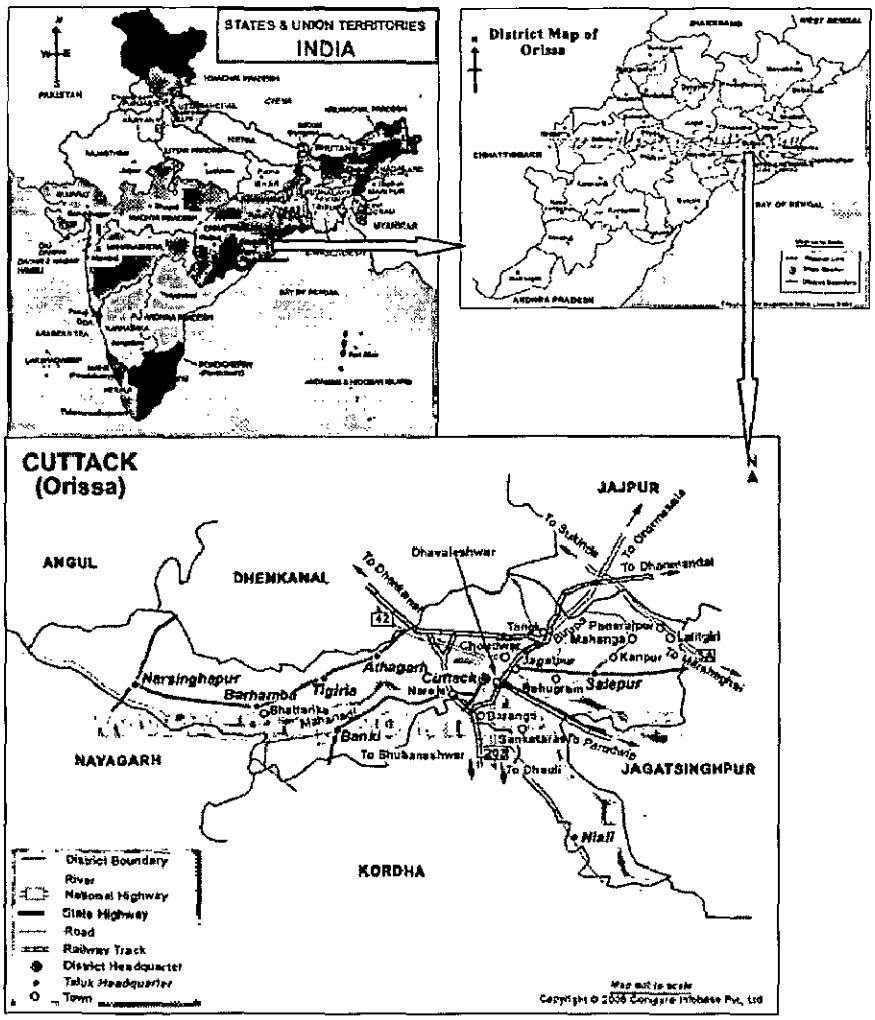
## 3.1. CUTTACK

### 3.1.1. Introduction

Cuttack, established in 989 by the Keshari dynasty, having a glorious history of over one thousand years, is one of the ancient cities in the country. It was the first capital of Orissa and occupied prime place in political evolution of the State until the construction of the capital city at Bhubaneswar.

### 3.1.2. Location

The city is located in a narrow space of land spreading over 121.9 sq. km. Its expansion is constrained by the flow of river Mahanadi and Kathojori along its boundary.




Map 3.1 Location map of Cuttack

**Table 3.1 Some Facts and Figures of Cuttack Related to SWM**

| | |
|---|---|
| Area | 134 sq. Km. |
| Population according to provisional | 6 lakhs (divided by 5=1, 20,000 Figures of census 2001households) |
| Total No. of Wards | 39 with populations ranging from 9,000 to 33,000 (however, there are only 34 wards in area covered by CUSIP) |
| No. of households | 1, 20,000 |
| Total road length | 615 km |
| Length of surface drains | 427 km |
| Length of house drains | 684 km |
| Total opening drain length | 1164 km |
| Average generation of garbage in a day | 360 MT (individual wards produce daily garbage ranging from 3.5 MT to 16.5 MT a day) |
| Average daily generation of bio-Degradable wastes vegetables, Green Leaves, etc. (other than cow-dung) | 116 MT |

Source: Cuttack Municipal Corporation

### 3.1.3. SWM in Cuttack Before CUSIP's Intervention

The Department of Solid Waste Management is under the Health Officer who is assist by 14 sanitary inspectors and 37 Ward Jamadars to ensure that the city kept clean. There are 1350 street sweepers, who work from 6.00 a.m. to 2.00 p.m. with one-hour recess. Night

sweeping is also being donning at bus terminals from 3.00 a.m. to 7.00 a.m. Each sanitary inspector is place in charge of two to three wards and each ward has a Jamadar to assist him in field supervision. Overall situation in the city is far from satisfactory.

1. There is no system of storage of waste at source. Most of the population deposit waste on the streets in the open spaces, drains, main storm water channels, etc., as and when waste is, generate and create a serious hazard for health and sanitation.
2. Segregation of recyclable waste is generally not practice. Most of the recyclable material is disposed of along with domestic and trade waste on the streets, in the drains, etc. Recyclable waste is therefore, generally found mixed with garbage on the streets, into the municipal bins and at the dumpsites.
3. There is no system of door-to-door collection of waste. Community bin facility given to the citizens is not efficient for depositing the waste. In absence of the facility of door-step-collection and inadequacy and in appropriateness of community bins for the deposition of waste, people throw the waste on the streets, in the storm water channels passing through the city as well as in the drains.
4. There is no system of Primary Collection of waste from the Hospitals and nursing homes. Most of the hospital and nursing homes throw their waste on the streets or into the municipal bins and a waste gets mixed up with the domestic, trade and institutional waste causing health risks.
5. No arrangement of primary collection of hotel and restaurant waste made. Hotels and restaurants therefore, dispose of their waste on the streets or into the municipal bins.
6. Vegetable, fruit, meat and fish markets do not have adequate storage facility with the result the market wastes is thrown in open space causing unhygienic conditions in the markets.

7. There is no system of Primary Collection of Construction waste. Generally, the people dispose of their construction waste on their buildings or on the streets nearby.
8. The main system of primary collection of waste is street sweeping. The entire city divided into beats among the 1350 sweepers (1200 permanent and 150 daily wastes).80% of them have handcarts, which are old and have outdated designs. The sweepers carry the street sweeping to the waste storage depots in traditional wheelbarrows.
9. There are no correct estimates available about the total quantity of waste generated in the city. One statement says that the city generates 360 MT of waste everyday whereas other statements which seems to be more accurate says that the city generates 244 MT of waste per day, which comprises of 128 MT of silt debris, and inert material and 116 MT organic and recyclable waste.
10. The city has 70 waste storage depots and 800 ill-designed dustbins for the storage of waste. The sweepers as well as the citizens an expected to deposit the waste at these depots. These waste storage depots are either open or masonry. At some places cement concrete bins also placed, all of them are unhygienic and unscientific.
11. There is no work norm prescribed. The sweepers are allotting work on ad hoc basis by the sanitary inspectors. The slum areas are not providing any service, except that few bins are place between the slums for the disposal of waste.
12. The transportation is donning in open trucks and open tractor trolleys causing nuisance to the citizens and environmental degradation. The waste is loaded manually into these vehicles, which is injurious to the health of workers.
13. The city did not have adequate land for waste disposal and was disposing of 90% of the waste in the river bed and low lying areas and only 10% of the was being taken

to the dump site. However, with a view to improve the system of waste disposal, the city has acquired 60 acres of land near Brajabiharipur for composting and disposal of waste. The waste generated in the city is taking to this newly acquired site and presently being disposed of in an unscientific manner.

14. The local body spends 4.5 crores annually towards salary and allowances of the staff engaged in SWM practices. Rs. 15 lakhs towards diesel, oil and lubricants for vehicles, Rs. 5 lakhs towards maintenance of vehicles and 30 lakhs towards the cost of implements.
15. Based on the critical findings Mr. Asnani has also made a number of valuable recommendations to streamline and strengthen Solid Waste Management practices in the city. Given the structural, financial and operational constraints, CMC was not in a position to implement these on its own. Now CUSIP has played a crucial supportive role through piloting innovative projects and extending required assistance at various levels.

### 3.1.4. SWM Initiatives in Cuttack City

Different studies launched at different times have estimated daily generation of solid waste in the city between 225 MT to 360 MT using varied sampling techniques. Mr. P.U.Asnani, however, arrived at a more realistic figure of 244 MT per day.

The Cuttack Municipal Corporation, despite its keen interest and commitment to the cause was hard pressed to arrange the financial resources on its own. Now, commencement of the Main Phase of the DFID assisted Cuttack urban Services Improvement Project since 1998, with a focus on solid waste management came as a great relief to the corporation. In subsequent years, both the CMC and CUSIP have made joint efforts to implement the valuable suggestions of the consultancy reports in a phased manner.

In the meanwhile, strict guidelines have been issued by the honorable Supreme Court for compliance by March' 2002. Thanks to the early initiative and drive launched by the corporation in collaboration with CUSIP, a very impressive progress has be achieved covering 13 out of 39 wards in the City. Steps are taken to bring the entire city under coverage within the given period.

The SWM initiative in Cuttack may be termed as successful pilot experiment, first of its kind in the state of Orissa this has made a significant contribution to promote environmental sanitation resulting in the reduction of morbidity mortality and other critical problems related to community health.

Community participation in these programmes has been very satisfactory and is a source of great inspiration for the future. Civil society institutions like CBOs, NGOs, press and other socio-cultural Organizations have become active partners in these activities. In fact, the decentralized, participatory and holistic solid waste management initiative in Cuttack City makes an ideal case study of urban good governance, worth sharing with the other stakeholders in the country.

### 3.1.5. Steps Taken to Improve SWM in Cuttack

Various steps has been undertaken by CMC and CUSIP to improve Solid Waste Management in Cuttack –

1. Refine and strengthen SWM strategy by conducting need assessment through appropriate agencies in Micro-settings at the ward level.
2. Ensure proper institutional arrangements viz. constitution of SWM cell within the Municipal Corporation, establishment of a regular surveillance system etc. for proper co-ordination and effective management of activities.

3. Build capacities of stakeholders through training/workshops and exposure visits.
4. Provide necessary equipment and supplies to the field staff engaged in SWM operations.
5. Construct needed infrastructure for composting and safe disposal of waste with special attention to bio-medical and other hazardous waste.
6. Evolve an appropriate legal framework through the State Government and other relevant provisions to address SWM issues.
7. Promote community and stakeholders participation through IEC, Awareness generation and social mobilization activities.
8. Undertake experimental and pilot programmes on SWM at ward level for the pre-testing and refinement of the strategy.
9. Establish a surveillance and monitoring system with due emphasis on social audit of the performance through active involvement of the community.
10. Gradual and steady expansion of the activities to the entire City in the light of the findings of the pilot experiment.
11. Involve different stakeholders in O&M issues and activities being undertaken with a view to achieve sustainability.

### 3.1.6. Contributions of CUSIP in The Field of SWM

Sensitizing key stakeholders: Municipal authorities, councilors and representatives of CBOs, NGOs, Line Agencies and other relevant institutions have been sensitized about the need to establish a scientific, hygienic and productive SWM system in the city. A number of workshops/meetings have been organized at various levels involving technical experts and different stakeholders with a view to promote understanding and share key concerns on SWM.

Consultancy Support: The pioneering studies undertaken by Ms. Dalal Consultants and Engineers Ltd., Calcutta and Mr. P.U.Asnani, Member Supreme Court's Committee on SWM, have been followed by the more detailed and empirical studies by Waste wise, Bangalore and consultants engaged for CUSIP from time to time. This has contributed for developing effective strategies and appropriate need based Action Plans. CUSIP is extending generous financial assistance for the purpose.

Training and Exposure Visits: Practical exposure is always considered more effective than theoretical learnings. Realizing this CUSIP has organized several exposure trips for CMC and CUSIP officials as well as Councilors of Municipal Council to important places such as Surat, Ahmedabad, Bangalore, Mirzapur, Vesakhapatanm, Hyderabad, Vijayawada etc.

Sanitary staffs of CMC such as Sanitary Inspectors, Zamadars and Sweepers have been trained by subject experts on the scientific and hygienic practices on Solid Waste Management.

A comprehensive training need assessment has been made and necessary training shall be imparted to key functionaries and CMC staff in near future.

Provision of Basic Equipment and Supplies: In the light of recommendations made by various consultants, CUSIP has supplied essential equipment and materials to CMC worth Rs. 1 Crore. CUSIP has proposed to extend assistance of Rs. 55 lakhs in the year 2001-2002 for SWM in Cuttack City.

Provision of SWM Infrastructure (Composting Plant): A 1 MT capacity composting plant has been built up at Nehurpalli in Ward No. 35. It has been handed over to CMC after successful trial run.

Another 5 MT capacity composting plant has been constructed at Sati Chaura which shall be commissioned shortly.

CUSIP has initiated measures for development of site and landfill arrangements at Braja Biharipur, which is being used by CMC as the terminal waste disposal point for the city.

### 3.1.7. Achievements

The initiatives undertaken in Cuttack City on Solid Waste Management have already shown visible out puts. Though a comprehensive impact assessment has not been made so far, the opinion surveys and physical inspection conducted by CUSIP at a limited scale provide reasonable ground to claim marked improvement in the field of solid waste management compared to the pre intervention baseline situation. The various achievements are -

1. Various studies and consultancy reports have made a threadbare analysis of macro and micro issues relating to SWM in Cuttack City based on which an integrated strategy has been drawn for the purpose.
2. Different stakeholders have been sensitized on the respective needs, roles and responsibilities in the area of Solid Waste Management.
3. Diverse capacity building exercises in the form of training, workshops, client-specific IEC packages and exposure visits have promoted informed participation and compliance at different levels.
4. Regular functioning of SWM cell in the Corporation has increased transparency, accountability and performance of the field staff associated with the SWM services.
5. The planned, decentralized, segregated house to house collection of Solid Waste is working properly in 13 wards of the city. The problems if any are being sorted out by timely enforcement of remedial measures.

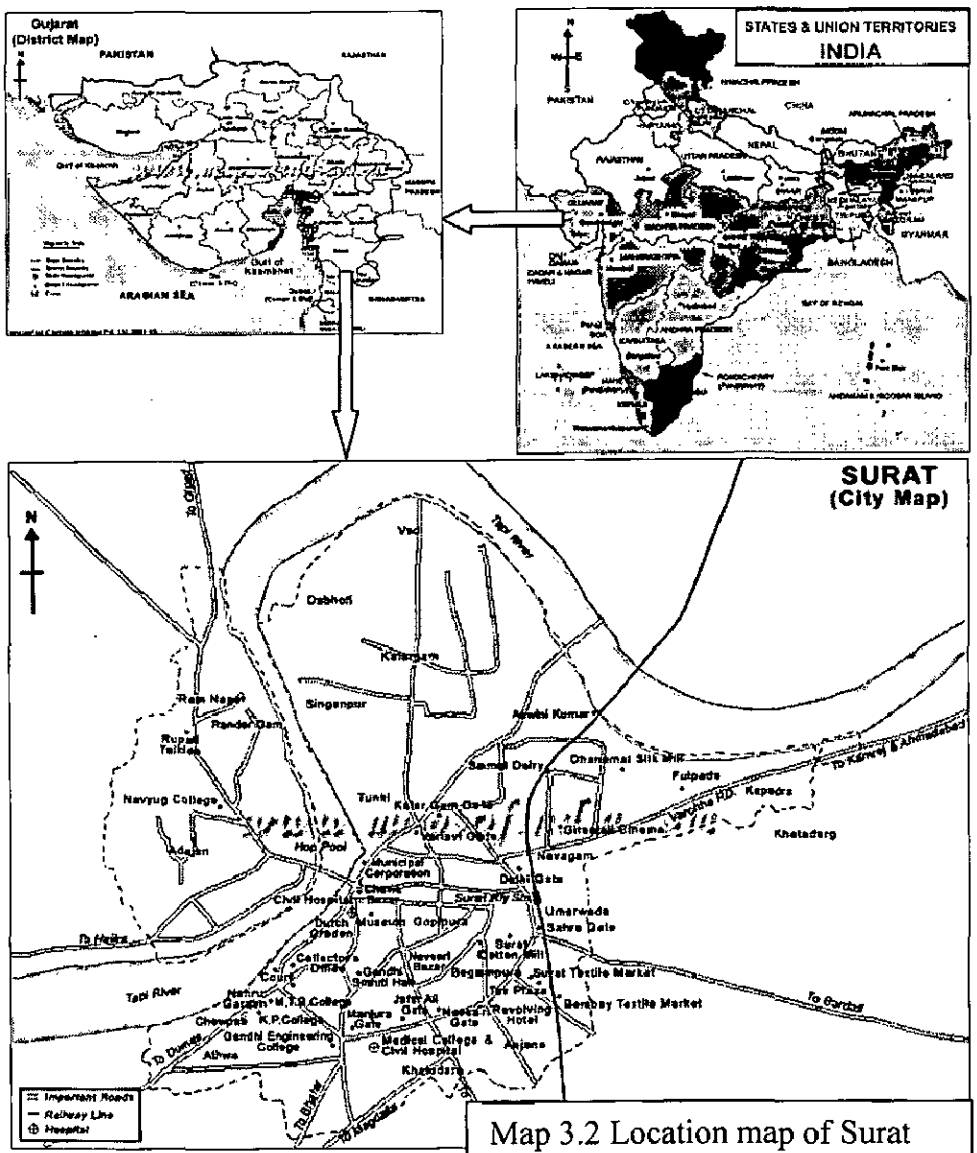
## 3.2. SURAT

### 3.2.1. Introduction

Surat is one of the cleanest city of India and is also known by several other names like "THE SILK CITY", "THE DIAMOND CITY", "THE GREEN CITY", etc.

### 3.2.2. Location

Surat is a city located on the western part of India in the state of Gujarat. It is one of the most dynamic city of India with one of the fastest growth rate due to immigration from various part of Gujarat and other states of India.




Map 3.2 Location map of Surat

**Table 3.2 Some facts and figures of Surat**

| | |
|---|---|
| Oldest Municipality | 1852 AD. |
| Area | 148.67 Sq.Km. |
| Population | 1.49 Million (1991) |
| | 2.72 Million (2001) |
| Density | 21673 Persons/Sq.Km. |
| No. of slum pockets | 305 |
| Zones | 7 |
| Ward Offices | 54 |
| No. of Election Wards | 34 |

Source: Surat Municipal Authority

The rapid urbanization and rise in population in Surat led to the growth of slums, increase in garbage and overflowing drains. In 1994, Surat was struck by an outbreak of a virulent disease somewhat like the plague. The disease caused panic countrywide and while the citizens blamed the municipality, the civic authorities in turn blamed the citizens for their lack of civic sense. It was a harsh reminder of what negligence in the area of solid waste management can lead to.

But what was most amazing was that within a span of 18 months the city made a complete reversal from a dirty, garbage-strewn city to become one of the cleanest cities in the country. This transformation was possible thanks largely to the Surat Municipal Corporation and the efforts of the community. Community participation played a key role in the rapid implementation of decisions taken by the corporation.

Subsequent to the disaster, the attitudes of the citizens changed and they diligently tried to improve its living conditions. Institutional changes were the first thing to happen. The city

was divided into six zones to decentralize the responsibilities for all civic functions. The officials responsible for solid waste management were made accountable for their work; and field visits were made mandatory for them each day.

The solid waste management department and other related departments were made to work and cooperate with one another. Grievance redressed cards were issued to people so that complaints could be registered. The complaint was attended to within 24 hours and the card returned to the citizen. In addition to the administrative changes, the changed laws had an important role to play in improving the conditions by also making the citizens aware of and responsible for certain preventive actions. Indeed, these are some of the very basic changes that need to be introduced in the functioning of all urban local bodies.

Thereafter, a fine of Rs. 50 was imposed for every offence of littering and it was doubled for every subsequent offence. The city roads were swept twice a day and the corporation, in an appreciable attempt, has engaged private sweepers to cover different inner areas of the town. Private contractors are also actively involved in the transport, collection, and disposal of solid waste.

### 3.2.3. The New and Modern Approach to the SWM is as stated below:

1. Integration of SWM with other activities viz. sewerage, water supply, health care, engineering departments, etc.
2. Emphasis was laid on Complaint redressal system, Grievance redressal system, Litter prevention system, Slum Up gradation & Rehabilitation, Field work, Daily meeting in this regard, etc.
3. Financial commitment: Equipment, Vehicles, communication.
4. Involving citizens: Positive involvement, penalizing truants, creating public awareness.

### 3.2.4. Present Status

1. Quantity of M.S.W. generation: - 950 M.T. /day
2. Collection and transportation: - 950 M.T. /day
3. Transportation system: - Dual transportation
4. Primary Transportation: - From point of generation to transfer station in respective Zones

**Table 3.3 Transfer stations and Zones of Surat**

| Name of Transfer station | Zone |
|---|---|
| Bhatar | Athawa |
| Katargam | North |
| Varachha | East |
| Anjana | South |
| Pal | West |

Source: SMC

5. Secondary Transportation: - From transfer station of respective zone to Khajod final disposal site (on Contract base)

Door to Door collection of garbage

To honor the guidelines provided by Hon'ble supreme court; door to door garbage collection system is made operative in 3 (three) of seven zones covering almost 50% of total population. Overall response to the facility is satisfactory.

Treatment and final disposal Bio Medical Waste

The centralized Bio Medical Waste treatment facility required with capacity of Incinerator. Autoclave and Shredder established in line with norms prescribed by B.M.W. (M. & H) Rules-1998 is in operation at Bhatar from 01/01/2003.

Treatment of Municipal Solid Waste

Agency named Shree Damodar Synthetic Limited, Mumbai is entrusted the work to establish W.T.E. plant of BOO base for concession period of 30 years at the approximate cost of Rs. 226 crore for derivation of energy from Municipal solid Waste.

A Special Purpose Vehicle (S.P.V.) Company named Surat Waste-Energy Pvt. Ltd. is formed and Registered with Registrar of the companies.

Agency has approached C.P.C.B. and M.N.E.S. to get Consent.

On getting approval to the proposed technology, necessary steps to install full scale plant shall be initiated.

### 3.2.5. Key Aspects Instrumental in Achieving the Objectives:

Field Work

i. 7.30 AM to 12.30 PM Daily. All Zonal chief, zonal officers, Dy. MOH, Dy. Er. and other staff daily working in the field
ii. Supervision of sweeping and cleaning by all
iii. Detection of problems during supervision-proactive
iv. Immediate message to concerned officer of zone by wireless/mobile
v. Compliance of message received by concerned officer
vi. Supervision of "Micro Planning" for sanitation, collection, transportation and final disposal of solid waste regularly.

vii. Cleanliness around the container, dust-bin and nuisance spots.

viii. Group safai in the afternoon

ix. Public health engineering work by Engg. Staff.

x. Regular checking of hotels, restaurants, lari, galla and food items for sanitation and hygiene point of view

Daily Meeting

i. Daily Meeting including holidays

ii. All zonal chiefs and divisional heads participate in the meeting

iii. Free & fair discussion and group decision making.

iv. Discussion and review of daily report of field work

v. Steps to solve the problem

vi. Cost-benefit analysis to achieve efficient systems.

vii. Sharing of experiences.

Complaints Redress System

i. All complaints receive a white card or red card which entitles them to an answer detailing action taken or to be taken.

ii. White card answered within 24 - 48 hours and it deals with 14 categories of sanitation and public health related complaints.

iii. Red cards answered within 3 - 7 days and it deals with 13 PHE related complaints.

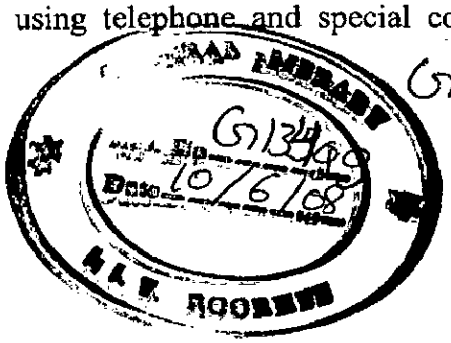
iv. 96% of complaints attended to, within specified time limit

Grievance Redress System

Citizen can lodge complaints on pagers. A grievance officer is appointed for each zone and HQ to deal with these complaints;

Complaints to be lodged manually at any of the ward offices during the office hours and round the clock at the zone offices;

Development of an Automated Complaint Lodging and Monitoring System to be undertaken to enable the public to lodge complaint using telephone and special code" 1913" is assigned for it by the' Dot.




Litter Prevention System

i. Litter patrol;
ii. Spot administrative charges for littering;
iii. All shops must maintain dustbins, ensure cleanliness of surrounding street areas;
iv. Restaurants and hotels to maintain separate bins, contents to be packed and disposed in designated disposal sites;
v. Education drive to persuade housewives to pack garbage, and dispose at designated bins;

Micro Planning

As mentioned in the Fieldwork it involves the following:

i. The whole city has been divided into 54 sanitary wards, which fall under the six administrative zones;
ii. Sanitary inspectors are in charge of each sanitary ward for sanitation and other public health activities;
iii. Ward level planning has been done for garbage collection, transportation and disposal;
iv. Selection of points for placing garbage bins, garbage containers, estimated amount of garbage generated, number of trucks and dumper placers required, time-place

movement (TPM) of the vehicle, trips required to collect and ferry it to dumping sites, number of sweepers and supervisors required, their duty time, shifts, etc. were critically considered while chalking out the micro-plan for garbage management;

v. The special needs of critical spots like vegetable markets, eating places, congested area with heavy traffic flow, public places, religious places and schools were given special consideration while formulating the ward-level plan; and

vi. The sanitary inspector of the ward is accountable and responsible for all the activities pertaining to public health.

Cleaning Schedule

i. Each area is cleaned at least once in 24 hours;

ii. Cleaning is carried out in two shifts during the day i.e. from 7.00 am to 11.00 am and 2.30 pm to 5.30 pm;

iii. Main roads and market places, public places and commercial areas are swept during night also;

iv. Garbage, which is collected from all garbage points located in different parts of the city, is transported by trucks to the dumping sites where, after being covered with earth, it is leveled by bulldozers;

v. The transportation of refuse is strictly in covered trucks to avoid spilling; and

vi. Insecticides are used in and around each garbage bin as well as at the dumping site to check the proliferation of germs.

Manpower and Machinery

i. The strength of sweepers and supervisory staff in the department has been increased considerably;

ii. Now there are 4,70 I sweepers and 18 chief sanitary inspectors, 55 sanitary inspectors, 130 sanitary sub-inspectors, 122 mukadams working in different wards;
iii. Entire public health department of the Surat Municipal Corporation functions under the Deputy Commissioner (Health and Hospital);
iv. Each ward with an approximate area of3.5 sq. kilometer and a population of50,000;
v. An average 50 or more sweepers and 5 supervisors are working for sanitation;
vi. Surat Municipal Corporation has deployed 140 vehicles for garbage collection and transportation;
vii. Each sweeper covers approximately 3,500 sq. m for sweeping everyday.

Private Sectors Participation

i. Privatisations in itiatives are: hiring of private vehicles with manpower for garbage collection and transportation and hiring of private vehicles with manpower for removal of animal carcasses;
ii. Private contractors entrusted with the scrapping and brushing during night;
iii. The hotel kitchen waste collected and transported by hotel owners and industrial waste disposed of by industrial organizations;
iv. Private contractors at present handled 50 per cent of the solid waste generated in the city everyday;
v. Private contractors work under strict supervision of the Surat Municipal Corporation staff and penalties are imposed on them for not performing their assigned work.

Regulatory Aspect

i. Monitoring of garbage disposal at the ward level is observed strictly;
ii. Each area is cleaned at least once in a day, while some vulnerable areas are cleaned at least twice a day;

iii. Despite rigorous cleaning schedule it has been observed that a section of the public and certain industries were not adhering to the rule of throwing garbage only in bins. Accordingly, the Surat Municipal Corporation introduced the practice of "spot administrative charges" for such offences. The Surat Municipal Corporation stand was that the charges were for additional service that the Surat Municipal Corporation would have to render for removing garbage thrown by the offender;

iv. Prosecution in the court of law and penal actions under the Bombay Police Act are also undertaken to check the garbage nuisance.

## 3.3. INFERENCES

1. There are no regulations governing the generation, segregation and onsite storage systems, thus hindering optimum functional efficiency of the management of solid wastes.
2. The wastes are transported, irrespective of their nature and hazard, by means that necessitate multiple handling at various points. This is not only dangerous for the persons handling the wastes but also reduces the overall efficiency of the collection system.
3. There are no formal and/or institutional provisions for the recovery, reuse and recycling of the wastes, due to which there is no economic returns to any institution of the formal sector from the process of SWM. This leads to disinterest on the part of agencies involved in SWM. As a consequence the involvement of the agencies concerned is more on the lines of disinterested activity rather than active participation.
4. The disposal practices of the BMC are not as per established norms, due to which the landfills of the BMC are a hazard for both the public health and the environment.
5. The NGOs and CBOs have not been given the necessary incentive and impetus due to which the communities awareness and participation in the SWM process is much below par.

From the study of the composition and characteristics of wastes the following facts that are of significance to the SWM process in city emerge:

1. Waste density is high.
2. The moisture content of the waste is also high.

3. The waste has a large percentage of organic contents with high portion of vegetable / putrescible materials.
4. There is a substantial amount of dust and dirt where sweeping and open ground storage of wastes is part of the collection system.

Due to the above mentioned characteristics of the waste the following issues relative to various aspects of application of technology become evident:

1. Due to the high moisture content of the wastes, incineration would generally not be self sustaining and would require energy input rather than produce recovery energy.
2. Waste with high organic content, biodegradation techniques such as methane generation and composting are technically more viable.

The following inferences are drawn from the case study of SWM

1. Solid Waste Management may be improved to a significant extent through streamlining existing human and physical resources. Institutional and managerial reforms contribute a lot for improved performance. Hence, constraint of funds does not necessarily restrict the scope for success.
2. The stakeholders such as CBOs, NGOs, Resident Welfare Associations, Merchants and traders Associations and various community groups are willing to participate and cooperate in the activities for Solid Waste Management.
3. Consultancy support and specific recommendations of subject experts have proved to be of great relevance for understanding the issues in details and tackling SWM related problems.
4. Workshops, training programmes and exposure visits have widened the vision and capacities of key personnel as well as elected representatives from Municipal

Corporation. This is reflected in their attitude and behavior in matters concerning SWM.

5. The options for extending SWM services in certain areas such as Hospitals, Nursing Homes, Market places, Hotels etc. on full/part cost recovery basis, may be tried, there exist vast untapped potential for these measures.

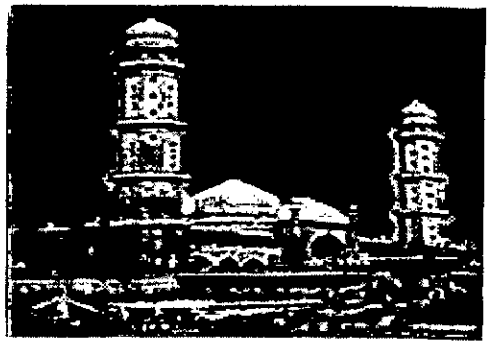
# CHAPTER 4

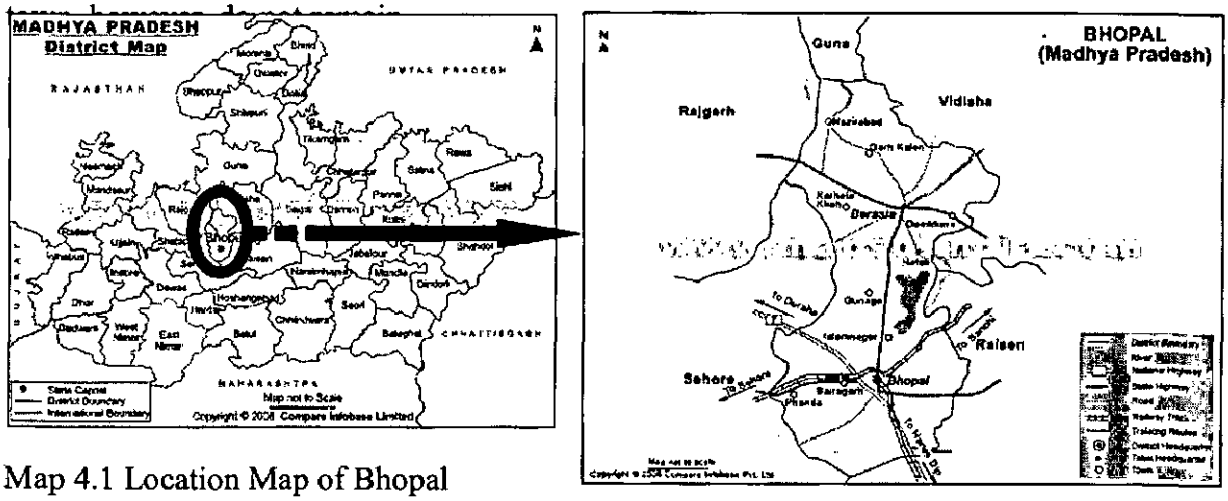
# STUDY AREA PROFILE

# CHAPTER 4: STUDY AREA PROFILE

## 4.1 INTRODUCTION

The origins of Bhopal city are a little obscure. It is said that Raja Bhoj, the famous Parmaring of Dhar, found Bhopal City in the 11th century at its present site. Another view is that the original city of Bhojpal (eventually corrupted to Bhopal) was first founded on the banks of Kolar River and then subsequently shifted to its present location. He created the Upper Lake by constructing an earthen dam across the Kolans River. The traces of the original town, however, do not remain. As per the former view Raja Bhoj, the famous Parmar king of Dhar, founded Bhopal City in the 11th century at its present site. He created the Upper Lake by constructing an earthen dam across the Kolans River. The traces of the original






Map 4.1 Location Map of Bhopal

## 4.2 EARLY BHOPAL

The city was established again and fortified in the 18th century by Dost Mohammed Khan, a chieftain of Aurangazeb, when he was invited by Rani Kamalawati as a protector of her

territory. The Lower Lake was created by Nawab Chhote Khan in 1794. The city remained a capital of a feudal state till it was merged in the Indian union in 1948.

Several dynasties have left their mark on the city. The antediluvian remains of the forts built by the Rajputs, Afghans and the Moguls silently speak of the battles, victories and failures of the past era. These icons are testimony to the grandeur of past and provide a marvellous treat to the eyes. Even by seeing the remains of the city one can have the glimpse of different cultures, which existed in the past. Many kings have ruled here and enriched the character of the city. Visiting the city is an immensely fascinating and rewarding experience.

## 4.3 POST INDEPENDENCE BHOPAL

In 1956 Bhopal was declared the capital of newly reorganized State of Madhya Pradesh. In the same decade, the Industrial Township of Bharat Heavy Electricals Limited (BHEL) was also established 3 km east of the then city boundary. As a result of these two interventions, Bhopal has witnessed a substantial population growth. Capital Project Township T. T. Nagar was built south of the lakes to support the capital. The military cantonment moved to Bairagarh area to the west of the old city.

In the decade 1971-1981, the city boundary was increased to bring BHEL Township and Bairagarh within the Bhopal Municipal Corporation limits. The wards increased from 39 to 56. The new wards added were 1-5 and 47-56 while some older wards were subdivided. In 1994, the number of wards in the city increased to 66 though the city boundary remained the same. Bhopal has not grown as a single city but as discreet townships, with sparse outgrowth in between, as follows:

**The old city and its Periphery:**

1. BHEL Township
2. Capital Project (T. T. Nagar)
3. Bairagarh
4. New out growth

Today Bhopal has blossomed into a city, which in spite of being modern upholds the patrician mark of its bygone rulers. The city provides a fascinating blend of scenic beauty with its lakes, parks, temples, mosques, gardens, museums, statues and buildings.

The comprehensive study for Bhopal Urban Area has been initiated by Bhopal Municipal Corporation. The study is being carried forward with continuous technical advice and guidance support of the Government of India, Ministry of Urban Employment and Poverty Alleviation and Ministry of Urban Development.

Bhopal is one of the fastest growing cities in the country. As per 2001 census, the population of Bhopal district is 18.38 lakhs out of which 14.35 lakhs live in Bhopal city, in 66 wards, covering a gross area of 285 sq. km. including the lakes and hills. This makes it a low-density city of 50 persons per hectare gross and 63 persons net if the lake area of 38 sq. km. is deducted. Even if the areas of steep hills are discounted, the density on habitable land remains low at 80 persons per hectare. Essentially Bhopal is a city of inhabited pockets with open areas and natural barriers in between.Bhopal district is almost 80% urbanized with most people living in the city of Bhopal. As the principal city of the region, it serves all towns and districts around, the nearest large city of Indore being about 180 km. to west.

Bhopal, the lake capital city of Madhya Pradesh, is continuously losing its grace and beauty under the growing pressure of up-gradation and densification of activities. The Basic infrastructure & transport scenario of Bhopal is in jeopardy as a natural outcome. This one may not realize apparently, as the problems are currently concentrated in a sparse manner. The potential and beauty of the city is getting lost amidst increasing services related problems. The crisis, chaos and risk of commuting as prevalent in other major urban centers of India, do exist in Bhopal. The situation is likely to be further grim in the coming years. There is urgent need to address the issue of urban transport as an important component to shape urban development and provide quality transport service to the community in the city.

Bhopal, the second largest city of Madhya Pradesh was made capital of state in 1956. It is the administrative and political nerve centre of the state. Nestled in beautiful surrounding of lakes and hills, it's surrounded by forests and poor agricultural land.

**Table 4.1 Bhopal City Profile**

| | |
|---|---|
| Area of the city | 285.00 Sq Km |
| Population | 14, 33,351(Census 2001) |
| Population Density | 50 pph |
| % of the State Population | 2.57% |
| Sex Ratio | 890 |
| % of Slum Population | 31.0 % |
| No of Wards | 66 |
| No of Zones | 14 |
| Average Rainfall | 1200mm |
| Water Supply | 234.3 MLD |
| Solid Waste | 600 MT per day generated |
| Height above MSL | Height varying from 460 to 625 MSL |
| Wind Direction | Westerly and south – westerly |

| | |
|---|---|
| Drainage pattern | Three main valleys provide the natural drainage |
| Physical features | Hilly terrain sloping towards north and southeast |
| Mineral Resources | There are no known, minerals |
| Soil Profile | Hard red soils with rocky outcrops and black cotton soil having depth ranging between 4' to 10' |

Source: Bhopal Development Plan

## 4.4 LOCATION AND LINKAGES

Bhopal is located on hilly terrain within the Malwa Plateau (23 16'N, 77 22'E). National Highway 12 (Beora – Jabalpur road), which links the city to many large cities in the north – west and the south – east. State Highways connect Indore and Sagar. The city is connected by the broad gauge railway line to Nagpur, Chennai, Delhi and Mumbai. The city is also served by regular air services to Mumbai, Delhi and Indore.

## 4.5 PHYSICAL AND GEOGRAPHICAL CHARACTER

### 4.5.1 Physical Features

Hillocks of different altitudes are situated along the southwest and northwest parts of the urban area, forming a continuous belt from the Singacholi up to the Vindhyachal range, to an elevation of 625 meters. The general ground level is between 460 and 500 meters along the city. The unusual topography has always provided unique attraction to the city.

There are 14 water bodies in and around Bhopal includes the two large lakes Upper and Lower lake in the east T.T. Nagar and its extension being developed on the southern side are separated by the old city by Upper Lake and Lower Lake. BHEL Township is separated from the new town as well as the old city by the railway.

### 4.5.2 Topography

Bhopal city nestles in a hilly terrain, which slopes towards north and southeast. Hillocks of different altitudes are situated along the southwest and northwest portion of the city, these hillocks from a continuous belt from Singarcholi up to Vindhyachal range. The height of Singarcholi near Lalghati is 625 M., which is a maximum in this area. The general ground level is however, nearly 460 M. along the southeastern and northeastern portion of the city. The remarkable topography of the city provides enchanting and panoramic views of the city and of natural scenic beauty. There are immense possibilities for landscaping and water front Development for recreation. However, hills and lakes are at present a great disadvantage in some respects. It is unsuitable for continuous Urban Development.

It creates physical barriers owing which interlinks between various parts of the city are often inconvenient and circuitous.

Large portion of city areas and New Bhopal are separated by hillocks and lakes, which act as barrier in social and cultural integration of these parts. The present city stands segregated distinctly in three parts. The T.T. Nagar and its extensions being developed on the Southern side is separated by the old city by two lakes- Upper Lake and Lower Lake, B.H.E.L. town is separated from the new township as well as the old city by Railway line. The future plan of the city must provide and improve physical links between these parts so as to encourage social and cultural integration of these townships.

Conspicuous Land Form:

The hillocks could be classified in the following three orders depending upon their altitude. This would facilitate to identify the areas suitable for development.

**1st order** – Singarcholi (Manwa Bhand), Lalghati, Idgah, and Fategarh situated to the North of Upper Lake.

**2nd order** – Shamla, Dharampuri and Arera Hills situated south-east of Upper Lake.

**3rd order** – M.A.C.T. Char-Imli, Shahpura, Kotra Sultanabad and other hillock adjoining south –east of Upper Lake.

The area to the East is comparatively plain without any significant landforms and gradually sloping towards northeast and forming the bowl shape land from. The areas to southeast beyond Shapura hill are gradually sloping towards Misrod.

Hill Ridges Plateaus:

Bhopal with its unique physiographic presents a picturesque setting extensive control of the skyline formation is envisaged. The ridges and hilltops or plateaus requiring visual aesthetic and conservation consideration are listed below:

1. Shamla Hill Ridge
2. Arera Hill Ridge
3. Char Imli Hill Ridge
4. Idgah Hill Ridge
5. Singar Choli Hill Ridge
6. Baghsewania, Laharpur, Amarawad Khurd Ridge
7. Singhpur Sewania Gond Hill Ridge
8. Sewania Gond Hill Ridge
9. Prempura-Dharampuri Hill Ridge
10. Chhawani Hill Ridge
11. Hill configuration around the Kaliasote and the Kerwa

All slopes of more then 8 degree and above needs to be prohibited for any construction or development on such slopes. They need to be extensively planted to stop soil erosion.

Geology and Soil:

The geological formations underlying the Bhopal area at the eastern edge of the Malwa Plateau are largely red sandstone strata, with the depth of the rock varying according to the slopes. The top portions of the hillocks generally consist of hard red soil, mixed with basaltic boulders. Black cotton soil is seen at various depths from 1 to 3.0m

### 4.5.3 Climatic Conditions

The city enjoys a moderate climate. Normally temperature ranges between 50oF and 104oF although highest temperature occasionally rises to 110oF. In such moderate climate, residential areas can be developed at higher densities as three to four storied buildings can be constructed without causing discomfort to the occupants.

The rainy season lasts from mid June to September, the winter from November to February, and summer from March to June. October sees the transition from rainy to the winter season. The average annual rainfall is round 1200 mm, falling predominantly during July and August. The average number of rainy days is approximately 40.

Wind Direction

Winds are predominant from the west and southwest during the monsoon. The presence of the lakes and hillocks create numerous and varying microclimates.

## 4.6 NATURAL DRAINAGE

The natural drainage of the city is provided by three main streams, which are of course, joined by small nallahs and rivulets. On the northeastern side, the drainage is provided by river Halali and on the southeastern side, it is provided by Kaliyasote River. Both these rivers drain out in Betwa, Halali near Vidisha and Kaliyasote near Bhoipur. On the southwestern side, the drainage is provided by various small nallahs, which drain out in Kolar River, which ultimately joins river Narmada.

The drainage water of old city including wastewater of straw products and cotton Mills is carried away by a Nallah, which joins river Halali, which is a perennial river. The water of this river is being used for irrigation purposes and very little discharge meets river Betwa near Vidisha. Moreover, the meeting point is on the down streamside of water works for Vidisha town. River Kaliyasote, which provides drainage on the southeastern side, joins Betwa near Bhojpur in Raisen District. There is hardly any possibility of utilization of this water on the way for irrigation purposes as passes through a hilly terrain. The water polluting industries located on this side will discharge supply to Vidisha. The Development of Mandideep Industrial growth Centre and its extensions need to be strictly controlled in respect of industries to be permitted in this area to avoid water pollution.

For the purpose of landscape studies, the natural drainage of Bhopal can be classified mainly in three categories viz. Dendritic (tree like branching), Basil and parallel pattern. These are the major landscape indicators revealing the biophysical phenomenon of the area. Broadly speaking the Dendritic pattern occurs in the southern part of the city this area is, therefore, favorable for birds, animals and life. All activities related with this element should be located in this area. The (part) Basil pattern occurs near Chhola and southeastern side of the city near BHEL. The area near Chhola has more potential for intensive

agriculture owing to availability of fine soil and sub soil water. This is the result of basil drainage pattern. The area near BHEL contains relatively less rich soil. It can, therefore, be used for general agricultural activities or City Park. The area suitable for birds, animals and plant life will require further studies in respect of soil, texture, structure, drainage order, vegetation etc. to work out detailed operation plan.

Industries proposed to be located on this side should be non-polluting type or it will have to be ensured that industrial water is fully treated before discharging the same in Kaliyasote, so that it does not cause pollution of Betwa, the source of watersupply to Vidisha, a growing town of the Region.

## 4.7 REGIONAL SETTING AND GROWTH PATTERN

Planning for Bhopal, which is one of the most beautiful million plus city, cannot be limited within its planning area. The developments taking place in the State Capital are considerably influenced by the socio-economic linkages, which are continuously changing and evolving in secondary and tertiary settlements system around Bhopal. Agricultural, forest, mineral and other produce supported by the State Capital Region, population holding capacity of the natural resource base of the subregion, national transport network and accessibility levels obtaining in the region and the sub-region, are some of the important factors which have to be taken cognizance of, in defining the role of Bhopal, in its regional and sub-regional context.

The employment opportunities offered by the state capital as well as similar opportunities which can be pre-empted through various fiscal policy measures for economic development in various nearly cities and sub-cities viz. Sehore, Vidisha, Hoshangabad and Itarsi around the mother city, Bhopal would determine the future distribution of population in and around Bhopal.

Bhopal being the State Capital is growing relatively at a rapid pace and is likely to promote increasing urbanization in and around it. The regional and sub-regional infrastructure will have to be strengthened to support increased urban productivity in manufacturing and supporting services. Bhopal which is growing at a rapid pace due to increasing migration not only from within the State but also from neighbouring seven states, calls for more pragmatic policies to absorb the population flow in a balanced manner. In the large context and longer perspective, development policies will have to consider the role of secondary cities and sub-cities described above to support the economic growth-taking place in the State Capital Region. It may be necessary to channelize the growth into other neighbouring cities and sub-cities to maintain the quality of life in the mother city, as well as in the region, as a long-term measure.

### 4.7.1 Growth Pattern

From the table it is evident that maximum growth has taken place in the southeast direction along the Hoshangabad Road. The level land, ease of transportation and nearness to Habibganj Railway station are major factors responsible for the southward growth of the city. It is to be noted that vast expense of the Upper Lake could not encourage the Westward growth of the city.

**Table 4.2 Growth of the city in different direction from center**

| Direction | Growth in Km. |
|---|---|
| North | 4.5 |
| Northeast | 4 |
| East | 8 |
| Southeast | 10 |
| South | 6 |
| Southwest | 5 |

| | |
|---|---|
| West | 1 |
| Northwest | 6 |

*Source; Bhopal Development Plan*

## 4.8 DEMOGRAPHIC AND SOCIAL PROFILE

Bhopal is the second largest city in the State with a population in 2001 of 14, 33,875. Upon reorganization of State's in 1956, Bhopal emerged as the capital of Madhya Pradesh, which was the starting point of the phenomenal change in its demographic trend.

### 4.8.1 Population Growth Trends

During 1951-61 the population growth was nearly 120%. In the decade of 1971-81, the establishment of Mandideep industrial area coupled with heavy commercialization, and expansion of Government services further gave impetus to the population, which recorded a phenomenal 74.35% decadal growth. Thereafter also the population continued to grow rapidly before declining to approx. 34.92% during 1991-2001. There is a clear indication that unusually high growth is now stabilizing and the rate will further slow down in the following decades particularly because the area base has significantly widened.

**Table 4.3 Urban Populations and Decadal Growth Rate (%)**

| Year | Population (in lakhs) | Period | Decadal Growth Rate |
|---|---|---|---|
| **1941** | 0.75 | | |
| **1951** | 1.02 | 1941-1951 | 36.02 |
| **1961** | 2.22 | 1951-1961 | 117.87 |
| **1971** | 3.84 | 1961-1971 | 72.62 |
| **1981** | 6.71 | 1971-1981 | 74.35 |
| **1991** | 10.62 | 1981-1991 | 58.38 |
| **2001** | 14.33 | 1991-2001 | 34.92 |
| **2005** | 16.76 | | |

Source: Bhopal Municipal Corporation

The growth in the population seems to be significantly attributable to mainly natural growth and Migration. The sample households have lived in the city for the more than 10 year and those that have moved neighborhood have moved from another part of the city.

**Table 4.4 Composition of Population Growth**

| **Composition** | **Population Increase during** | | | |
|---|---|---|---|---|
| | **1981- 1991** | **% of total** | **1991 - 2001** | **% of total** |
| **Natural Increase** | 307095 | 45.75 | 264020 | 24.85 |
| **In – migration** | 84657 | 12.51 | 126980 | 14.59 |
| **Total Increase** | 391753 | | 391000 | |

Source: Bhopal Municipal Corporation

Movements are more prevalent amongst high and middle-income families. These families are more likely to have moved from another urban area and whilst more poor families than rich move from rural areas, the poor too are more likely to have moved from an urban area.

### 4.8.2 Urbanization and Migration

Bhopal is the most urbanized districts of the state. As per 2001 census, 80.53% of the district population lives in urban areas, predominantly, in the city. In between 1901 to 1921, the urbanization declined as a result of plague outbreaks. The urban population then rose steadily from its low 30.4% in 1921 to 43.3% in 1951. In 1956, Bhopal was made the state capital and, in the same decade, the industrial township of BHEL was established. This led to substantial population-increase and by 1961 the urbanization of the district rose to 61.6%. In subsequent decades, rate of urbanization seems to be eventually stabilizing at about 80%.

**Table 4.5 Urbanization of Bhopal City**

| YEAR | % URBAN TO TOTAL POPULATION |
|---|---|
| 1901 | 40.80 |
| 1911 | 34.20 |
| 1921 | 30.40 |
| 1931 | 35.20 |
| 1941 | 39.10 |
| 1951 | 43.30 |
| 1961 | 61.60 |
| 1971 | 68.60 |
| 1981 | 74.90 |
| 1991 | 78.80 |
| 2001 | 80.53 |

Sources: Census of India

Land Population Ratio

The share of population of various parts of the city has shown distinct characteristics. As the city growth outwards the share of population of the old area to the over all city have reduced drastically. For example, the population share of the main city was 70% during 1970s, which has now reduced to only 40%. The main gainer of the population is the area named as: Neori (19.30%), Misrod (16.14%) and BHEL extension (16.97%),

Population Projection

The population projections for the Bhopal Planning Area up to the year 2011 were made on the basis of different standard statistical procedures. The projected population is presented in Table- It can be noticed that presently the Bhopal planning area is estimated to have 16.76 lakhs population and will be 21.21 lakhs in 2011 and 25.54 in 2021.nearly in next 15 years population of Bhopal will increase by about more than1.5 times.

**Table 4.6 Population Projections**

| *Population Year* | *Pop. (In lakhs)* | *Average Decadal Growth-rate (%)* |
|---|---|---|
| **1981** | 6.71 | 74.81 |
| **1991** | 10.62 | 58.38 |
| **2001** | 14.33 | 34.92 |
| **2007(Projected)** | 16.76 | |
| **2011(Projected)** | 21.21 | |
| **2021 (Projected)** | 25.54 | |

Source: Author

### 4.8.3 Population Density Planned and Unplanned Area

1. Over Habitable areas only (excluding areas under water body, forest, steep contours)
2. Planned Areas basically comprises New Bhopal and other areas that have come up in a planned fashion.
3. Unplanned Areas include Old Bhopal, Jhuggis, and colonies that have grown up haphazardly.
4. Special Areas include Cantonment, Universities, Airport and Industrial Areas.
5. Net density in unplanned areas = 619 persons / hectare the residential density and employment densities are:

Total population/residential land= 410 persons/ Ha.

Commercial emp./comm. Area =391 emp./Ha.

Industrial emp./Indus. area = 119 emp./Ha.

PSP emp. / PSP area = 188 emp/Ha.

These figures are indicators of the intensities in which land is being used by the three sectors of employment: commercial, industrial and public-semi public activities

**Table 4.7 Density Patterns (Gross Densities) Over Different Areas**

| Development status | Zone Area (Ha) | Habitable Area (Ha) | Developed Area Without Roads (Ha) | Population | Gross Density pph (Pop. / Zone Area) | Net density pph (Pop. / Dev. Area) |
|---|---|---|---|---|---|---|
| **Planned area Grand** | 8388 | 7604 | 3518 | 717755 | 86 | 204 |
| **Unplanned Area** | 2659 | 2344 | 1302 | 805978 | 303 | 619 |
| **Special Area** | 6502 | 4608 | 2130 | 190722 | 29 | 90 |
| **Rural area** | 54611 | 44335 | 2138 | 265664 | 5 | 124 |
| **Total** | 72160 | 58890 | 9087 | 1980119 | 27 | 218 |

Source: Census of India

### 4.8.4 Age Structure of The Population

According to census of India, about 14.5% of Bhopal population is in 0-6 year of age. The percentage share of each age group is shown in the following table. From the table it can be observed that about two fifth of population of Bhopal are children in the age group of 0-14 year. The working age population group (15-45 years) is about 54 percent.

**Table 4.8 Age structure of the Population**

| Age group | Percentage | Cumulative Percentage |
|---|---|---|
| **0-14** | 39.7 | 39.7 |
| **15-19** | 9.9 | 49.7 |
| **20-24** | 10.1 | 59.8 |
| **25-29** | 8.4 | 68.2 |
| **30-39** | 12.9 | 81.1 |
| **40-49** | 9.0 | 90.1 |
| **50-59** | 4.9 | 95.0 |
| **Above 60** | 4.97 | 100 |
| **Total** | 100 | |

Source: Census of India.

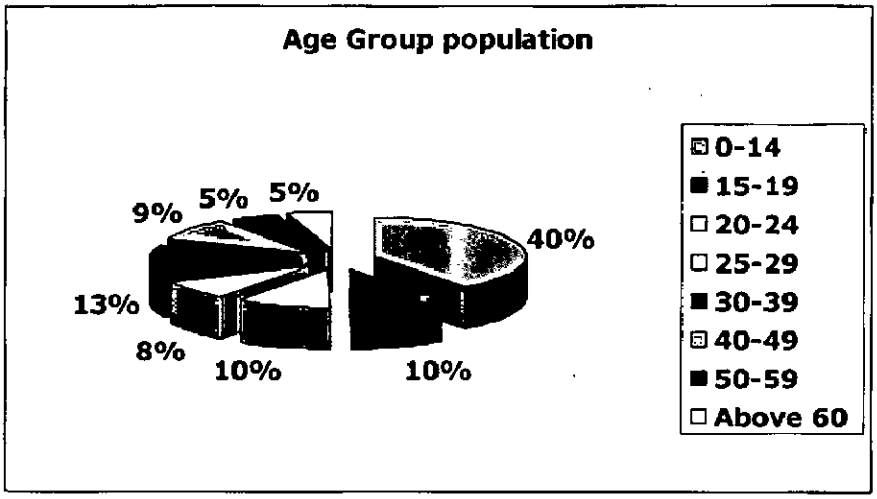



Figure: 4.2 Age Structure of the Population

## 4.9 LAND USE

### 4.9.1 Land Use Classification

The Development Plan 1994-2005 has various lands use classification categories like industries, commerce, residences, schools, roads etc. to comprehend the quantum of land utilization for various uses, their functional interrelationship, environmental problems etc.

1. Residential
2. Commercial
3. Industrial
4. Public-Semi-Public and Utilities
5. Recreational
6. Transportation
7. Agriculture
8. Wasteland
9. Forest
10. Water Bodies

### 4.9.2 Existing Land Use

The Bhopal Development Plan 2005 was planned for projected population of 25 lakhs. The Population of Bhopal was not grown up to the expected growth. It is estimated that in 2005 Bhopal has population of approximately 17 lakhs population. The implementation of the development plan 2005 has been assessed by field observations. The BDP envisaged around 17500 ha of developed area till 2005 but the actual developed area in the 2005 was 10400.

**Tab. 4.9 Status of Bhopal Planning Area**

| SR NO. | AREA | AREA (in ha.) |
|---|---|---|
| 1 | DEVELOPED AREA | 10400 |
| 2 | UNDEVELOPED AREA | 49706 |
| | **TOTAL PLANNING AREA** | **60106** |

Source: Bhopal Development Plan

Residential

The development plan (1994 -2005) envisaged 8190.00 Ha. of land for residential development which includes area around the city. Nearly 59% of the area proposed was utilized under the same use. Some of the areas like Gehukheda, Sankhedi, Katara, Navibaagh and outer areas of all the zones are not developed.

Commercial

Development plan 1995-2005 envisaged land utilization rate for commercial use as 0.4 Hectare per thousand people. The land, which was reserved for commercial use, was 650

Hectare distributed under different categories according to the requirement of planning units out of this total 60 percent land of commercial use has been developed.

Industrial

A close appraisal of land use distribution of Development Plan 1994-2005 indicates that except the industrial use proposed along Bhopal Diwanganj road and on the other side of the railway line in village Sajidabad, Maholi and Bhanpur, the other areas proposed for industrial activities in addition to the existing have come up. This forms 75 percent of the total land proposed under the industrial use, while the 25 percent industrial land could not be developed due to non-availability of concession for industrial development from the concerned Depts.

Public and Semi Public

The plan 1994-2005 envisaged 10% percent land for PSP purposes. The review of the plan indicates that out of 1746 Hectares land reserved for this use 1250 hectares land developed under the PSP. The land for PSP use which could not be developed and still available for development includes areas on Arera Hills and PSP uses in all the ten Planning units have scope of development for this purpose.

Transportation

Most of the proposed roads in South Bhopal have been developed except few, which could not be developed due to topographical configurations and site conditions.

Recreational

The recreational use, which was envisaged in 1994-2005 plans, was of the order of 17 percent of the total purposed land for city development. From the study of the recreational

development under the heading lake front development an city parks. It is evaluated that Lake Front and city park development is of the order of 50 percent of the total proposed area. Areas, which could not be developed as city parks, are near Lalghati junction, near Aish Bagh Stadium, opposite to Vidhan Sabha, adjacent to western Side of Regional College, western slope of MACT hillock and area around the PHE treatment unit in PU4 near Sai-Baba Mandir.

**Table 4.10 Existing Land Use and Proposed Land Use**

| S. No. | Category | Existing Dev. Area in Ha | % | Proposed Dev. Area in Ha | % |
|---|---|---|---|---|---|
| 1 | **Residential** | 4980 | 47 | 8190 | 46.48 |
| 2 | **Commercial** | 410 | 4 | 650 | 3.71 |
| 3 | **PSP and PUF** | 1250 | 12 | 1746 | 9.96 |
| 4 | **Industrial** | 900 | 9 | 1389 | 7.93 |
| 5 | **Transportation** | 1350 | 15 | 2600 | 14.85 |
| 6 | **Recreational** | 1600 | 13 | 2925 | 16.71 |
| **Total** | | 10400 | | 17500 | |

Source: Bhopal Development Plan

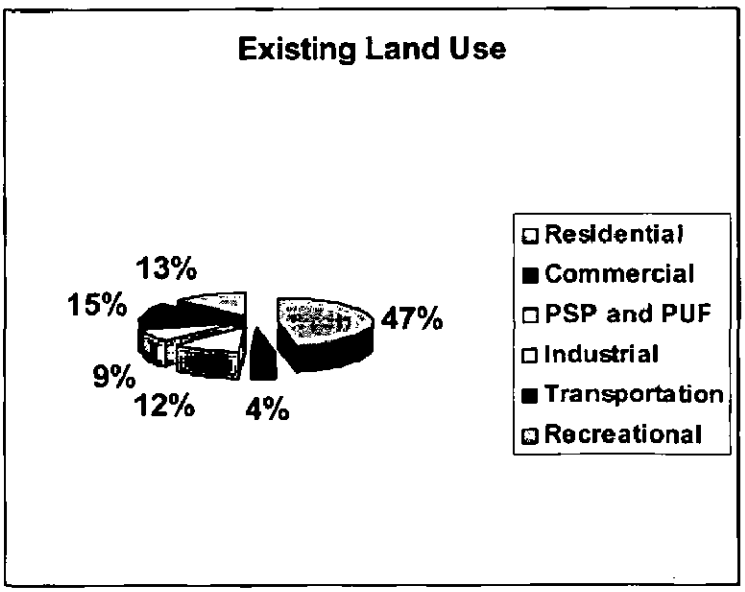



Figure: 4.3 Existing Land Use

# CHAPTER 5

# DETAILED STUDY FOR SWM OF BHOPAL CITY

# CHAPTER 5: DETAILED STUDY FOR SWM OF BHOPAL CITY

## 5.1 INTRODUCTION

Solid Waste Management is perhaps the most essential house-keeping service required by urban dwellers to maintain their quality of life. In India, this service lags behind, leading to some chaos in the urban sector. Institutional weaknesses, shortages of human and financial resources, improper technology, inadequate coverage, improper collection, transportation, disposal and lack of overall proper planning are associated with the weakness of solid waste management system in most of the cities of India. This has significant implications for the health of residents, municipal staff, industrial workers and overall urban investment climate.

Bhopal is only a small exception. City dwellers are facing the hazards of improper and inadequate solid waste management. This has crippled not only the general health and hygiene management of the city, but has also adversely influenced the poverty alleviation programmes. The city requires substantial improvement in the SWM practices prevailing to raise the over-all quality of life in view of the irreversible urbanization. To maximize efficiency and effectiveness of municipal management system, it is necessary to tackle the problem systematically by appreciating in a city specific manner the different dimensions of SWM and devise cost effective systems which would be viable in the available socio-economic and politico-environmental setting.

Bhopal Municipal Corporation has now given a serious look to these problems and has also begun mobilizing community and technical expertise from relevant support organizations.

Is the Bhopal **"Hiroshima"** of India?

Bhopal, the capital city of Madhya Pradesh, a Province in Central India, is known for its rich natural endowments and the diversity of its natural, physical and cultural resources. It is located in a hilly undulating region (550-600 meter MSL). The hinterland of Bhopal slopes north and southeast. The hillocks and lakes in the city create favorable conditions for environmental conservation and city management practices because of its gradient. Two main streams i.e. Betwa and Narmada, the former flowing towards north and the later flowing towards west, provide the drainage to the city. Halali nallahs from the northwest and Kaliasot from southeast meet Betwa and Kolar from the southwest joins river Narmada.

Bhopal is also the *"Hiroshima"* of India. In 1984 the Union Carbide Chemicals factory mismanagement caused leakage of poisonous gas MIC (Methyl Isocynate) leading to the death of over 5000 persons and the permanent impairment of almost a hundred thousand others. After a protracted legal battle some succor has been provided to those affected. This has left a permanent psychological scar over the city of Bhopal.

Bhopal has a subtropical moderate climate where the temperature ranges between 07 deg Cls (January) to 45 deg Cls (May). The average annual rainfall is between 125 – 150 cm most of them being experienced during July-September. Two lakes (upper and lower) give distinct character to the city. Besides providing scenic and aesthetic beauty these are perceived the lungs of the city. It not only fulfils the habitat obligation of drinking water but also lends fun and pleasure (water sports) for the city dwellers. However, the growing population and increasing refuse in all its states (solid, liquid and gas) has started affecting adversely the ecological and environmental aspects of the city. The improper SWM practices would further deteriorate the life sustaining aspects of lakes in the city and the Lake. The Municipal Corporation of Bhopal is spread over an area of 285.88 square Kms which can be classified as follows:

| | |
|---|---|
| OLD CITY | 41.58 Sq. Kms |
| BHEL | 44.18 Sq. Kms |
| NEW CITY | 77.97 Sq. Kms |
| VILLAGE AREA | 122.15 Sq. Kms |

## 5.2 MUNICIPAL DEMOGRAPHY

Till 1950, Bhopal experienced a gradual increase in population. But with the establishment of BHEL Plant and declaration of Bhopal as a capital city its population swelled from 1.0 Lakh in 1951 to 2.22 Lakhs in 1961 (118% Growth Rate). During the two decades of 1961-81 the population of Bhopal tripled (6.71 Lakhs) and in 1991 it touched the million marks. According to 2001 census the population of Bhopal city is 14, 33,875 (39% decadal growth rate)

Pull factor of Bhopal has been the major factor for unprecedented growth of population. Within the city 64% of the work force is engaged in tertiary activities, 32.8 % in secondary activities and 3.2 % in the primary activities. The work force distribution reflects the predominance of administrative functions as well as people's involvement in the informal sector.

The city does have some large industrial houses in and around its periphery. The main industries are:

1. BHEL
2. Railway Coach Factory
3. Mandideep Industrial Growth Centre and
4. Govindpura Industrial Area.

Besides there are very small scale industries like saw mills, oil mills, printing presses and dairies are relatively unorganized.

The city is divided into 66 Wards and 14 Zones. The elected body has a term of 5 years. The corporation performs its function as per the provisions of an Act governing the Municipal Corporations in the State. The administration of the corporation is under the Mayor. The Municipal Commissioner is the CEO, and is a senior State Administrative Service Officer. The Municipal Commissioner is assisted by a work force of municipal officers. For the purpose of SWM activities the Commissioner is assisted by 2-health officers.

The SWM department of Bhopal Municipal Corporation has work force of 1900 persons for street sweeping, 300 for transportation and disposal of waste and 580 temporary labors for collection and transportation of waste.

### 5.2.1 BMC's Budget

The budget of Bhopal Municipal Corporation in the financial year 2005-06 was Rs 312.31 crore. Solid Waste Management is the single largest expenditure head in the municipal fund, account for an average of over 24 per cent of the revenue expenditure over the assessment period. This head covers expenditure incurred in conservancy operations of the BMC, including salaries of supervisory and field staff and operation and maintenance of a fleet of vehicles for solid waste collection and transportation. On an average, over 70 per cent of expenditure under this head is attributed to salary expenses. Expenditure under this head has increased at a CAGR of about 3.5 per cent over the assessment period.

## 5.3 PRESENT STATUS OF SWM IN BHOPAL

The exact quantity and characteristic of waste produce in Bhopal is not known, but the BMC reports that 600MT/day of solid waste is generated in the urban area. Most waste dumped on open land or outside the containers. The BMC reports that 60% of the city area is cleaned and swept daily, 30% twice per week and 10% fortnightly. At present municipal waste is crudely dumped at the Bhanpur village trenching ground, at about road and during the rainy season 16km from the city. There is no proper access most of the refuse vehicles do not reach the disposal site.

**Table 5.1 Waste composition in Bhopal**

| Type of Waste | % Composition |
|---|---|
| **Household** | 70 |
| **Commercial** | 25 |
| **Hospital** | 1 |
| **Industrial & Construction debris** | 14 |
| **Total** | 100 |

Source : Bhopal development plan

**Table 5.2 Physical Characteristics of Waste**

| S.No. | Characterstics | Content |
|---|---|---|
| 1 | Paper | 9.01 |
| 2 | Plastic | 12.38 |
| 3 | Metal | 0.39 |
| 4 | Glass | 0.55 |
| 5 | Ash and fine earth | 44.73 |

| | | |
|---|---|---|
| 6 | Total composite able matter | 52.44 |
| 7 | Moisture contents | 42.66 |
| 8 | Organic matter | 35.78 |
| 9 | Calorific value (Kcl/Kg) | 1421.32 |

Source : Bhopal development plan

**Table 5.3 Chemical Characteristics of Waste**

| S. No | Moisture | pH value | Organic | Carbon | Nitrogen | Phosphorus P2O5 % | Potash K2O % | C/N Raito |
|---|---|---|---|---|---|---|---|---|
| 1 | 42.66 | 6.99-9.03 | 35.78 | 23.53 | 0.94 | 0.66 | 0.51 | 21.58 |

Source : Bhopal development plan

### 5.3.1 Composition of Waste

M.P.State Agro Development Corporation has set up a compost plant of 120 MT/per day capacity on a plot of land adjoining the land fill site. The plant is run at 60% of installed capacity. The company pays lease rent of Rs.10, 000 per year for 20,000 Sq Mt. of land given for the compost plant by the Corporation.

### 5.3.2 Collection of Waste

For efficient waste collection management system the BMC has divided into 14 Zone, the work relating to primary collection of waste has been decentralized at the zone level where it is supervised by health officers with the assistance of ward level inspectors/ Daroga, Sanitary super-wiser.

Figure: 5.1 Collection of Solid Waste

Primary Collection

The primary collection involves waste disposal by households and commercial and institutional places. 70 percent of waste is generated from the households and is disposed by households either on streets society bins or organized collection points in the deferent parts of the city.

Secondary Collection

The BMC covers the task of secondary collection and disposal. In Bhopal three different transportation systems are used:

1. Open trucks
2. Dumper-placers, and
3. Tractor Trolley

### 5.3.3 Solid Waste Management Staff

There are 1720 sweepers in 66 wards for sweeping work. The time of sweeping is 7.00 am to 11.00 am morning and 2.30pm to 5.30pm afternoon, Sweeper is provided wheel barrow, 1 long broom an panzer, they have been given specified sweeping area called beat, which

they clean and collect the garbage in the wheel barrows and take it to the waste storage sites commonly known as collection points.

**Table 5.4 Zone Wise Distribution of Solid Waste management Staff**

| SN | Staff | Total Staff | Zones | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 1 | Chief Health Officer | A.N | | | | | | | | | | | | | | |
| 2 | Health Officer/Zonal Officer | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 |
| 3 | Chief Sanitary Inspectors | 3 | 1 | | | | | 1 | | | | 1 | | | | |
| 4 | Sanitary Inspectors | 17 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 3 | 1 | 1 | 1 |
| 5 | Sanitary Supervisor | 23 | 1 | 1 | 1 | 5 | 2 | 3 | 1 | 1 | 2 | 1 | 2 | 1 | - | 2 |
| 6 | Jamadars | 26 | 0 | 4 | 3 | 0 | 2 | - | 5 | 3 | 2 | 1 | 3 | 0 | 2 | 1 |
| 7 | Ward supervisor | 17 | 3 | 2 | 1 | 1 | 2 | 3 | 0 | 0 | 1 | 2 | 0 | 1 | 1 | 0 |
| 8 | Safai Karamchari | 1900 | 109 | 191 | 139 | 198 | 170 | 134 | 181 | 117 | 124 | 105 | 116 | 102 | 97 | 117 |
| 9 | Driver | 55 | 5 | 8 | 3 | 4 | 5 | 6 | 5 | 4 | 7 | 2 | 2 | 1 | 1 | 1 |

Source : Bhopal Municipal Corporation

### 5.3.4 Transportation of Waste

BMC has 77 fleets of vehicles for collecting and transporting waste from collection points to the disposal site. Each of the vehicles is allotted specific area for collection and transportation to Bhanpur site. The collection vehicles attend collection point daily and the other location as per the schedule or as per the directions of Health officers

# SOLID WASTE TRANSPORTATION ROUTE MAP

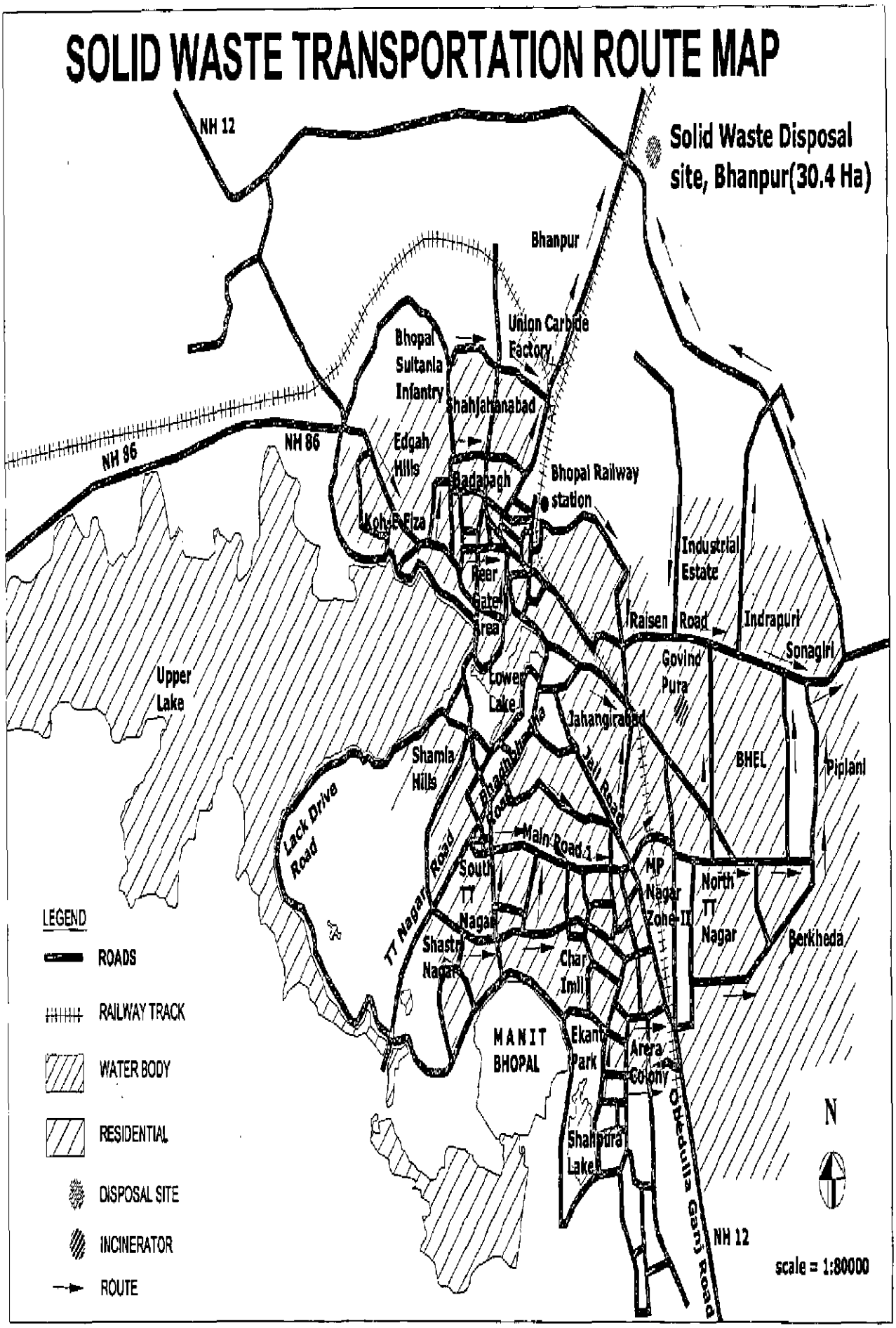


**Table 5.5 Number and Type of Vehicles Utilized For Transportation**

| S. No. | Type of vehicle | Nos. | Capacity (average) in Tones | Trips per day | Total collection per day in Tonnes |
|---|---|---|---|---|---|
| 1 | Trucks (Mini) | 32 | 3.0 | 2 | 192 |
| 2 | Tractor Trolley | 18 | 2.0 | 2 | 32.0 |
| 3 | Refuse compactors | 11 | 6.0 | 2 | 132 |
| 4 | Mini compactor | 2 | 6.0 | 2 | 24.0 |
| 5 | Dumper Placers each with 5 bins | 9 | 2.0 | 2 | 90.0 |
| | | | | **Total** | **450 tons/day** |

Source : Bhopal Municipal Corporation

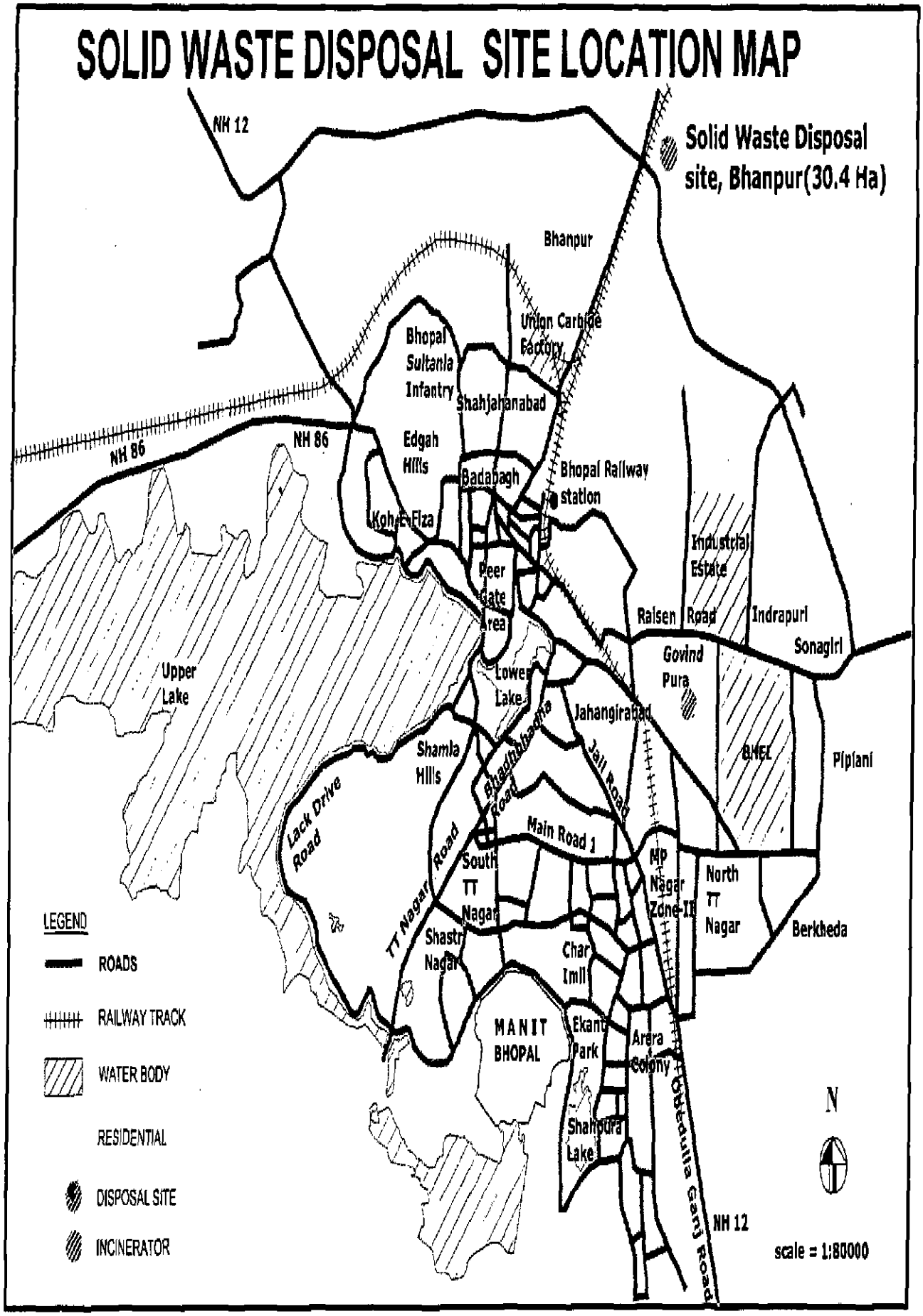
Average lifting and transportation waste to Bhanpur landfill site is 450 T/d.

No transportation is done on Sundays and public holidays, Backlog is therefore created on the day following the holidays.

### 5.3.5 Disposal of Waste

The BMC has 30.4 hectares land for waste disposal. The waste generated in the city is deposited at this land fill site. The land fill site is situated in Bhanpur village at a distance of 16 kms from the city. No scientific method of waste disposal is adopted. All waste is disposed of at the landfill site adopting of crude dumping of waste. Almost 230 to 280 trips are made to land fill site by 72 Vehicles ever day.

The disposal site at Bhanpur also has a waste processing plant which has been commissioned and run by M.P. Agro state organization installed capacity of Bio fertilizer is 100MT/day of composting.


SOLID WASTE DISPOSAL SITE LOCATION MAP
NH 12
Solid Waste Disposal site, Bhanpur(30.4 Ha)
Bhanpur
Union Carbide Factory
Bhopal Sultania Infantry
Shahjahanabad
NH 86
NH 86
Edgah Hills
Badabagh
Bhopal Railway station
Kohe-Fiza
Peer Gate Area
Industrial Estate
Raisen Road
Indrapuri
Sonagiri
Govind Pura
Upper Lake
Lower Lake
Jahangirabad
Shamla Hills
Bhadbhada Road
Jail Road
BHEL
Piplani
Lack Drive Road
Main Road 1
South TT Nagar
TT Nagar
MP Nagar Zone-II
North TT Nagar
Berkheda
Shastri Nagar
Char Imli
MANIT BHOPAL
Ekant Park
Arera Colony
Shahpura Lake
Obedulla Ganj Road
NH 12
LEGEND
ROADS
RAILWAY TRACK
WATER BODY
RESIDENTIAL
DISPOSAL SITE
INCINERATOR
N
scale = 1:80000

### 5.3.6 Bio Medical Waste

The Bio Medical Waste generated from Govt. and Private Hospitals and regulated at source and collected in different bags as per BMW rules. BMW wastes are collected in 223 hospitals/ Nursing Home and Transported in close vehicles to Private all India Nursing Home Association (Bhopal Incinerators Ltd. Govindpura). The Plant is installed at Govindpura Industrial area Bhopal.

Govt. Hamidya Hospital, Gas Rahat Super Hospital (Vidisha Bypass road), Chirayu and Hajela Nursing home also have their own Incinerator system. The total generation BMW wastes about 4 to 5 T /day which are being treated as per the BMW rules.

### 5.3.7 Communal Storage of Waste

BMC has 990 official Communal Waste Storage sites as under:

**Table 5.6 Communal storage of waste**

| S.N. | Waste Storage | Nos. of sites |
|---|---|---|
| 1. | Kachara ghar (dustbin) | 50 |
| 2. | Metal Containers | 350 |
| 3. | RCC Rings | 300 |
| 4. | Open Sites | 210 |
| 5. | Containers | 80 |
| | **Total** | **990** |

Source : Bhopal Municipal Corporation

The above shown sites (1) to (4) are not suitable for temporary storage of waste. The RCC bins overflow and open sites pose a problem of health and sanitation. The metal containers are well utilized.

### 5.3.8 Works Norms

The street sweepers on an average are given 10,000 Sqft. of sweeping area. This is reduced to 7500 Sqft. in the area where drains are also to be cleaned.

The working hours are from 6:30 AM to 10:30AM and 3:00PM to 6:00PM

### 5.3.9 Expenditure For Solid Waste Management

This is the single largest expenditure head in the municipal fund, account for an average of over 25 per cent of the revenue expenditure over the assessment period. This head covers expenditure incurred in conservancy operations of the BMC, including salaries of supervisory and field staff and operation and maintenance of a fleet of vehicles for solid waste collection and transportation. On an average, over 70 per cent of expenditure under this head is attributed to salary expenses.

# CHAPTER 6

# ANALYSIS AND FINDINGS

# CHAPTER 6: ANALYSIS AND FINDINGS

## 6.1 DESCRIPTION OF BMC STAFF SET UP

Bhopal municipal area has population about 17 lakhs and produced 600 MT/day solid wastes. BMC is lacking in staff, machinery and automobiles is unable to carry out its work effectively. The BMC has 1900 sanitary workers.

**Table 6.1 Existing Auto-mobile in the Bhopal Municipal Corporation**

| Vehicle type | Nos. | Vehicle type | Nos. |
|---|---|---|---|
| Trucks | 32 | Auto Rickshaw | 11 |
| Tipper (with 4 dumpers) | 01 | JCB | 02 |
| Refuge Compactor | 11 | Mini Refuge Compactor | 02 |
| Sewer Cleaning Vehicle | 03 | Loader | 01 |
| Dumpers | 09 | Crane | 01 |
| Trolleys | 18 | | |

Source: Integrated Urban Development in Madhya Pradesh, Bhopal

**Table 6.2 Existing Sanitary Workers in the Bhopal Municipal Corporation**

| Workers | Nos. |
|---|---|
| Street Sweeping | 1900 |
| Transportation And Disposal Of Waste | 300 |
| Temporary Labors | 580 |
| Total | 2780 |

Source : Bhopal Municipal Corporation

## 6.2 SOLID WASTE DESCRIPTIONS

Waste composition: Approximately 50% organic

Collection rate: 60-70%

Recycling: Carried out by scavengers

Composting: Private company composts 20% (120 MT/day) adjacent to the

Landfill site; compost is sold commercially

Landfill: 30.4 hectares, open dumping

Expenditure: 25% of municipal budget. Current cost recovery includes a conservancy tax as part of property tax/sanitary tax.

**Table 6.3 Solid Waste Management**

| | |
|---|---|
| GDP (USD) | 2358 |
| Waste generation (kg/person/day) | 0.43 |
| Collection rate (%) | Less than 70 |
| Treatment fees (USD/Person/Year) | Less than 1 |
| Rate of expenditure in total budget (%) | 25 |
| Recycling | Informal (Metal, grass, plastic, composting) |
| Incineration treatment rate | 0 |

Source : Bhopal Municipal Corporation

There is a clear increase in waste generation with the advance of economic development. Waste is mostly comprised of paper, compared to the high rate of organic waste (over 50%). In winter, there are differences in the composition of waste, such as increases in waste ash, as a result of changes in lifestyles. Plastic bags used for wrapping and paper are

on the increase in city. The scale of municipal budgets is small; however, the rate of expenditure for treatment fees in the overall budget is extremely large.

Informal collection is mainly carried out by scavengers. Incineration is an effective method to inoculate and reduce waste however; initial costs for the construction of facilities are high. Running costs are high when waste with high water content is generated, such as kitchen waste, and air pollution countermeasures for dioxins and soot and dust are necessary.

If there are no economic reserves, the introduction of this type of treatment method can be difficult. However, incineration is a relatively safe and simple method of treatment for waste that should be separated and inoculated such as medical waste.

## 6.3 CALCULATION

The year 2021 envisages a comprehensive and sustained solid waste management system with modern and scientific answers to collection, transportation and disposal of about 1550 MT/Day of solid waste and biomedical waste.

**Table 6.4 Forecasting of Solid Waste for Future**

| S.N | DESCRIPTION | 2006 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|
| 1 | Total Waste generated (MT/Day) | 600 | 910 | 1230 | 1550 |
| 2 | % waste collected to generated | 60 | 80 | 90 | 95 |
| 3 | % of waste processed | 15 | 90 | 90 | 100 |
| 4 | Total Vehicle Capacity / total waste generated | 0.7 | 1.0 | 1.0 | 1.0 |
| 5 | Trips / vehicle | 2 | 3 | 4 | 4 |

Source : Author

### 6.3.1 Requirement of Sanitary Workers

Waste produced per head is 0.43kg/person/day.So the total waste produced is (16, 67,000) x0.43= 717 MT/day, for the 2007 population

The capacity of tractor to carry the SW is 2.0 tonnes.

Capacity of Mini truck is 3.0 tonnes.

Capacity Dumper Placers each with 5 bins is 2.0 tonnes

Assume if five people in one family. So one sanitary worker required for 70 families (Or 3 sanitary workers per 1000 population)

One mini truck makes 2 trips a day

One tractor makes 2 trips a day

The total no. of Sanitary Workers required is 5028 but the BMC has 2248 no. of workers so the additional numbers of workers required are:

5028-2780=2248 Nos.

The total 2248 nos. of workers are required for better solid waste collection, transportation and disposal in present day.

**Table 6.5 Requirement of fund for better management of solid waste**

| S.N. | Particular | Cost in Crore |
|---|---|---|
| 1 | Up-gradation of existing land fill site Bhanpura | 0.40 |
| 2 | Collection system requirement<br>1200 Nos of covered container: | |
| | 1000 nos of 1 Cum. @ 15000 each | 1.50 |
| | 200 nos of 4.5 Cum. @ 35000 each | 0.70 |
| 3 | Transportation Management system:<br>(To meet out future requirement for transporting to new land fill site, with optimum cost) | |

| | | |
|---|---|---|
| | (a) 20 no compactors capacity 14 cum.@ 20,00000 each | 4.00 |
| | (b) Dumper 18 no placers 4.5 cum. @ 10, 00000 each | 1.80 |
| 4 | Nala Cleaning machine @ 4 nos. | 0.50 |
| 5 | Covered body vehicles for slaughter house waste transport to trenching ground. @ 10, 00000 each one nos. | 0.10 |
| 6 | Other equipment | |
| | (a) Auto Riskshaw total nos. of 66 @ 1,50000 each | 0.99 |
| | (b) Wheel barrow nos. 1500 @ 1600 each | 2.40 |
| | (c) Trucks mini model nos. 4 nos. @ 3,50000 | 0.15 |
| 7 | Transfer point 4 nos. | 0.80 |
| | Dumper 8 nos. @ 18,00000 | 1.44 |
| 8 | Slaughter house (modern) | 4.00 |
| 9 | **Land fill management**<br>Land requirement for Next 30 years waste generation 200 acrs. (Excluding waste recycling unit) | 0.2 |
| | Site selection Base line data, Geotechnical, topographical,<br>Hydrological investigation studies (EIA), Cost of infrastructure development and other arrangements as per MSW rules. | 1.15 |
| | 2 nos of Bulldozer@ 60, 00,000 each | 1.20 |
| | | |
| | 2 nos. of compactors @ 25, 00000 each | 0.50 |
| | 4 nos. of Excavator @ 20, 00000 each | 0.80 |
| | 4 nos. of Dumper @ 12, 00000 each | 0.48 |
| 10 | Yearly development cost for Next 5 years (Rs. In Cr. 2.50 + 2.75 + 3.02 + 3.32 + 3.65) Liners system/ leach ate collection system monitoring and soil cover etc. as per MSW rules. | 15.24 |
| 11 | Composing plant capacity 200 T/Day | 0.80 |
| 12 | Incinerator – 5 lakhs 1 no. | 0.05 |
| 13 | Recycling unit of waste material 1 no. | 15.00 |
| | **Total** | **54.20** |

Source :Bhopal Municipal Corporation

## 6.4 ISSUES AND MEASURES IN COLLECTION

A large number of people can be found who dispose of waste in streets, open yards, and drains. As a result, the employment of necessary personnel and percentage of the budget to address this issue are high, due to the use of street sweeping as a central part of collection activities. Additionally, collection rates are low due to an insufficient number of personnel and collection vehicles, as well as difficulties in entering narrow streets. However, the municipal government included the participation of residents and businesses from the very first stage of the plan and made effective use of existing human resources and equipment, thereby developing a new method for waste collection through public-private cooperation.

## 6.5 ISSUES AND MEASURES IN THE PROMOTION OF RECYCLING

Scavengers make a major contribution to the reduction of waste. However, scavengers who rummage in waste bins and scatter garbage expose and are exposed to environmental and hygienic problems. As pointed out by Bhopal, the problem is one that needs to be addressed, as a large number of scavengers are poor and include women and children. Advantages include lessening the impact on the health of scavengers as well as the surrounding environment, creation of new jobs, solutions for financial problems, and the first step towards the development of recycling businesses.

The most effective method to increase recycling rates is separation in households. Objective of decreasing waste, recycling must address issues such as the understanding and cooperation of residents, enlarging the market for recycled materials, and the construction and development of fully equipped recycling facilities. In targeting the intermediate layer that possesses an awareness of environmental problems, various measures have been

successful, such as the distribution of cash or coupons to residents that have collected recyclable materials. City carries out composting.

There are one case that demonstrates the use of waste from markets as materials for composting, as well as active participation and cooperation among the municipal government, and businesses. In this issue, problems arise from difficulties in selling the compost. Compost contains high nitrogen levels and is suitable as fertilizer for cultivating vegetables. Compost is less expensive than chemical fertilizers and has less of an impact on the soil. Cities understand the necessity of introducing appropriate recycling methods and technology, as well as promoting recycling business.

## 6.6 ISSUES AND MEASURES IN FINANCING

The rate for waste treatment fees in the general budget is high, and because there is a lack of finances, there are a number of cases where fees are levied in order to cover treatment costs. One method to increase cost effectiveness is the creation of partnerships with residents and the private sector.

## 6.7 ISSUES AND MEASURES IN SWM ADMINISTRATION

BMC has indicated that the necessary points for effective solid waste management are:

1. Systematic and organized management;
2. Understanding and cooperation of residents; and
3. Increasing administration capacity and introduction of appropriate technology.

In general, countries in Asia have strong centralized governments. The authority of local government is weak, as the authority and budgets necessary for management are not transferred to the city. Because solid waste management is an area in which the local

authority has responsibility, regulations and systems lag behind, as compared with air and water pollution measures that are directly managed by the central government. Guidance by the central government and transfer of authority for solid waste management must be promoted. Understanding and cooperation of residents is a most essential element in solid waste management. As indicated by Bhopal waste is the "responsibility of all", and everyone has an "equal share of responsibility". If the number of people that dispose of waste improperly, decrease the burden for activities such as street sweeping can be lessened. If waste can be separated at source, recycling rates can increase and waste decrease? In order to enhance understanding and awareness of residents, campaigns and education on the issues, as well as concrete actions that can be taken by the individual, are necessary. At the same time, with the direct participation of residents, costs for cleanup will decrease, and support and contributions of residents to environmental sanitation will rise. City are searching for ideas on the planning and implementation of concrete measures in order to minimize health and environmental impacts from solid waste; in other words, the most appropriate treatment methods to address each specific situation within financial, human resource and technological limitations. In this regard, ownership and capacity building of local governments is essential. Participation in training courses carried out by support organizations and dispatch of experts, as well as independent study groups are effective.

## 6.8 MAJOR CHALLENGES

The major challenge facing the Bhopal Municipal Corporation is to increase the awareness of the public to dispose of waste in designated storage bins and containers. Residents generally prefer to dispose of waste when and where it is generated. The practice of recycling is not well organized and segregation of recyclable waste at source has not yet

been adopted. As a result, recyclable waste is intermixed with garbage disposed at different places.

The Bhopal Municipal Corporation has not yet been able to adopt a system of door-to-door collection of waste, and street sweeping remains the main method of waste collection to date. Like other cities in developing countries, the emphasis of the municipal corporation is on the collection and transportation of solid waste; the issue of disposal is of less priority.

Solid waste in Bhopal is composed of materials that can be composted (approximately 50%); therefore, composting is a technique that can greatly relieve pressure on landfill sites. Composting plants compost about 20% of the total waste.

### 6.8.1 Financial Challenges

Improvements in planning, financial and managerial capacity are major strategies for the Municipal Corporation. Additionally, the Municipal Corporation aims to increase operating revenue through user charges, service taxes, landfill taxes and tipping fees. These measures would relieve financial limitations that are currently issues for the Municipality. Well-trained human resources remain a bottleneck for effective planning and management, which are being improved by ongoing capacity building activities. Partnerships with the private sector, community groups and NGOs are also sought as major strategies. The Municipal Corporation has paid special attention to legal impediments and labour concerns for private sector participation.

## 6.9 FINDINGS

1. Storage of waste at source is not fully taking place as people prefer to dispose the waste as and where it is generated.

2. Segregation of recyclable wastage is not yet adopted and often found mixed with garbage disposed at different places.
3. The system of door-to-door collection of waste is not yet adopted and street sweeping is the main method of waste collection.
4. For street sweeping the old city area is divided into beats (divisions) and 10,000 Sq. Feet area is allotted to one sweeper.
5. In the newly developed area 1,900 sweepers are engaged to clean the street of 541 Km of length. New Bhopal and BHEL area is generally cleaned by group of sweepers.
6. In 68 villages sweeping is done once in a week by a group of sweepers.
7. There are 88 colonies developed by BDA, Housing Board Colony and PWD where cleaning is not done by these sweepers.
8. The street sweeping is done by the team of 3 members, out of them one sweeps the street, other cleans open drains and the third one picks up the waste in the cart.
9. Transportation of the waste is done through various vehicles like trucks, trolleys, refuse compactors and dumpers etc. No transportation is done on public holidays and Sundays.
10. About 600 MT of SW is generated in the city per day. This is collected through street sweeping and from the communal waste storage sites.
11. MP State Agro Development Corporation has setup a compost plant of 120 MT per day capacity on a plot adjoining the landfill site.
12. The BMC has 30.4 hectares of land for waste disposal which is situated 16 Kms away from the city. The waste is disposed off at the landfill site in orthodox method of dumping.
13. The efficiency of the Solid Waste collection mechanism is low, where 60% of the Solid Waste generated is been collected and disposed.

14. The mechanism also lacks in the synchronization between the collection storage and transportation of Solid Waste Management.
15. The Waste is not at all segregated as Organic and Other Wastes.
16. The Municipal Corporation doesn't have Biomedical waste Disposal System.
17. No waste segregation done. Currently no waste segregation is done by BMC and only 20% of wastes are processed (Composting process).
18. Unscientific disposal technique the method of disposal is not scientific as per MSW rules 2000 for disposal of next 30 years

# CHAPTER 7

# STRATEGIES FOR SWM

# CHAPTER 7: STRATEGIES FOR SWM

## 7.1 TO COLLECT GARBAGE DATA

Presently the solid waste amount of the city is estimated by visual measurement, but not by actual measure of weight. Visual measurement usually involves personal error and this method is very difficult to get accurate reliable data. It is needed to collect the solid waste management data, such as collected garbage weight data, disposed garbage weight data and garbage generation data.

To make policy planning of solid waste management, not visual measurement, but measurement by a weighbridge is needed now.

1. To install weighbridge: At the entrance of final disposal site, a weighbridge, connected with a computer to record the data, will be installed to weigh the every truck.
2. The record of solid waste weight data. The recorded data consists of truck number, weight of truck, collection area, and collection time.
3. The analysis of solid waste generation (collection) and composition data.

To make future policy planning of solid waste management, correct data is needed calculating capacity and lifetime of landfill site or estimating efficient numbers of collection trucks. And tracing or surveying the data, effectiveness of solid waste management can be found.

Also each year, government should carry out the study of composition of water contents, study the increase of plastic pores and large burden on collection and land filling. Recently various new products of chemicals and compound materials are generating a large share of the market. Solid waste composition analysis should be conducted.

## 7.2 TO LEGISLATE SOLID WASTE MANAGEMENT LAW

The solid waste management law should be legislated. The law makes clearly to any activities concerned this waste management what part citizen; enterprise and government should take of responsibilities. Factory or company should treat especially industrial waste, which generated these under governmental control. Citizen, businessman, factory owner and even government should receive a punishment for activity in violation of the law of Solid Waste Management.

**Table 7.1 Considerable items**

| Items to be described | Explanatory substance |
|---|---|
| Industrial waste | Definition of industrial waste, Industrial waste collection, transportation and treatment system controlled by local government,<br><br>Responsibility of industry which generates waste, such as collection , transportation and treatment , Standardization of treatment facility,<br><br>Responsibility of private industrial solid waste management company |
| Service area | Solid waste management service should cover whole city area. |
| Responsibility | Roll and responsibility of citizen, Roll and responsibility of businessman and enterprise, Roll and responsibility of government. |
| Subsidy | Financial assistance from central government to local government for constructing solid waste management facility, such as sanitary landfill site, hospital incinerator, night soil treatment facility and transfer station. |
| Definition of solid waste management, collection, | To make clear the definition. |

| | |
|---|---|
| transportation, treatment and disposal | |
| Hospital waste | Definition of infectious hospital waste, Collection, transportation and disposal system of infectious hospital waste |
| Constructive standardization of solid waste treatment facility | To make clear the standards of solid waste treatment facility. |
| Punishment | Punishment for illegality of Solid Waste Management Law |
| Reduction, recycling strategy | Source reduction, reuse, recycling, material recycling |
| Solid waste management planning | Authority should make solid waste management planning for future 15years. |

Source : Author

## 7.3 TO MINIMIZE SOLID WASTE GENERATION

BMC should formulate solid waste reduction programs. Source reduction and resource recycling program, specifically

**Waste reduction activities in cooperation with citizens**

1. On site guidance for owners of office buildings,
2. Waste separation to make an easy waste recycling,
3. My Bag campaign
4. Promotion of using recycled products

**Waste reduction activities by the government**

5. Reducing the waste collection frequency from 3 times a week to 2 times a week,
6. Making local recycling center,
7. Every kinds of solid waste from business areas have being charged by BMC.

## 7.4 TO MAKE THE FINAL DISPOSAL SITE SELECTION AND SCREENING CRITERIA

To prevent environmental pollution or ground water contamination, it is an importance for determining the selection method of final disposal site, draft example of landfill site selection and screening criteria as followings,

**Table 7.2 Landfill Site Selection and Screening Criteria**

| Criteria | Absolute | Considerations |
|---|---|---|
| **Area Capacity**<br><br>**Haul Distance** | The site area should be sufficient for a landfill with a target service life of not less than10 years. | The area should be sufficient for a landfill with target service life of approximately more than 30 years this calculation based on 7.8 ha / 100,000 population, 0.5 kg / person / day, 0.7 t/m3 density and 10 m depth).<br><br>The minimum land area depends on the total service population, waste characteristics and generation rate, and expected landfill service life.<br><br>Avoid areas more than 25 km or 40 minutes travel time from the waste generation<br><br>If the distance or travel time is more than the indicated limits, investment in either larger transfer station may be necessary |
| **Social condition** | Proximity to Sensitive Land users | Avoid areas within 500 m of residential and industrial developments and within 1 km. |

| | | |
|---|---|---|
| | or airports The site should not be located in existing or proposed residential, commercial or urban development areas, and areas with archeological, cultural historical importance & an airport. | Of memorial sites, Mosques, schools, historical site is otherwise isolated from these sensitive receivers.<br><br>Avoid areas encroaching boundaries of any non-participating municipality.<br><br>The site should not be located within 5 km of an airport<br><br>The site should be located so as to reduce bird-strike hazard to aircraft. |
| **Geologic Conditions, Soil / Land Conditions & Topography** | The site should not be located within 500 m of active fault lines.<br><br>The site should not be located in soft and settling soils (sand, coarse sand, and fine sand) with a potential for liquefaction, | Avoid areas with sinkholes, caverns or solution channels.<br><br>Avoid jointed, fractured or fissured rocks, carbonate rocks (limestone) or other porous rock formations.<br><br>If the site is to be located within an area of fissured, fractured or similar rock, stringent engineering design will be required to avoid landfill gas and leachate migration to groundwater. |

| | | |
|---|---|---|
| | slumping or erosion. | Areas with underground mines should be avoided.<br><br>Avoid areas with highly permeable soils (loamy fine sand, loamy sand, sandy loam, fine sandy loam and very fine sandy loam). Use of areas with high permeability soils will necessitate the use of appropriate liners and engineering measures to contamination of groundwater by leachate and landfill gas migration.<br><br>Avoid hilly area with ground slopes. Land filling within hilly areas is feasible but steep slopes will increase the costs associated with the engineering and access inspection arrangements. |
| **Calamity**<br><br>Occurrence of Flooding or Seismic Conditions | | Avoid locating site in areas prone to Flooding. Also avoid salt lakes, swamplands.<br><br>Engineering design should include protected measures, such as impervious dikes and liners to protect sites against a 50- year flood.<br><br>Avoid areas with an average return period between 50 to 80 years for an earthquake of magnitude 6 and above.<br><br>If the entire municipality is subject to this |

| | | |
|---|---|---|
| | | seismic risk, engineering measures may be applied to avoid the risk of groundwater contamination |
| **Environmental Pollution & Local Ecological Conditions**<br><br>Proximity to Groundwater Resources or Perennial Surface Waters. | The site should not be located in or up gradient of shallow unconfined aquifers for drinking water supply.<br><br>The site should not be located within 500 meters up gradient of any surface waters used for drinking purposes. | The sites should not be located within ecologically sensitive areas proclaimed by law as national and conservations parks<br><br>Avoid areas considered part of a 10-year recharge area for existing or future potable water sources and confined aquifers (deep wells) for drinking water supply.<br><br>Avoid areas 500 meters up gradient of private or public drinking, irrigation or livestock water supply wells. Moreover consideration of groundwater level is needed.<br><br>Existing or future drinking wells may be abandoned if alternative water supply sources / sites are readily and economically available, and the owners have given written consent to the potential risk of abandoning their wells.<br><br>Avoid areas within 500 meters up gradient of a perennial river or stream.<br><br>The conditional requirement may be adjusted if it |

| | | |
|---|---|---|
| | | is feasible to protect the stream from contamination through engineering measures.<br><br>Avoid areas within 500 meters of any ecologically sensitive areas proclaimed by law. |
| **Current and Future Land use** | | The site should not be located in areas with valuable mineral and energy resources, tourist destinations or across major transportation routes.<br><br>Avoid areas classified as prime agricultural land and areas with major water, gas, electrical power or communication transmission infrastructure .The site may be located where there are existing infrastructure routes as long as their presence will not affect the landfill operation or rerouting is economically feasible. |

## 7.5 TO APPROACH GRADUALLY SEMI-AEROBIC SANITARY LANDFILL SITE

Semi Aerobic Landfill Site works as a leachate treatment facility. Inside of this landfill site, leachate is treated and quality is improved by itself at the same time of decomposition process. So the operation cost is also the least.

**Table: 7.3 Comparison among Semi-Aerobic Method and other conventional method**

| | Anaerobic Landfill Site •Open Dump• | Improved Sanitary Landfill Site | Semi-aerobic Landfill Site | Aerobic Landfill Site |
|---|---|---|---|---|
| Construction cost | • | • | • (Low) | ×(High) |
| Operation cost | • | • | • (Low) | × |
| Decomposition | × | × | • (Short) | •(Short) |
| Stabilization | × | × | • (Short) | •(Short) |
| Methane Gas Generation | × | × | • (small) | •(small) |

- • Good,
- • Moderate,
- × Negative

## 7.6 TO PROVIDE INFECTIOUS HOSPITAL WASTE MANAGEMENT TO HOSPITAL ADMINISTRATORS

First of all, Doctors, nurses and workers in the hospitals should be aware of how dangerous the infectious hospital wastes are.

The recycling activity of infectious hospital wastes is like to be a criminal action. Government has to crusade the recycling of infectious hospital waste, and has to start a campaign of stopping the recycle and to reconfirm those dangers for doctors, nurse, workers in hospitals and clinics.

# CHAPTER 8

# PROPOSALS, RECOMMENDATIONS AND CONCLUSION

# CHAPTER 8: PROPOSALS, RECOMMENDATIONS AND CONCLUSION

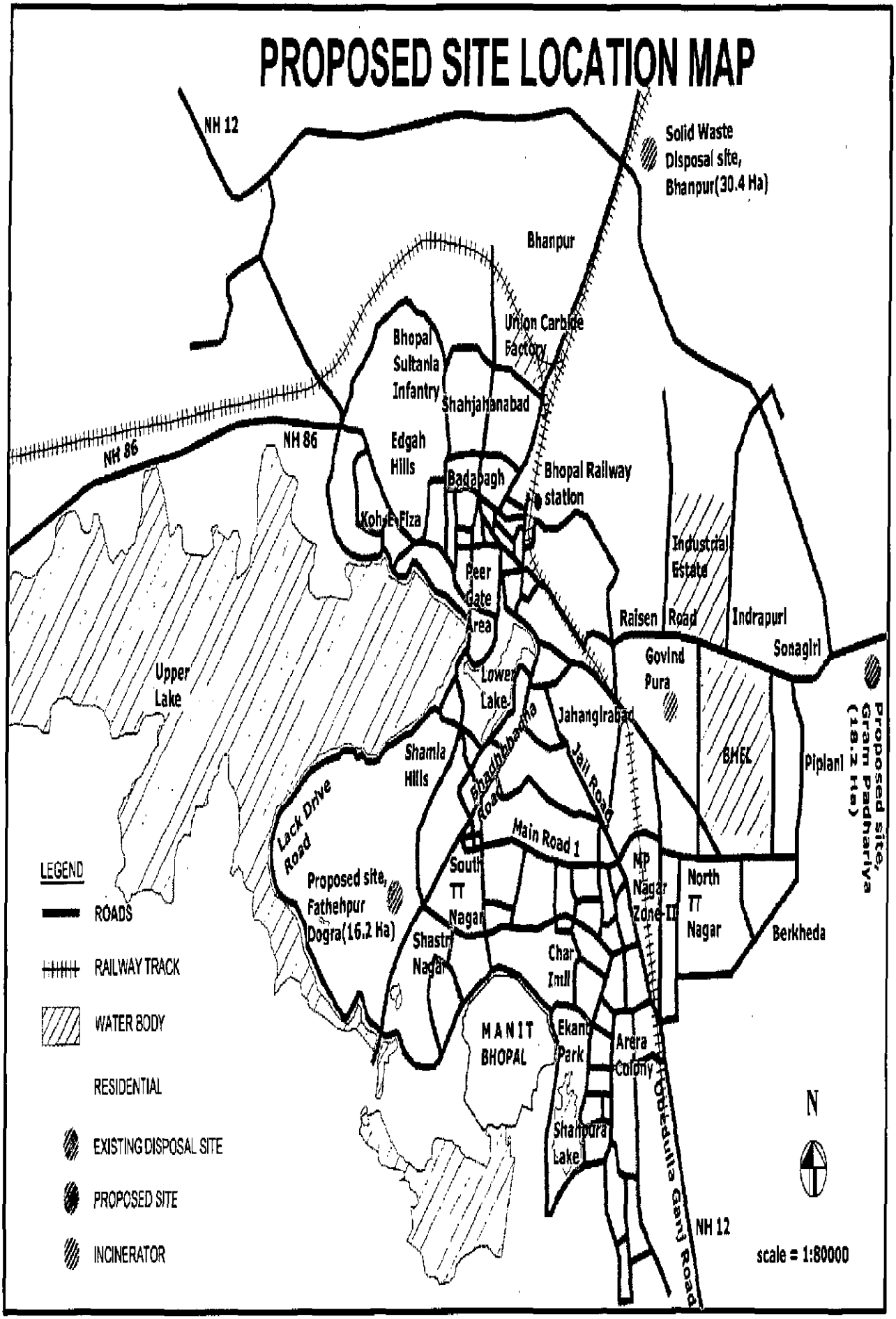
## 8.1 PROPOSALS FOR THE IMPROVEMENT OF SWM SYSTEM

1. There is only one site for disposal of solid waste, so acquire new site for disposal and treatment of solid waste, because the old site is situated north Bhopal that is too much away from south Bhopal.
2. The reduction at the source can be done by putting two types of plastic buckets in the house one for bio degradable waste and other for non biodegradable waste. The non biodegradable waste can be directly collected by rag pickers from the house the rag pickers can recycle that latter. In return of this the BMC can charge some nominal amount from the rag pickers. By this method the SW can be reduced at the source by 30 to 50 % and the problem of disposal can be solved to some extent.
3. Collection efficiencies shall be improved though the provision of appropriate containers (of 1m3 and 4.5 m3, depending on access and population density), using corporation sweepers and local community arrangements to convey domestic waste from household to the containers. With minimize manual handing.
4. Improved transportation of waste shall be by appropriate vehicles, minimizing manual handing. Compactor vehicles empty the waste mechanically from the 1 m3 containers into the compactors, whereas dumper placer trucks collect the lager 4.5 m3 containers for direct transport to the landfill site.
5. Improved final treatment and disposal of domestic solid waste, by the construction and use of a sanitary landfill, being the least-cost option available for waste disposal.
6. Garbage bins has to be provided at regular intervals of two types:

a. Local garbage bins at the interval of 100 meters of 1 tonnes capacity – Here people from the houses will come and throw the garbage.

b. Community garbage bins at the interval of 500 metes of 4.5 tonnes capacity - The sanitary workers will collect the SW from the local garbage points and dump them in the community bins. From here tractors and trippers will pick up the SW to the disposal sites. This has to be placed on the wide and main roads to provide enough space for the movement of vehicles.

7. In planned colonies housing societies can be held responsible for the maintenance of the open spaces of their area.
8. The industrial establishments, big shops, commercial, institutes, private institutes, shops, market complexes can be given the responsibility by the BMC to keep their surrounding area clean.
9. Increase the number of staff and no of vehicles to meet the requirements.
10. The required sanitary workers can be hired on contract basis also.


PROPOSED SITE LOCATION MAP
NH 12
Solid Waste
Disposal site,
Bhanpur(30.4 Ha)
Bhanpur
Union Carbide
Factory
Bhopal
Sultania
Infantry
Shahjahanabad
NH 86
NH 86
Edgah
Hills
Badabagh
Bhopal Railway
station
Kohe E Fiza
Industrial
Estate
Peer
Gate
Area
Raisen Road
Indrapuri
Sonagiri
Govind
Pura
Upper
Lake
Lower
Lake
Jahangirabad
Shamla
Hills
Bhadbhadaa
Road
Jail Road
BHEL
Piplani
Proposed site,
Gram Padhariya
(18.2 Ha)
Lack Drive
Road
Main Road 1
Proposed site,
Fathehpur
Dogra(16.2 Ha)
South
TT
Nagar
MP
Nagar
Zone-II
North
TT
Nagar
Berkheda
Shastri
Nagar
Char
Imli
MANIT
BHOPAL
Ekant
Park
Arera
Colony
Shahpura
Lake
Obedulla Ganj Road
NH 12
LEGEND
ROADS
RAILWAY TRACK
WATER BODY
RESIDENTIAL
EXISTING DISPOSAL SITE
PROPOSED SITE
INCINERATOR
N
scale = 1:80000

## 8.2 RECOMMENDATIONS

### 8.2.1 Collection of Municipal Solid Wastes

1. Littering of municipal solid waste shall be prohibited in city area notified by the State Governments. To prohibit littering and facilitate compliance, the following steps shall be taken by the municipal authority, namely:-
   a. Organizing house-to-house collection of municipal solid wastes through any of the methods, like community bin collection (central bin), house-to-house collection, collection on regular pre-informed timings and scheduling by using bell ringing of musical vehicle (without exceeding permissible noise levels);
   b. Devising collection of waste from slums and squatter areas or localities including hotels, restaurants, office complexes and commercial areas;
   c. Wastes from slaughter houses, meat and fish markets, fruits and vegetable markets, which are biodegradable in nature, shall be managed to make use of such wastes;
   d. Bio-medical wastes and industrial wastes shall not be mixed with municipal solid wastes and such wastes shall follow the rules separately specified for the purpose;
   e. Collected waste from residential and other areas shall be transferred to community bin by hand-driven containerized carts or other small vehicles;
   f. Horticultural and construction or demolition wastes or debris shall be separately collected and disposed off following proper norms. Similarly, wastes generated at dairies shall be regulated in accordance with the State laws;
   g. Waste (garbage, dry leaves) shall not be burnt;
   h. Stray animals shall not be allowed to move around waste storage facilities or at any other place in the city or town and shall be managed in accordance with the State laws.

2. The municipal authority shall notify waste collection schedule and the likely method to be adopted for public benefit in a city.
3. It shall be the responsibility of generator of wastes to avoid littering and ensure delivery of wastes in accordance with the collection and segregation system to be notified by the municipal authority.
4. Increased efficiency in primary collection of domestic solid waste from households and small commercial establishments, to at least 85% of households in high-density areas, and 60% in the lower density (generally) sub-urban areas, with minimize manual handing.

### 8.2.2 Segregation of Municipal Solid Wastes

In order to encourage the citizens, municipal authority shall organize awareness programmes for segregation of wastes and shall promote recycling or reuse of segregated materials. The municipal authority shall undertake phased programme to ensure community participation in waste segregation. For this purpose, regular meetings at quarterly intervals shall be arranged by the municipal authority with representatives of local resident welfare associations and non-governmental organizations.

Source segregation of solid waste is practiced in the city and shall be effectively increased and materials of value shall be segregated for recycling and income generation. Waste material from demolition sites such as timber, masonry and other process-able wastes shall be diverted to the transfer stations and reused. In consultation with Community development groups, creation of rag pickers' societies shall be initiated in slums. Based on a survey of process-able and recyclable wastes being generated and the various reuses they can be put to, such societies shall be facilitated in contacting all such

Units and industries that can reuse them, thereby creating a corporation assisted rehabilitation and employment generation program.

1. Improved and safer working conditions for municipal waste operators.
2. Improved final treatment and disposal of domestic solid waste
3. Improved management of the process in accordance with the recommendations of the Supreme Court.

### 8.2.3 Storage of Municipal Solid Wastes

Municipal authority shall establish and maintain storage facilities in such a manner as they do not create unhygienic and unsanitary conditions around it. Following criteria shall be taken into account while establishing and maintaining storage facilities, namely:-

1. Storage facilities shall be created and established by taking into account quantities of waste generation in a given area and the population densities. A storage facility shall be so placed that it is accessible to users;
2. Storage facilities to be set up by municipal authority or any other agency shall be so designed that wastes stored are not exposed to open atmosphere and shall be aesthetically acceptable and user-friendly;
3. Storage facilities or 'bins' shall have 'easy to operate' design for handling, transfer and transportation of waste. Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black;
4. Manual handling of waste shall be prohibited. If unavoidable due to constraints, manual handling shall be carried out under proper precaution with due care for safety of workers.

### 8.2.4 Transport Action of Municipal Solid Wastes

Vehicles used for transportation of wastes shall be covered. Waste should not be visible to public, nor exposed to open environment preventing their scattering. The following criteria shall be met, namely:-

1. The storage facilities set up by municipal authority shall be daily attended for clearing of wastes. The bins or containers wherever placed shall be cleaned before they start overflowing;
2. Transportation vehicles shall be so designed that multiple handling of wastes, prior to final disposal, is avoided.

### 8.2.5 Processing of Municipal Solid Wastes

Municipal authority shall adopt suitable technology or combination of such technologies to make use of wastes so as to minimize burden on landfill. Following criteria shall be adopted, namely:-

1. The biodegradable wastes shall be processed by composting, vermicomposting, anaerobic digestion or any other appropriate biological processing for stabilization of wastes.
2. Mixed waste containing recoverable resources shall follow the route of recycling. Incineration with or without energy recovery including pelletisation can also be used for processing wastes in specific cases. Municipal authority or the operator of a facility wishing to use other state-of-threat technologies shall approach the Central Pollution Control Board to get the standards laid down before applying for grant of authorization.

### 8.2.6 Disposal of Municipal Solid Wastes

Land filling shall be restricted to non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing. Land filling shall also be carried out for residues of waste processing facilities as well as pre-processing rejects from waste processing facilities. Land filling of mixed waste shall be avoided unless the same is found unsuitable for waste processing. Under unavoidable circumstances or till installation of alternate facilities, land-filling shall be done following proper norms.

### 8.2.7 Institutions

1. Bhopal Municipal Corporation
2. Private sector
3. Increased private sector and community participation
4. For the private sector involved in solid waste management, incentives shall be introduced for improved performance.

Awareness campaigns shall be taken up in all slums and through the midi about waste minimization, source segregation, healthy ways of storage at source and reuse. This is aimed at increasing level of community participation

## 8.3 CONCLUSION

SWM is a vital, ongoing and large public service system, which needs to be efficiently provided to the community to maintain aesthetic and public health standards. Municipal agency will have to plan and execute the system in keeping with the increasing urban areas and population.

The solid waste management in this city is not functioning properly. It is the matter of serious concern for this city. Every year in the rainy season infectious diseases spread due to the inefficient SWM, people become ill.

BMC has total 66 wards having population of 14, 33,351(Census 2001) lacks. Its area is 285 km2. There is no separate department for the management of solid wastes in BMC .In each division this wok is done under the supervision of sanitary inspector.

Bhopal is growing at the rate of 34% decadal growth or even more (there is no record of unauthorized construction and population). The population of this city went on increasing but the number of staff went on decreasing.

The study area of this project is the municipal area of Bhopal

This proposed project gives proposal for the improvement of the existing SWM system in Bhopal. Proposal will improve the SWM system including collection, transportation, segregation and disposal of the waste.

The proposed project will improve the environmental conditions of the city. City will have a healthy look and the image of the city will improve hence it will be one of the clean cities of the country.

When the solid waste management of the city will be better then the hygienic condition of the city will increase. City will become clean and beautiful.

There has to be systematic effort in the improvement in various factors like institutional arrangement, financial provisions, appropriate technology, operations management, human resource development, public participation and awareness, and policy and legal framework for an integrated SWM system. To achieve Cleanliness, which is next to Godliness, it is necessary to design and operate an efficient SWM system. Public co-operation is essential for successful operation of such a system. Finally, there is also a need to new site and technologies for improve solid waste management system of the city.

Finally, as noted earlier, successful MSWM depends on adequate financing, enabling legislation, and a supporting institutional and policy environment. In many cases this will require changes in the way government institutions currently operate and will necessitate recognition of the importance of effective MSWM for a city sustainable development.

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## ANNEXES

### Table A 1: Physical Characteristics of Municipal Solid Waste in Indian Cities

| Population range (in millions) | No. of cities surveyed | Paper | Rubber, leather and synthetics | Glass | Metal | Total compostable matter | Inert material |
|---|---|---|---|---|---|---|---|
| 0.1 to 0.5 | 12 | 2.91 | 0.78 | 0.56 | 0.33 | 44.57 | 43.59 |
| 0.5 to 1.0 | 15 | 2.95 | 0.73 | 0.56 | 0.32 | 40.04 | 48.38 |
| 1.0 to 2.0 | 09 | 4.71 | 0.71 | 0.46 | 0.49 | 38.95 | 44.73 |
| 2.0 to 5.0 | 03 | 3.18 | 0.48 | 0.48 | 0.59 | 56.67 | 40.07 |
| 5.0 and above | 04 | 6.43 | 0.28 | 0.94 | 0.80 | 30.84 | 53.90 |

Note: All values are in per cent calculated on wet weight basis.

Source: India infrastructure report

### Table A 2: Physical Composition of Municipal Solid Waste in 1 million plus Cities and State Capitals in India (Average values)

| | | Recyclables | | | | Others including inert | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name of the city | Total compostable | Paper, etc. | Plastic | Glass | Metal | Inert | Rubber and leather | Rags | Wooden matter | Coconut | Bones | |
| Indore | 48.97 | 6.10 | 5.77 | 0.55 | 0.15 | 31.02 | 2.95 | 2.41 | 1.17 | 0.91 | 0.00 | 100 |
| Bhopal | 52.44 | 9.01 | 12.38 | 0.55 | 0.39 | 18.88 | 0.09 | 2.65 | 1.35 | 2.25 | 0.01 | 100 |
| Dhanbad | 46.93 | 7.20 | 5.56 | 1.79 | 1.62 | 26.93 | 2.77 | 4.14 | 1.56 | 1.52 | 0.00 | 100 |
| Jabalpur | 48.07 | 7.67 | 8.30 | 0.35 | 0.29 | 26.60 | 2.15 | 4.42 | 1.49 | 0.66 | 0.00 | 100 |
| Jamshedpur | 43.36 | 10.24 | 5.27 | 0.06 | 0.13 | 30.93 | 2.51 | 2.99 | 4.29 | 0.22 | 0.01 | 100 |
| Patna | 51.96 | 4.78 | 4.14 | 2.00 | 1.66 | 25.47 | 1.17 | 4.17 | 1.43 | 2.34 | 0.89 | 100 |
| Ranchi | 51.49 | 3.17 | 3.45 | 1.79 | 1.45 | 25.92 | 1.45 | 4.97 | 2.74 | 3.19 | 0.38 | 100 |
| Bhubaneshwar | 49.81 | 5.74 | 5.70 | 0.46 | 0.79 | 27.15 | 2.10 | 3.21 | 2.85 | 2.20 | 0.00 | 100 |
| Ahmedabad | 40.81 | 5.28 | 5.29 | 0.79 | 0.30 | 39.28 | 0.92 | 5.00 | 1.22 | 1.02 | 0.10 | 100 |
| Nashik | 39.52 | 9.69 | 12.58 | 1.30 | 1.54 | 27.12 | 1.11 | 2.53 | 0.34 | 4.12 | 0.15 | 100 |
| Raipur | 51.40 | 8.31 | 7.07 | 0.76 | 0.16 | 16.97 | 1.47 | 3.90 | 1.43 | 6.44 | 0.08 | 100 |
| Asansol | 50.33 | 10.66 | 2.78 | 0.77 | 0.00 | 25.49 | 0.48 | 3.05 | 3.00 | 2.49 | 0.95 | 100 |
| Bangalore | 51.84 | 11.58 | 9.72 | 0.78 | 0.35 | 17.34 | 1.14 | 2.29 | 2.67 | 2.28 | 0.01 | 100 |
| Agartala | 58.57 | 8.11 | 4.43 | 0.98 | 0.16 | 20.57 | 0.76 | 2.17 | 0.00 | 2.56 | 1.69 | 100 |
| Agra | 46.38 | 6.12 | 8.72 | 0.85 | 0.11 | 30.07 | 1.97 | 3.92 | 1.68 | 0.19 | 0.00 | 100 |
| Allahabad | 35.49 | 7.27 | 10.33 | 1.23 | 0.40 | 31.01 | 1.83 | 7.34 | 2.08 | 2.74 | 0.30 | 100 |
| Daman | 29.60 | 10.54 | 8.92 | 2.15 | 0.410 | 34.80 | 2.60 | 4.90 | 1.60 | 4.48 | – | 100 |
| Faridabad | 42.06 | 8.57 | 13.73 | 0.83 | 0.18 | 26.52 | 2.52 | 4.14 | 1.26 | 0.19 | – | 100 |
| Lucknow | 47.41 | 6.87 | 7.45 | 0.92 | 0.29 | 18.01 | 5.38 | 9.48 | 2.10 | 2.09 | 0.00 | 100 |
| Meerut | 54.54 | 4.95 | 54.48 | 0.30 | 0.24 | 27.30 | 0.49 | 4.98 | 0.95 | 0.66 | 0.12 | 100 |
| Nagpur | 47.41 | 6.87 | 7.45 | 0.92 | 0.29 | 18.01 | 5.38 | 9.48 | 2.10 | 2.09 | – | 100 |
| Vadodara | 47.43 | 5.98 | 7.58 | 0.47 | 0.47 | 27.80 | 1.28 | 4.86 | 1.55 | 2.58 | – | 100 |
| Gandhinagar | 34.30 | 5.60 | 6.40 | 0.80 | 0.40 | 36.50 | 3.70 | 5.30 | 3.70 | 3.30 | – | 100 |
| Visakhapatanam | 45.96 | 14.46 | 9.24 | 0.35 | 0.15 | 20.77 | 0.47 | 2.41 | 0.68 | 5.51 | – | 100 |
| Dehradun | 51.37 | 9.56 | 8.58 | 1.40 | 0.03 | 22.89 | 0.23 | 5.60 | 0.32 | – | – | 100 |
| Ludhiana | 49.80 | 9.65 | 8.27 | 1.03 | 0.37 | 17.57 | 1.01 | 11.50 | 0.80 | 0.00 | – | 100 |
| Guwahati | 53.69 | 11.63 | 10.04 | 1.30 | 0.31 | 17.66 | 0.16 | 2.18 | 1.39 | 1.38 | 0.26 | 100 |
| Kohima | 57.48 | 12.28 | 6.80 | 2.32 | 1.26 | 15.97 | 0.18 | 1.86 | 1.70 | 0.00 | 0.35 | 100 |

*Note:* Increasing use of plastics is changing the composition of municipal solid waste and causing harm in the processing of waste.

## Table A 3: Chemical Characteristics of Municipal Solid Waste in Indian Cities

| Population range (in million) | Nitrogen as total Nitrogen | Phosphorous as $P_2O_5$ | Potassium as $K_2O$ | C/N Ratio | Calorific Value kcal/kg. |
|---|---|---|---|---|---|
| 0.1 to 0.5 | 0.71 | 0.63 | 0.83 | 30.94 | 1009.89 |
| 0.5 to 1.0 | 0.66 | 0.56 | 0.69 | 21.13 | 900.61 |
| 1.0 to 2.0 | 0.64 | 0.82 | 0.72 | 23.68 | 980.05 |
| 2.0 to 5.0 | 0.56 | 0.69 | 0.78 | 22.45 | 907.18 |
| 5.0 and above | 0.56 | 0.52 | 0.52 | 30.11 | 800.70 |

Source: India infrastructure report

## Table A 4: Chemical Characteristics of Municipal Solid Waste plus (Average Values) of 1 million plus Cities and State Capitals.

| Name of city | Moisture | ph Range | Volatile matter | C per cent | N per cent | P per cent as $P_2O_5$ | K per cent as $K_2O$ | c/n ratio | hcv Kcal/ kg |
|---|---|---|---|---|---|---|---|---|---|
| Indore | 30.87 | 6.37–9.73 | 38.02 | 21.99 | 0.82 | 0.61 | 0.71 | 29.30 | 1436.75 |
| Bhopal | 42.66 | 6.99–9.03 | 35.78 | 23.53 | 0.94 | 0.66 | 0.51 | 21.58 | 1421.32 |
| Dhanbad | 50.28 | 7.11–8.01 | 16.52 | 9.08 | 0.54 | 0.55 | 0.44 | 18.22 | 590.56 |
| Jabalpur | 34.56 | 5.84–10.94 | 46.60 | 25.17 | 0.96 | 0.60 | 1.04 | 27.28 | 2051 |
| Jamshedpur | 47.61 | 6.20–8.26 | 24.43 | 13.59 | 0.69 | 0.54 | 0.51 | 19.29 | 1008.84 |
| Patna | 35.95 | 7.42–8.62 | 24.72 | 14.32 | 0.77 | 0.77 | 0.64 | 18.39 | 818.82 |
| Ranchi | 48.69 | 6.96–8.02 | 29.70 | 17.20 | 0.85 | 0.61 | 0.79 | 20.37 | 1059.59 |
| Bhubaneshwar | 59.26 | 6.41–7.62 | 25.84 | 15.02 | 0.73 | 0.64 | 0.67 | 20.66 | 741.56 |
| Ahmedabad | 32 | 6.2–8.0 | 63.80 | 37.02 | 1.18 | 0.67 | 0.42 | 34.61 | 1180 |
| Nashik | 74.64 | 5.2–7.0 | 59 | 34.22 | 0.92 | 0.49 | – | 38.17 | 3086.51 |
| Raipur | 29.49 | 6.65–7.99 | 32.15 | 18.64 | 0.82 | 0.67 | 0.72 | 23.50 | 1273.17 |
| Asansol | 54.48 | 6.44–8.22 | 17.73 | 10.07 | 0.79 | 0.76 | 0.54 | 14.08 | 1156.07 |
| Bangalore | 54.95 | 6.0–7.7 | 48.28 | 27.98 | 0.80 | 0.54 | 1.00 | 35.12 | 2385.96 |
| Agartala | 60,.06 | 5.21–7.65 | 49.52 | 28.82 | 9.96 | 0.53 | 0.77 | 30.02 | 2427 |
| Agra | 28.33 | 6.21–8.1 | 18.90 | 10.96 | 0.52 | 0.60 | 0.57 | 21.56 | 519.82 |
| Allahabad | 18.40 | 7.13 | 29.51 | 17.12 | 0.88 | 0.73 | 0.70 | 19.00 | 1180.12 |
| Daman | 52.78 | 5.88–6.61 | 52.99 | 30.74 | 1.38 | 0.47 | 0.6 | 22.34 | 2588 |
| Faridabad | 34.02 | 6.33–8.25 | 25.72 | 14.92 | 0.80 | 0.62 | 0.66 | 18.58 | 1319.02 |
| Lucknow | 59.87 | 4.8–9.18 | 34.04 | 20.32 | 0.93 | 0.65 | 0.79 | 21.41 | 1556.78 |
| Meerut | 32.48 | 6.16–7.95 | 26.67 | 15.47 | 0.79 | 0.80 | 1.02 | 19.24 | 1088.65 |
| Nagpur | 40.55 | 4.91–7.80 | 57.10 | 33.12 | 1.24 | 0.71 | 1.46 | 26.37 | 2632.23 |
| Vadodara | 24.98 | – | 34.96 | 20.28 | 0.60 | 0.71 | 0.38 | 40.34 | 1780.51 |
| Gandhinagar | 23.69 | 7.02 | 44 | 25.5 | 0.79 | 0.62 | 0.39 | 36.05 | 698.02 |
| Visakhapatanam | 52.70 | 7.5–8.7 | 64.4 | 37.3 | 0.97 | 0.66 | 1.10 | 41.70 | 1602.09 |
| Dehradun | 79.36 | 6.12–7.24 | 39.81 | 23.08 | 1.24 | 0.91 | 3.64 | 25.90 | 2445.47 |
| Ludhiana | 64.59 | 5.21–7.40 | 43.66 | 25.32 | 0.91 | 0.56 | 3.08 | 52.17 | 2559.19 |
| Guwahati | 70.93 | 6.41–7.72 | 34.27 | 19.88 | 1.10 | 0.76 | 1.06 | 17.71 | 1519.49 |
| Kohima | 64.93 | 5.63–7.7 | 57.20 | 33.17 | 1.09 | 0.73 | 0.97 | 30.87 | 2844 |

Source: India infrastructure report

## Table A 5: Composting Plants in India

| No. | State | City | Facility manufacturer | Installed capacity |
|---|---|---|---|---|
| 1. | Andhra Pradesh | Vijayawada | Excel Industries Ltd | 125 TPD |
| 2. | | Thirumala | NA | NA |
| 3. | | Vizianagaram | NA | NA |
| 4. | Assam | Kamarup | NA | NA |
| 5. | Chhatisgarh | Dhamtari | NA | NA |
| 6. | | Rajnandgaon | NA | NA |
| 7. | | Jagdalpur | NA | NA |
| 8. | | Rakpur | NA | NA |
| 9. | | Korba | NA | NA |
| 10. | | Bhilai | NA | NA |
| 11. | | Durg | NA | NA |
| 12. | | Raigad | NA | NA |
| 13. | Delhi (UT) | Delhi | Nature And Waste Inc India (BALSWA Plant) | 500 TPD |
| 14. | | Delhi | Private Organo-PSOS Plant, (Tikri Plant) | 150 TPD |
| 15. | | Delhi | MCD Plant, Okla | 300 TPD |
| 16. | | Delhi | NDMC Plant, Okla | 300 TPD |
| 17. | Gujarat | Ahmedabad | Excel Industries Ltd, Ahmedabad | 500 TPD |
| 18. | | Junagadh | NA | NA |
| 19. | | Rajkot | NA | NA |
| 20. | Goa | Margao | M/s. Comets International Ltd | 40 TPD |
| 21. | Himachal Pradesh | Shimla | L&T | 100 TPD |
| 22. | | Solan | Janseva Trust | 50 TPD |
| 23. | | Sirmour | NA | NA |
| 24. | | Dharamshala | NA | NA |
| 25. | | Bilaspur | NA | NA |
| 26. | | Una | NA | NA |
| 27. | | Hamirpur | NA | NA |
| 28. | | Kangra | NA | NA |
| 29. | | Kullu | NA | NA |
| 30. | | Mandi | NA | NA |
| 31. | Karnataka | Bangalore | Karnataka Compost Development Corporation | 350 TPD |
| 32. | | Bangalore | Terra-Fersia Bio-Technologies Ltd | 100 TPD |
| 33. | | Mysore | Vennar Organic Fertilizer Pvt. Ltd | 200 TPD |
| 34. | | Mangalore | NA | NA |
| 35. | Kerala | Thiruvananthapuram | POABS Envirotech Pvt. Ltd | 300 TPD |
| 36. | | Kozhikode | NA | 300 TPD |
| 37. | | Adoor | NA | NA |
| 38. | | Attingal | NA | NA |
| 39. | | Chalakundy | NA | NA |
| 40. | Madhya Pradesh | Bhopal | M. P. State Agro Industries | 100 TPD |
| 41. | | Gwalior | NA | 120 TPD |
| 42. | Maharashtra | Nasik | M/s. Live Biotech | 300 TPD |
| 43. | | Aurangabad | M/s. Satyam Bio-fertilizer Co. Ltd | 300 TPD |
| 44. | | Thane | M/s. Leaf Biotech Ltd | 300 TPD |
| 45. | Meghalaya | Shillong | M/s. Anderson Biotech Pvt. Ltd | 150 TPD |
| 46. | Orissa | Puri | M/s. Krishi Rashyan, Kolkata | 100 TPD |
| 47. | Pondicherry | Pondicherry | Pondicherry Agro Services and Industries | 100 TPD |
| 48. | Tamil Nadu | Tiruppur | IVR Enviro Project (P) Ltd | 100 TPD |
| 49. | | Nagercoil | NA | NA |
| 50. | West Bengal | Kolkata | M/s. Eastern Organic Fertilizer P. Ltd | 700 TPD |

Source: India infrastructure report