# MUNICIPAL SOLID WASTE MANAGEMENT IN CHANDIGARH

Project Report submitted in partial fulfillment of the Degree of

Bachelor of Technology

In

Civil Engineering

Under the Supervision of

Mr. Mudit Mishra

By

Nilay Nikhanj (101657)

To

Department of Civil Engineering

Jaypee University of Information Technology

Waknaghat, Solan-173234, Himachal Pradesh

## CERTIFICATE

This is to certify that the project report entitled "**MUNICIPAL SOLID WASTE MANAGEMENT IN CHANDIGARH**" submitted by **Nilay Nikhanj (101657)** in partial fulfillment for the award of degree of B.Tech Civil Engineering of Jaypee University of Information Technology, Waknaghat has been carried out under my supervision.

This work has not been submitted partially or wholly to any other University or Institute for the award of this or any other degree or diploma.

Signature of supervisor …………………………

Name of Supervisor Mr. Mudit Mishra

Designation Lecturer, JUITW

Date ……………………..

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Date …………………….                                    Nilay Nikhanj

Place : JUIT Waknaghat B.tech(4th year), Civil Engg

**ABSTRACT**

Solid work is one of the biggest problems of India. In the past two decades population of India has increased to a very great extent. This project is an attempt to find the ways in which the enormous quantity of solid wastes currently disposed off on land can be reduced by recovering materials and energy from wastes, in a cost effective and environmental friendly manner.

In this thesis the present status of the city of Chandigarh has been studied. Looking at the present condition few proposals have been made and for that all the aspects of solid waste management have been taken into account. In the proposed system the main emphasis is on segregation, processing and landfilling. These few factors really hold the key for any good management system.

The author of this thesis work hopes that this work will be taken for reference when the rules for the solid waste management will be made.

## TABLE OF CONTENTS

**CHAPTERS**

**List Of Figures**

# List of Tables

# INTRODUCTION

## 1.1 General

Since the very beginning of this world all the living beings of this planet including animals, birds with human beings have been generating wastes for making their lives luxurious and pleasant in every possible way. Before the start of industrial revolution the major proportion of waste generated was managed by nature itself. But after industrial revolution some new forms of waste came into existence like introduction of polythene bags and some other types of polythene which were very hard to treat and thus they were a significant threat to environment, so from the starting of industrial revolution need to manage solid waste became increasingly important so as to reduce threat to human live and environment. With shift of the increasing population to cities, urban population densities increased, oil and natural gas heating grew in popularity, and society became increasingly industrialized. The two root causes for th increasing urgency of solid waste problems are urbanization and industrialization.

## 1.2 Need of Study

Municipal solid waste management (MSWM) is one of the major environmental problems of Indian cities. Improper management of municipal solid waste (MSW) causes hazards to inhabitants. Various studies reveal that about 90% of MSW is disposed of unscientifically in open dumps and landfills, creating problems to public health and the environment. Here we will study about the Municipal solid waste management of the beautiful city Chandigarh. Chandigarh is known for its well patterned roads and well managed traffic, and a neat and clean city. So it will be interesting to study the MSWM of this city.

## 1.3 Objectives of study

In the present study, an attempt has been made to provide a comprehensive review of the characteristics, generation, collection and transportation , disposal and treatment technologies of MSW practiced in Chandigarh. The study pertaining to MSWM for Indian cities has been carried out to evaluate the current status and identify the major problems. Various adopted treatment technologies for MSW are critically reviewed, along with their advantages and limitations. The study is concluded with a few suggestions, which may be beneficial to encourage the competent authorities to work towards further improvement of the present system.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 General

Waste is a pejorative term for unwanted materials. The term can be described as subjective and inaccurate because waste to one person is not waste to another.

Solid Waste means any garbage, refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facilities and other discarded materials including solid, liquid, semi-solid or contained gaseous material, resulting from industrial, commercial, mining and agricultural operations and from community activities, but does not include solid or dissolved materials in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges that are point sources.

### Municipal Solid Waste

MSW commonly known as trash or garbage, refuse or rubbish is a waste type consisting of everyday items that are discarded by the public.

The composition of municipal waste varies greatly from country to country. In countries which have a developed recycling culture, the waste stream consists mainly of intractable wastes such as plastic film, an un-recyclable packaging. At the start of the 20$^{th}$ century, the majority of domestic waste (53 %) in the UK consisted of coal ash from open fires. In developed countries without significant recycling it predominantly includes food wastes, yard wastes, containers and product packaging, and other miscellaneous wastes from residential, commercial, institutional and industrial sources.

## 2.2 Functional Elements of Municipal Solid Waste Management

The activities involved in the solid waste management have grouped into six functional elements:

1. Waste generation.
2. On-site handling, storage and processing.
3. Collection.

4. Transfer and transport.
5. Processing and recovery.
6. Disposal.

The interrelationship between the elements is shown in figure.

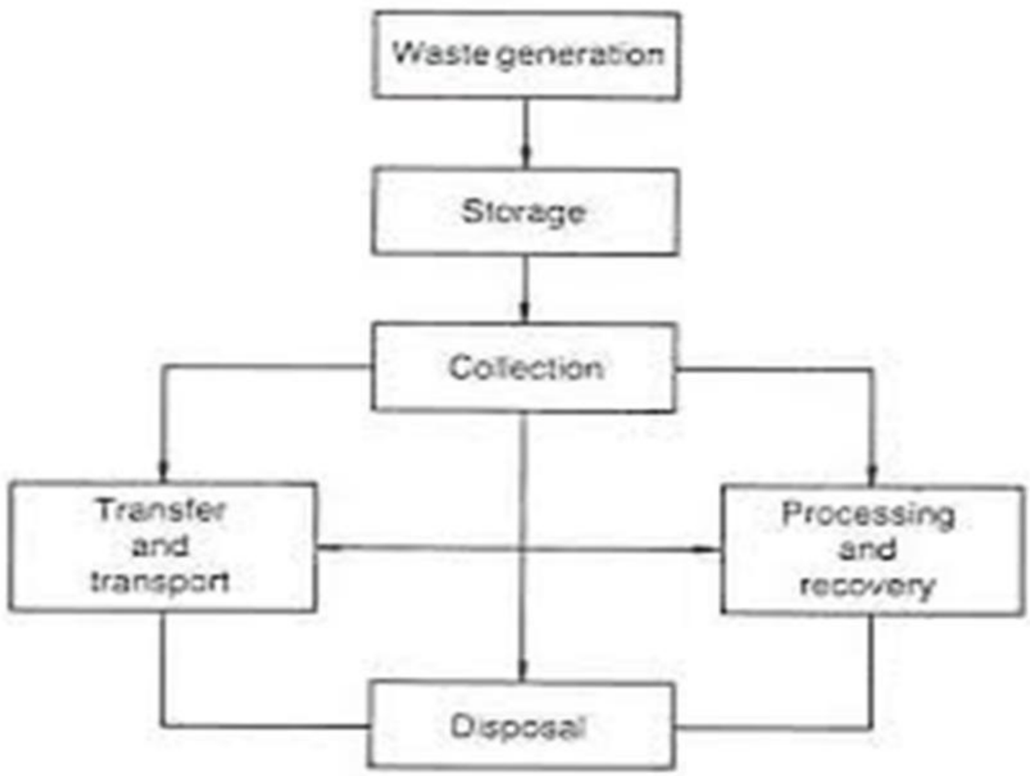


**Figure 1 : Functional elements in MSW**

### 2.2.1 Solid waste generation

Solid wastes include all solid or semisolid material that has no longer considered of sufficient value to be retained. Estimation of solid waste quantities:The quantity and general composition of the waste material that is generated is of critical importance in the design and operation of solid waste management.

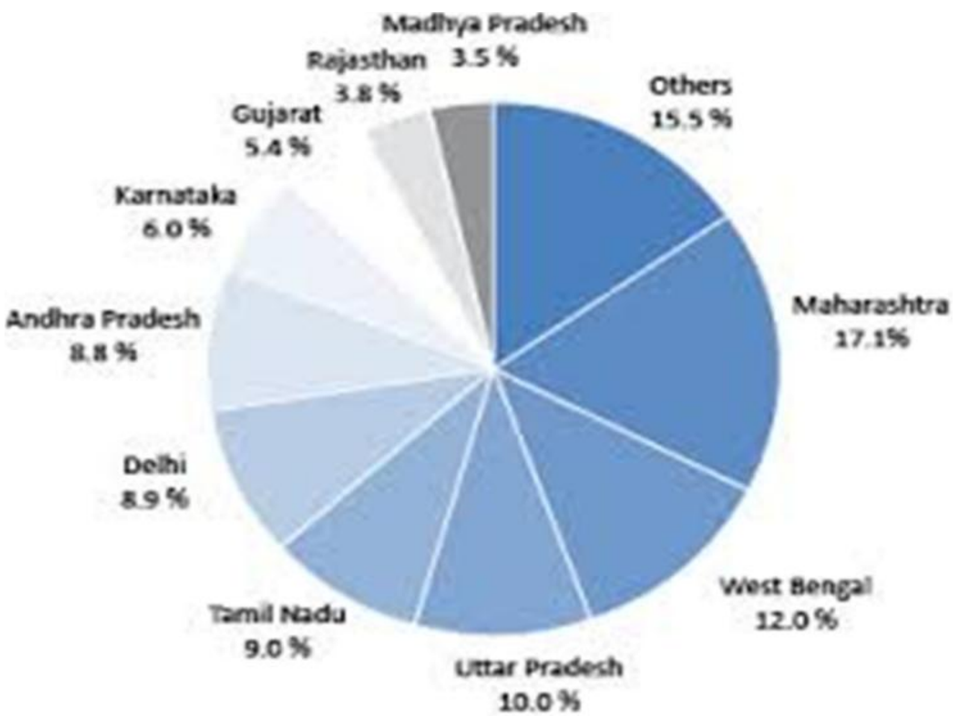


**Figure 2 : Share of states in urban MSW generated**

### 2.2.2 Waste handling and Storage at the source

**(a) On Site Handling:** refers to the activities associated with the handling of solid wastes until they are placed in the containers used for their storage before collection. It may also be required to move loaded containers to the collection point and to return the empty containers to the point where they are stored between collections.

**(b) On Site Storage:** The factors that must be considered in the on-site storage of solid wastes include.

1. Type of containers.
2. The container location.
3. Public health and aesthetics.
4. The collection method.

**Containers**

There are different types and capacities of containers used for on-site storage of solid wastes. But because of increasing costs (labo, workers compensation, fuel and equipment costs) there is a strong movement toward the use of large containers that can be emptied mechanically using a vehicle equipped with an articulated pick up mechanism.

**Container locations:**

In newer residential areas, containers are placed by the side or rear of the house. In old residential areas containers are placed in alleys. In high rise apartments storage containers are placed in a basement or ground floor service area.

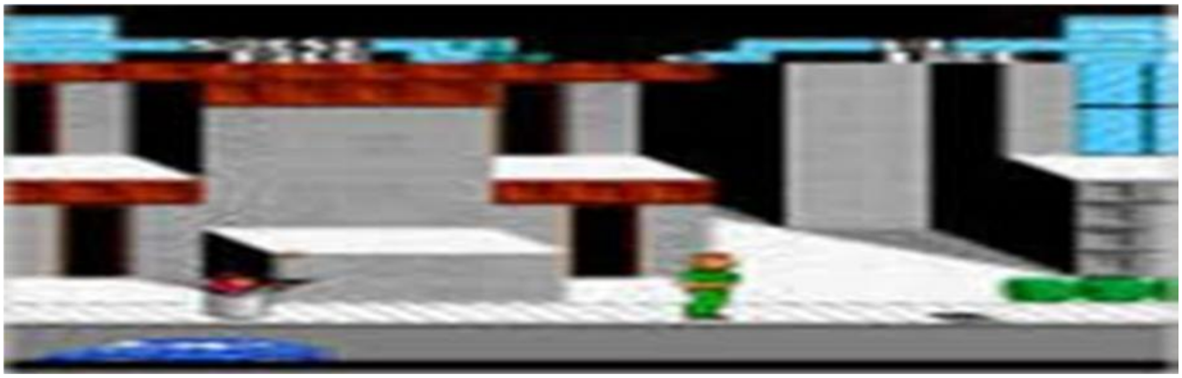

**Figure 3 : typical storage location for on-site containers for an apartment complex.**

### 2.2.3 Collection

This includes gathering the solid wastes and recyclable materials and transport of these materials to either the processing facility, transfer facility or the disposal site.

**Types of collection**

**Community bins –** they are placed in convenient locations, where the community members carry The waste and throw it in. This method is comparatively cheaper to other methods. This is the most widely adopted method in western countries. For this method to be adopted it is important that the bins are covered, they are aesthetic, they are attented to regularly, kept clean, easy to handle and separate bins are provided for recyclable, mixed, paper and biodegradable waste.

**Door to Door collection –** The waste is placed at the doorstep at a set time when the waste Collector arrives. In this method, it is the collector of the waste has the resbonsibility to collect the waste separately. This method is very convenient for the householder, however requires homeowner cooperation.

**Block collection –** the collection vehicles arrive at a particular place or a set day and time to collect waste from the households. Households bring their waste containers and empty directly into the vehicle.
This method requires a higher homeowner cooperation and scheduled service.

**Curbside collection –** the homeowner is responsible for placing the containers to be emptied at the curb on the collection day and for returning the empty containers to their storage location until the next collection.

### 2.2.4 Transfer

The transfer of wastes from smaller collection vehicle to larger transport vehicle and, the Subsequent transport of the wastes usually over long distances, to a processing or disposal site.

The transfer usually takes place at a transfer station.

In India many methods have been adopted for the transfer of waste from either the pushcarts to trucks or bins to truck. In Ahmedabad, door to door collection method is adopted. Here once the waste is collected in pushcarts, it is transferred to large covered metal bins having separate compartments for storage of segregated waste. The most common method or transfer is manual transfer from community bin to trucks by 2 to 3 workers. The transfer of waste directly from pushcarts to trucks by meeting at a specified time and place called synchronization points is suggested by (Karadimas,2004), which is a suitable option for the door to door collection method.

Transportation of waste is carried out by the municipalities employing vehicles like open trucks,tractor-trailers, tipper trucks and dumper placers. According to calculations done on a basis of waste density, waste generated etc. indicate that on an average 320m3 capacity is required for daily transportation of waste generated by 1 million population. However, a study carried out in 1996 stated that out of the 44 cities that were studied, 70% of these cities did not have 320m3 transport capacity (Boyar, et al 1996). Many improvements have been made since then including the introduction of container-carriers and dumper-placers that was done by 1997 (Gupta, et al 1998). Bangalore itself has about 13 dumper placers (Ramachandra, et al, 2003) that do two trips a day.

### 2.2.5 Sorting, processing and transformation of Solid Waste

This functional unit encompasses the recovery of the sorted materials, processing of solid waste and transformation of solid waste that occurs primarily in locations away from the source of facilities and disposal sites. Sorting includes separation of bulky items, separation of waste components by size waste generation.

Sorting of the mixed waste usually occurs at a material recovery facility, transfer stations, combustion using screens, manual separation of waste components, and separation of ferrous and non-ferrous metals.

**Waste processing and transformation:** Solid waste processing reduces the amount of material requiring disposal and, in some cases produces a useful product. Examples of solid waste processing technologies include material recovery facilities, where recyclable materials are removed and/or sorted; compo sting facilities where organics in solid waste undergo controlled decomposition; and waste-to-energy facilities where waste becomes energy for electricity.

Landfilling continues to be required even if solid waste processing technologies are employed because all of these technologies produce some sort of residue or handle only a portion of the waste stream. For example, landfilling is still required for ash and bypass Waste (waste that can't be burned) from waste-to energy facilities. Thus, solid waste processing technologies do not replace landfilling; rather they are a part of an integrated system that reduces the amount of material that requires landfill disposal.

**The different types of processing techniques are**

**Recycling and reuse -** the process, by which materials otherwise destined for disposal are collected, reprocessed or remanufactured and are reused. The recycling and reuse (the use of a product more than once in its same form for the same or other purpose) sector of waste management in cities of Asian developing countries is potentially high. Its economic assessment is a difficult task since it is practised in an informal way.

**Composting:** Composting is a biological process of decomposition carried out under controlled conditions of ventilation, temperature, moisture and organisms in the waste themselves that convert waste into humus-like material by acting on the organic portion of the solid waste (Sathishkumar, et al 2002). It produces a sludge, which is high in nutrients and can be used as a fertilizer. This is one element of an integrated solid waste management strategy that can be applied to mixed municipal solid waste (MSW) or to separately collected leaves, yard waste or food waste. There are various methods of composting, which are:

**Bangalore method -** This is an anaerobic method conventionally carried out in pits. The waste and the soil is alternatively laid out in layers and then is covered with a solid layer to prevent flies, odour and water seepage. This material is allowed to decompose for 4 to 6 months after which the stabilised material is taken out and used as compost.

**Indore method -** this method is similar to Bangalore method, however to ensure aerobic condition the material is turned at specific intervals. First turn is given manually after 4-7 days. 2nd turn is given after 5-10 days and further turning is normally not required and the compost is ready in 2 to 4 weeks.

**Windrow composting :** is a common method of composting, it involves the stabilization of organic solid waste through aerobic degradation. The waste is piled in heaps with approximately a height of 3 m, width of 1.5 m and varying lengths. The waste is left for 60 days for decomposition with weekly turnings to aerate the heaps. After which, it can be sieved and the compost is obtained.

**Vermicomposting:** is a comparatively new method in composting, it stabilizes the organic solid waste through earthworm consumption that converts the material into earthworm casting. Vermicomposting is the result of combined activity of microorganisms and earthworms.

The main Parameters, which determine the potential of recovery of energy from wastes

(including MSW), are:

- Quantity of waste, and
- Physical and chemical characteristics (quality) of the waste

The important physical parameters requiring consideration include:

- Size of constituents
- Density

* Moisture content

Smaller size aids in faster decomposition of the waste. Waste of high density reflects a high proportion of biodegradable organic matter and moisture. Low-density wastes, on the other hand, indicate a high proportion of paper, plastic and other combustibles.

High moisture content causes biodegradable waste fraction to decompose more rapidly than in dry conditions. It also makes the waste rather unsuitable for thermo-chemical conversion (incineration, pyrolysis / gasification) for energy recovery, as heat must first be supplied to remove moisture.

**Bio-chemical conversion**: This process is based on the enzymatic decomposition of organic matter by microbial action to produce methane gas or alcohol. It is preferred for wastes having high percentage of organic biodegradable (putriscible) matter and high level of moisture/water content, which aids microbial activity.

**Biogasification:** also called biomethanisation is the process of decomposing biomass with anaerobic bacteria to produce biogas. This process produces Biogas containing approximately 60:40 mixtures of methane (CH4), and carbon dioxide (C02) and simultaneously generating an enriched sludge fertilizer- with an energy content of 22.5 MJ/m3. In Anaerobic digestion (AD) the organic fraction of municipal solid waste offers the advantage of both a net energy gain by producing methane as well as the production of a fertilizer from the residuals (Edelmann, Wet aI2000).

**Landfill gas recovery :**The waste deposited in a landfill gets subjected, over a period oftime to anaerobic conditions and its organic fraction gets slowly volatilised and decomposed. This leads to production of landfill gas containing about 45-55% methane, which can be recovered through a network of gas collection pipes and utilised as a source of energy.

**Thermochemical conversion:**

**Incineration** -is one of the most effective means of dealing with many wastes, which reduces their harmful potential, and often to convert them to energy form.lncineration is the controlled burning of waste in a purpose built facility. It involves the process of direct burning of wastes in the presence of excess air at the temperatures of about 800°C and above (The Expert Committee, 2000). The process sterilizes and stabilises the waste. For most wastes, it will reduce its volume to less than a quarter of the original. Most of the combustible material is converted into ash and carbon dioxide (Sathishkumar, et al 2002). In practise, about 65-80 % of the energy content of the organic matter can be recovered as heat energy, which can be utilised either for direct thermal applications, or for producing power.

**Pyrolysis:** is also referred to as destructive distillation or carbonisation. It is the thermal decomposition of organic matter at high temperature (about 900°C) in an inert (oxygen deficient) atmosphere or vacuum, producing a pyroligenous liquid having high heat value and is a feasible substitute of industrial fuel oil. The fuel produced is very clean and has very desirable properties, and is a promising possible alternative to fossil fuels. IH2 produces oils with a low total acidic number of less than one percent for all the different biomass sources, and has a low oxygen level that so small it cannot be detected. The fuel produced has multiple uses including various applications for transportation and energy generation. The majority of fuel produced has a boiling point in ranges similar to gasoline and diesel, including boiling points appropriate for jet fuel.

### 2.2.6 The 3 Rs of Solid Waste Management

**Reduce**

Avoid wasteful consumption of goods. Begin by asking yourself: "Do I really need it?" Indoing so, we minimize waste and conserve our natural resources. Reduce the amount ofunnecessary packaging. Adopt practices that reduce waste toxicity.

**Reuse**

Whenever practicable, reuse items that are still useful instead of just throwing them away. Maintain and repair durable products. Borrow, rent or share items that are not usedfrequently. Sell or donate goods instead of throwing them out. **It** would greatly help if wepatronize goods that are reusable, rather we patronize goods that are reusable, rather thanthrowaway types.

**Recycle**

Waste should be treated as a valuable resource. Items that are useless or oflittle value to one person often have significant value to another within a different setting or time. The process whereby portions of waste material are sorted and used for something of benefit is called recycling.

**2.2.7 Disposal**

Non-engineered disposal: This is the most common method of disposal in low-income countries, which have no control, or with only slight or moderate controls. They tend to remain for longer time and environmental degradation could be high, include mosquito, rodent and water pollution, and degradation of the land.

**Sanitary Landfill -** method of controlled disposal of municipal solid waste (refuse) on land. The method was introduced in England in 1912 (where it is called controlled tipping). Waste is deposited in thin layers (up to 1 metre, or 3 feet) and promptly compacted by heavy machinery (e.g., bulldozers); several layers are placed and compacted on top of each other to form a refuse cell (up to 3 metres, or 10 feet, thick). At the end of each day the compacted refuse cell is covered with a layer of compacted soil to prevent odours and windblown debris. All modern landfill sites are carefully selected and prepared (e.g., sealed with impermeable synthetic bottom liners) to prevent pollution of groundwater or other environmental problems. When the landfill is completed, it is capped with a layer of clay or a synthetic liner in order to prevent water from entering. A final topsoil cover is placed, compacted, and graded, and various forms of vegetation may be planted in order to reclaim otherwise useless land--e.g., to fill declivities to levels convenient for building parks, golf courses, or other suitable public projects.

In India in many metropolitan cities, open, uncontrolled and poorly managed dumping is commonly practiced, giving rise to serious environmental degradation. More then 90% of MSW in cities and towns are directly disposed of on land in an unsatisfactory manner. Such dumping activities in many coastal towns has lead to heavy metals rapidly leaching into the

coastal waters. In the majority of urban centers, MSW is disposed of by depositing it in low-lying areas outside the city without following the principles of sanitary landfilling. Compaction and levelling of waste and final covering by earth are rarely observed practices at most disposal sites.

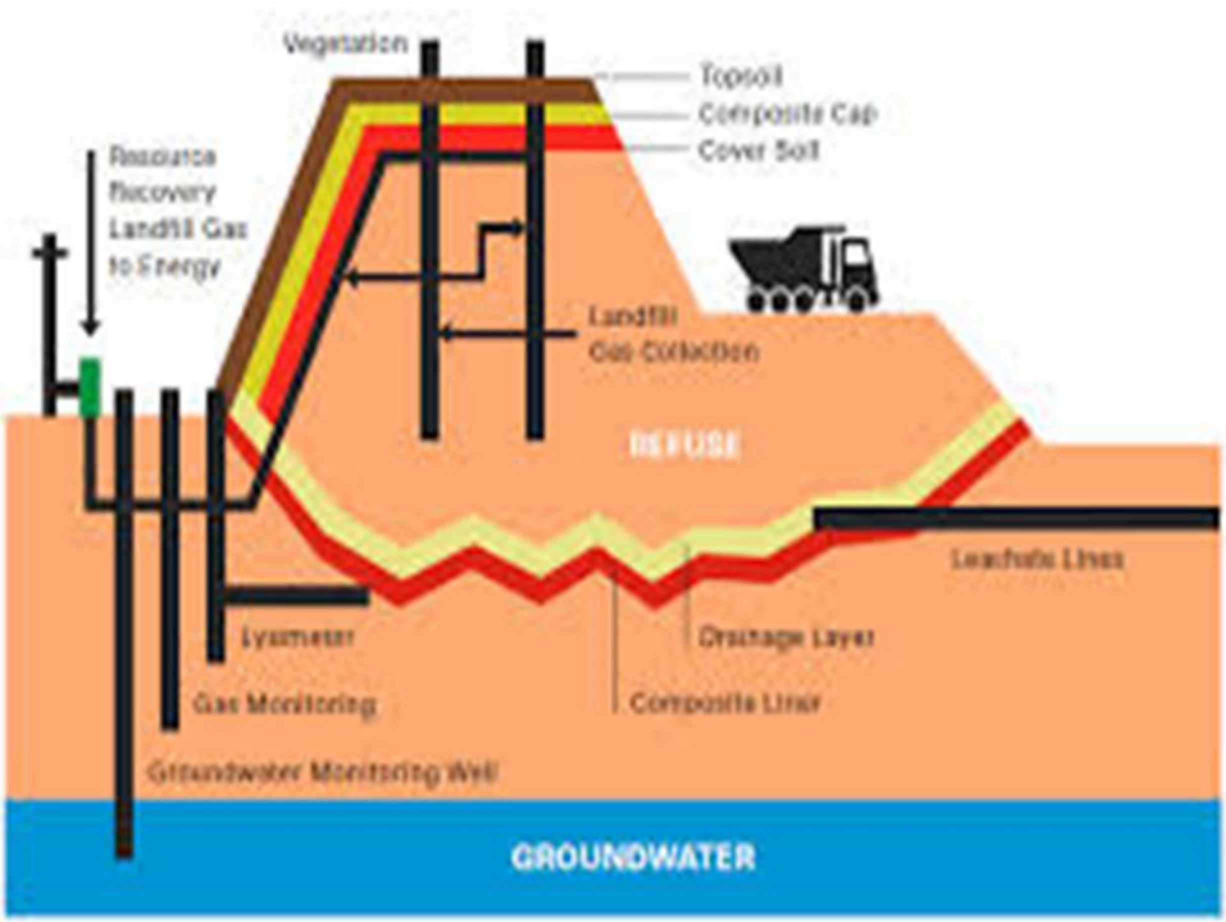


**Figure 4: Landfilling**

### 2.3 Case Studies

Solid Waste Management in Indian cities has emerged as a major concern over the past fewyears. The rise in urban population and economic growth in the absence of an effective management mechanism has manifested in the current state of solid waste management in

Indian cities which is far from perfect. Given the present situation, the quantum of waste generated in cities especially larger ones with higher population is expected to increase. Greater attention needs to be focused towards devising appropriate and effective mechanisms for waste treatment and disposal in urban centres.

**Table 1: Per capita generation, disposal and collection efficiency of MSW for India states**

| S.No | State | Per capita generation | Per capita disposal | Collection efficiency |
|---|---|---|---|---|
| 1. | India | 377 | 273 | 72 |
| 2. | Andhra | 346 | 247 | 74 |
| 3. | Bihar | 411 | 242 | 59 |
| 4. | Gujarat | 297 | 182 | 61 |
| 5. | Karnatka | 292 | 234 | 80 |
| 6. | Haryana | 326 | 268 | 82 |
| 7. | Kerala | 246 | 201 | 82 |
| 8. | Madhya | 229 | 167 | 73 |
| 9. | Maharashtra | 450 | 322 | 72 |
| 10. | Orissa | 301 | 184 | 61 |
| 11. | Punjab | 502 | 354 | 71 |
| 12. | Rajasthan | 516 | 322 | 62 |
| 13. | Tamil Nadu | 294 | 216 | 73 |
| 14. | Uttar Pradesh | 439 | 341 | 78 |
| 15. | West Bengal | 158 | 117 | 74 |

**Table 2: SWM system of various cities of india**

| S.n | City | State | Region | Class | Number | Quantum of generated (TPD) | Quantum of supplied the landfill (TPD) | Waste to the Dumps (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | Agartala | Tripura | NE | 1 | 1 | 200 | 100 | 20 |
| 2 | Ahmedaba | Gujarat | Western | 1 | 1 | 2300 | 1800 | 78 |
| 3 | Asansol | West Bengal | Eastern | 2 | 2 | 250 | 230 | 92 |
| 4 | Chandigar | UT | Norther | 2 | 1 | 400 | 300 | 75 |
| 5 | Delhi | Delhi | Norther | I | 3 | 6800 | 6400 | 94 |
| 6 | Faridabad | Haryana | Norther | I | 4 | 450 | 375 | 83 |
| 7 | Greater Murnbai | Maharashtra | Western | I | 4 | 6500 | 6500 | 100 |
| 8 | Guwahati | Assam | NE | 1 | 1 | 350 | 150 | 42 |
| 9 | Indore | Madhya | Central | 1 | J | 600 | 325 | 54 |
| 10 | Jaipur | Rajasthan | Western | 2 | 2 | 1100 | 990 | 90 |
| 11 | Jamshedp | Jharkhand | Eastern | 1 | 2 | 280 | 240 | 85 |
| 12 | Kanpur | Uttar Pradesh | Norther | 1 | 1 | 1500 | 1200 | 80 |
| 13 | Kochi | Kerala | Souther | I | I | 250 | 25 | 10 |
| 14 | Kozhikod | Kerala | Souther | 2 | 1 | 300 | 50 | 16 |
| 15 | Lucknow | Uttar Pradesh | Norther | 1 | N il | 1198 | 1050 | 87 |
| 16 | Ludhiana | Punjab | Norther | 1 | 2 | 850 | 850 | 100 |
| 17 | Mangalore | Karnataka | Souther | 2 | 1 | 200 | 175 | 87 |
| 18 | Mysore | Karnatka | Souther | 2 | I | 350 | 150 | 43 |
| 19 | Pune | Maharashtra | Western | 1 | 1 | 1300 | 1000 | 90 |
| 20 | Shirnla | Himachal | Norther | 2 | 1 | 65 | 40 | 61 |
| 21 | Surat | Gujarat | Western | I | 2 | 1225 | 1175 | 95 |
| 22 | Vadodara | Gujarat | Western | I | 1 | 550 | 300 | 54 |

### 2.3.1 Snapshot of Potential Cities

**Delhi**

The city of Delhi generates 6500 TPD of waste and currently has three dumpsites, where6400 TPD of waste is supplied.Thecity hasan engineered landfill.

**Kanpur**

The city of Kanpur generates 1500 TDP of waste and supplies 1200 TDP of it to the dumpsite. The city does not have an engineered landfill.

**Jaipur**

The city of Jaipur generates **1100** TPD of waste and supplies 990 TPD to its twodumpsites. The city is under the process of constructing an engineered landfill.

**Pune**

The city of Pune generates 1300 TPD of waste and supplies 1000 TPD to its single dumpsite. The city does not have an engineered landfill.

**Surat**

The city of surat generates 1255 TPD of waste and supplies 1175 TPD to two of its dumpsites. The city already has an engineered landfill and is in the process of developing a second one as well.

**Ludhiana**

The city of Ludhiana generates 850 TDP of waste and supplies 850 TDP to its two dumpsites. The city does not have an engineered landfill.

**Ahmedabad**

The city of Ahmedabad generates 2300 TDP of waste and supplies 1800 TDP to the dumpsite.

# Chapter 3

## Present Status of SWM in Chandigarh

### 3.1 General Description of the city

Chandigarh is a city in Northern India that serves as the capital of the states of Punjab and Haryana. The city of Chandigarh was the first planned city in India post - independence in 1947 and was known internationally for its architecture and urban design. The city was reported to be the cleanest in India in 2010, based on a national government study.

### 3.1.1 Location

Chandigarh is located near the foothills of the sivalik range of the Himalayas in northwest India. The exact cartographic co-ordinates of Chandigarh are 30.74°N 76.79°E. The surrounding districts are Mohali, Patiala and Roopnagar Punjab, Panchkula and Ambala Haryana. The boundary of the state of Himachal Pradesh is also minutes away from its north border. It has an average elevation of 321 metres (1053 ft).

### 3.1.2 Climate

Chandigarh has a humid subtropical climate characterised by a seasonal rhythm: very hot summers, mild winters, unreliable rainfall and great variation in temperature (−1 °C to 46 °C). The average annual rainfall is1110.7 mm. The city also receives occasional winter rains from the Western Disturbance originating over the Mediterranean Sea. Cold winds usually tend to come from the north near Shimla, capital of Himanchal Pradesh and from the state of Jammu and Kashmir, both of which receive their share of snowfall during wintertime.

### 3.1.3 Demography

As of 2011 India census, Chandigarh had a population of 960,787 with metro populationof 1,025,682, making for a density of about 9258 (7900 in 2001) persons per square kilometer Males constitute 55% of the population and females 45%. The sex ratio is 829 females for every 1,000 males which is the lowest in the country, up from 777 in 2001. Chandigarh has an average literacy rate of 86.77%, higher than the national average; with male literacy of 90.81% and female literacy of 81.88%. 10.8% of the population is under 6 years of age.

## 3.2 Municipal Corporation Chandigarh

An Ordinance namely the Punjab Municipal Corporation Act, 1976 as extended to Union Territory Chandigarh by the Punjab Municipal Corporation Law (Extension to Chandigarh ) Ordinance, 1994 was promulgated by the President of the India with effect from 24th day of May 1994 and the Municipal Corporation of Chandigarh came into being.

Under Section 4 of the aforesaid ordinance, the Govt. of India appointed Sh. A.R. Talwar, Finance Secretary, Chandigarh Administration as Special Officer to exercise the powers and discharge the functions of Municipal Corporation, Chandigarh until the day on which the first meeting of the Corporation is held after the commencement of this Ordinance.

Aforesaid Ordinance took the shape of the Act namely the Punjab Municipal Corporation Act, 1976 to as extended the Union Territory Chandigarh by the Punjab Municipal Corporation Law (Extension toChandigarh ) Act, 1994.( Act No. 45 of 1994 )

As per provision contained in Section 47of the aforesaid Act Shri M.P. Tyagi, I.A.S. was appointed as first Commissioner of the Corporation w.e.f. 19.5.1995 and thereafter and Sh. S.K. Gathwal, I.A.S. replaced him w.e.f. 8.7.1996. The said commissioners continued to exercise the powers to discharge the functions of the Municipal Corporation, Chandigarh until 23.12.1996 i.e. the day the first meeting of the elected body of the Corporation was held.

**Corporation shall be composed of the following member, namely :-**

(i) member to be directly elected, representing wards :

(ii) nine members with voting rights to be nominated by the Administrator, from amongst the persons who are eminent of distinguished in public affairs or those who have special knowledge or practical experience in respect of municipal administration.

(iii) the member of the House of the people representing the constituency which comprises wholly or partly, the Municipal Area, with the right the vote.

The Corporation, unless sooner dissolved shall continue for five years from the date Corporation appointed for its first meeting and no longer.

**Table 3: List of commissioners**

| S.no. | **Name** | **From** | **To** |
|---|---|---|---|
| **1** | Sh. M.P. Tyagi | 19-05-95 | 27-08-96 |
| **2** | Sh. Satish Gathwal | 27-08-96 | 08-07-99 |
| **3** | Sh. M.P. Singh | 08-07-99 | 06-12-04 |
| **4** | Sh. P.S. Aujla | 06-12-04 | 06-12-2007 |
| **5** | Dr. Roshan Sunkaria | 16-04-08 | 15-04-2011 |
| **6** | Sh. Brijendra Singh | 15-04-2011 | 01-06-2011 |
| **7** | Mrs Prerna Puri | 02-06-2011 | 28.02.2012 |
| **8** | Mr Vivek Pratap Singh | 28.02.2012 | |

### 3.3 Current Status of Solid Waste Management in Chandigarh

In Chandigarh, MSW generation is 360.85 gm/capita/day – 0.146 ton/capita/year.

Municipal Corporation, Chd. is collecting daily around 370 tonnes of municipal waste, out of 380 tonnes generated daily, from all over Chandigarh and hand over the waste to the Processing Plant at Dadu majra which process the waste and convert that into RDF (Revised Derived Fuel) and dump the rejected into Dumping Ground at Dadu majra.

### 3.4 Current System

The Municipal Corporation of Chandigarh is doing its best to manage the solid waste generation and to minimize its effect as under:

*SANITATION DEPARTMENT*

The Health Department of the Municipal Corporation is headed by **Additional Commissioner-I** The City Municipal Corporation has deployed a work force of 1652 Safaiwalas in its regular pay-scales and 112 safaiwalas on daily wages basis for sweeping the roads and lanes and for the collection of street sweepings etc. As per census for the year 2001 total population of Chandigarh is 8,06,515 and the length of road is 1489 kms. In addition some areas have been given on contract for its maintenance of sanitary condition and the contractors have deployed 433 safaiwallas. The roads and lanes are swept daily in two shifts.The shifts are as under :-

| | **Morning Shift** | **Afternoon Shift** |
|---|---|---|
| **WINTER** | 7.00 A.M. to 12.00 P.M. | 2.00 P.M. to 5.00 P.M. |
| **SUMMER** | 6.00 A.M. to 11.00 A.M. | 3.00 P.M. to 6.00 P.M. |

*LIST OF SANITATION ZONES*

The whole city has been divided into four zones are per details given below and the supervisior has been made the incharge of the Zones for the purpose of Sanitation and refuse removal services:-

| INCHARGE OF ZONES | AREAS |
|---|---|
| Sh. R.R.Yadav, Health Supervisior | Sector 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 15, 16, 17, 18, 19, 26, 27, 28 and Khuda Jassu Colony, Dhanas Colony, Indl. Area Phase I, Colony No. 4, Bapu Dham Colony, Transport Area, Timber Market, Police Colony |
| Sh. P.K.Pushkarna, Health Supervisior | Sector 20, 21, 22, 23, 24, 25, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 38 (West), 44, 45, 46, 47, 48, 49, 50, 51, D.M.C. and Village Dadu Majra, Shahpur Colony, Indl. Area Phase II, Ram Darbar, Hallo Majra, Deep Complex, Air port Road, Labour Colony No. 5, Vill. Burail, Village Faidan |
| Sh. Jagjit Singh, Health Supervisior | Sector 39, 40, 41, 42, 43, 52. 61, 55 and 56, Pandit Colony, Kuldeep Colony, Madrasi Colony, Nehru Colony, Adarsh Colony, Shastri Colony, Village Attawa, Badheri, Buterla, Kajheri, Palsora, Maloya and Maloya Colony |

**Table 4: List of Sanitation Zones**

The sweeping work is done on all working days from Monday to Saturday and as per requirement on Sunday and holidays due to he visit of V.I.Ps and V.V.I.P and on the occasion of processions and demonstrations etc.

*GARBAGE COLLECTION BINS*

The city corporation has provided garbage collection containers at strategic paints as per details given below where the residents of adjoining areas are required to dispose off their house hold and horticulture waste either individually or collectively by privately organized door to door collection on cost recovery basis.

- Garbage Bin of 6.5 Cu Ms – 45
- Garbage Bin of 4.5 Cu Ms – 580

### 3.5 TRANSPORATION AND DISPOSAL OF MSW:

The Corporation has deployed 48 drivers and 9 cleaners on the vehicles engaged in the transportation of M.S to Additional Drivers are engaged on contract as and when required. Besides that 4 to 6 Safai walas are deputed on each tractor open truck fand compactor and one Safaiwala in each dumper placers. About 300 tonns of Municipal Solid waste is transported and disposed off at the site of dumping ground situated at the west of Sector 38 near Dadu Majra Labour colony. At present the waste is disposed off through the process of 'Land-filling'. The Corporation is in the process of establishing facilities for the processing of Municipal solid waste by converting it into compost and wormi-compost. The corporation has engaged karnatka compost development Corporation as consultant for the said project. The proposal for setting up a unit for power generation is also in the pipe line.

**Table 5: Details of Solid Waste Management Vehicles**

| NAME OF VEHICLE | NO OF VEHICLES |
|---|---|
| Tractors | 19 |
| Dumper Placers | 31 |
| Compactors | 6 |
| Carrier Sets | 12 |
| Trallies | 7 |
| Open Trucks | 2 |
| J.C.B. | 1 |
| Tippers | 2 |
| Bob-Cat | 1 |
| Heavy Chain Buldozer | 1 |
| | |

### 3.6 Treatment

#### 3.6.1 Dadu majra plant

The municipal solid waste processing plant in Dadu Majra in Sector 25 West, Chandigarh, India, was inaugurated on 21st May. This plant is for the benefit of the common man and only need is to sustain this project to make it a success. This would not only rid the city of stink and pollution but would provide

eco-friendly alternative fuel. The plant, a public private initiative between Jaiprakash Associates Ltd and the Municipal Corporation, Chandigarh, has been completed in a stipulated time frame as per the agreement which was signed on 30th December 2005 and its foundation stone was laid by Gen Rodrigues on 21st February 2006, said Mr. Rajiv Gaur, President, Jaiprakash Associates Limited.

**Figure 5: A view of plant**

**Figure 6 : Treatment plant**

### 3.6.2 Site sensitivity index for landfilling

The main concerned agency CPCB had selected a set of 32 attributes for the calculation of an integratedindex for ranking of municipal solid waste disposal sites. The selected attributes are grouped into'Zcategories viz accessibility, receptor, environmental, socioeconomic,waste management

practices, climatological and geological. Sensitivity Index is a scale indicating degree of sensitivity of individual attribute. This scale ranges from '0' (indicating low or very less potential hazard) to '1' (indicating a high potential hazard).Thus, for each attribute a four level sensitivity scale (00.25, 0.25-0.50, 0.50-0.75 and

0.75-1.00)has been considered. A numerical value called weight has been assigned to each category,in accordance with the relative magnitude of impact using a pair wise comparison technique.Within a category, the weight of each attribute is assigned by following the same procedureof pair wise comparison. A total of 1000 points weights are assigned to all the 32 attributesgrouped into 7 categories shown in the table.

**Table 6 : Standard for the development of site sensitivity index**

| Table for the development of site sensitivity index | | | | | |
|---|---|---|---|---|---|
| **S.No.** | Attribute | 0.0-0.25 | 0.25-0.50 | 0.50-0.75 | 0.75-1.00 |
| accessibility related | | | | | |
| 1 | type of road | NH | SH | Local road | no road |
| 2 | Distance from collection area | <10 kms | 10-20 kms | 20-25 kms | >25 kms |
| Receptor related | | | | | |
| 3 | Population within 50 mts | 0-100 | 100-250 | 250-1000 | >1000 |
| 4 | Distance to nearest drinking water source | >5000 m | 2500-5000 m | 1000-2500 m | <1000 m |
| 5 | Use of site by near by residents | Not used | Occasional | Moderate | regular |
| 6 | Distance to nearest building | >3000 m. | 1500-3000 m | 500-1500 m | <500 m |
| 7 | Land use/zoning | Completely remote | Agricultural | Industrial | Residential |
| 8 | Decrease in property value | >5000 m | 2500-5000 m | 1000-2500 m | <1000 m |
| 9 | Public utility facilty within 2 kms | Industrial area | Airport | Hospital | National heritage |
| 10 | Public acceptibility | Fully accepted | with suggestions | with major changes | not accepted |
| Environmental related | | | | | |
| 11 | Critical environment | not critical | pristine, natural area | wetlands, flood plains | habitation of endangered species |

| | | | | | | |
|---|---|---|---|---|---|---|
| 12 | | distance to nearest surface water | >8000 m | 1500-8000 m | 500-1500 m | <500 m |
| 13 | | Depth to ground water | >30 m | 15-30 m | 5-15 m | <5 m |
| 14 | | Contamination | No | Soil only | biological | Air, water |
| 15 | | water quality | Standard | potable | Polluted | highly polluted |
| 16 | | Air quality | residential standard | Industrial standard | Polluted | highly polluted |
| 17 | | Soil quality | No contamination | Average | Contaminated | highly contaminated |
| Socio-economic related | | | | | | |
| 18 | | Health | No problem | Moderate | High | Severe |
| 19 | | Job opportunity | High | Moderate | Low | Very low |
| 20 | | Odour | no odour | Moderate | High | Intensive foul |
| 21 | | Vision | Site not seen | partially (25 %) | partially (75 %) | Fully seen |
| Waste management practice related | | | | | | |
| 22 | | waste qty/day | <250 tons | 250-1000 tons | 1000-2000 tons | >2000 tons |
| 23 | | Life of site | >20 yrs | 10-20 yrs | 2-10 yrs | <2 yrs |
| Climatological related | | | | | | |
| 24 | | Precipitation effectiveness index | <31 | 31-63 | 63-127 | >127 |
| 25 | | Climatic features contributing to air pollution | No problem | Moderate | High | Severe |
| Gelogical related | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 26 | | Soil permeability | >10 ˆ-7 cm/s | 10 ˆ-5 to 10 ˆ-7 cm/s | 10 ˆ-3 to 10 ˆ-5 cm/s | <10 ˆ-3 cm/s | |
| 27 | | Depth of bedrock | >20 m | 10-20 m | 3-10 m | <3 m | |
| 28 | | Susceptibilty to turn erosion and runoff | Not Susceptible | Potential | Moderate | Severe | |
| 29 | | Physical characteristics of rocks | Massive | Weathered | weathered | Highly earthed | |
| 30 | | Depth of soil layer | >5 m | 2-5 m | 1-2 m | <1 m | |
| 31 | | Soil pattern | <1 % | 1-2 % | 2-5 % | >10 % | |
| 32 | | Seismic zones | Zone 1 | Zone 2 | Zone 3 | Zone 4 | |

**Table 7: decision Criteria for a landfill site selection**

| Total score of SSI | Site description |
|---|---|
| <300 | Less sensitive to the impacts |
| | |
| 300 to 750 | Moderate |
| >750 | highly sensitive to the impacts |

## 3.7 Handling and Disposal

About 100 MT tons of waste reaches at Dadu Majra every day out of which only 80 MT is processed though the capacity of the plant is 100MT per day. Characterization of waste has been done as a part of project work and various components of wastes are shown in the table given below.

**Table 8: Characterization of solid waste.**

| S.No | Component | Percentage |
|---|---|---|
| 1. | Stone | 5 |
| 2. | Organic | 70 |
| 3. | Plastic | 8 |
| 4. | Clothe | 8 |
| 5. | Paper | 8 |
| 6. | Inert Material | 1 |

### 3.7.1 Refuse-derived fuel

Refuse-derived fuel (RDF) or solid recovered fuel/ specified recovered fuel (SRF) is a fuel produced by shredding and dehydrating solid waste (MSW) with a Waste converter technology .RDF consists largely of combustible components of municipal waste such as plastics and biodegradable waste. RDF processing facilities are normally located near a source of MSW and, while an optional combustion facility is normally close to the processing facility, it may also be located at a remote location.

Non-combustible materials such as glass and metals are removed during the post-treatment processing cycle with an air knife or other mechanical separation processing. The residual material can be sold in its processed form (depending on the process treatment) or it may be compressed into pellets, bricks or logs and used for other purposes either stand-alone or in a recursive recycling process.

Advanced RDF processing methods (pressurised steam treatment in a waste autoclave) can remove or significantly reduce harmful pollutants and heavy metals for use as a material for a variety of manufacturing and related uses. RDF is extracted from municipal solid waste using mechanical heat treatment, mechanical biological treatment or waste autoclaves.

The production of RDF may involve some but not all of the following steps:

Preliminary liberation

Size screenig

Magnetic separation

Coarse shredding

Refining separation.

### 3.7.2 Compost

Composting is a natural biological process. Carried out under controlled conditions, it hastens the decomposition of organic waste and reduces its volume, creating a stable, soil-enriching humus. The microorganisms that function in composting have basic requirements. To achieve an acceptable product, adequate amounts of air, water, and nutrients must be supplied. Proper control of surface area, temperature, and acidity is also necessary.

Microorganisms involved in organic waste degradation also need carbon as an energy source and nitrogen for protein synthesis. The carbon-to-nitrogen ratio required by these microorganisms is 30-to-l, whereas, municipal solid waste has a much larger ratio of 150-to-l or higher. Thus, nitrogen added to reduce the carbon-to-nitrogen ratio will enhance the composting process. Other elements needed by the microorganisms may not be available during their initial rapid build up. These elements may be added as necessary. The addition of lime neutralizes some of the organic acids released during decomposition, maintains a desirable acidity range, and reduces the loss of nitrogen gas. The added nutrients combined with the nutrients released during breakdown of the organic waste remain in the compost as a valuable resource for plant growth. The biological activity and temperatures higher than 140°F destroy pathogens and most weed seed, resulting in a final product that is safe to use.

Analysis of compost was done on three parameters namely PH, electrical conductivity and bulk density and their values are provided in the table given below:

**Table 9: Analysis of Compost**

| S.No | Parameter | Value |
|---|---|---|
| 1. | PH | 7.01 |
| 2. | Electrical conductivity | 1.413 kcl |
| 3. | Bulk density | 0.85 gmcc |

**Reject**

Reject is the material which is of no use. Reject consists of leftovers of plastic, paper, cloth and other non-biogdegradable material which cannot be put in use

# Chapter 4

## PUBLIC AWARENESS AND PUBLIC PARTICIPATION

### 4.1 Introduction

A comprehensive Solid Waste Management plan has to incorporate all the functional elements along with public participation and economic viability. It is imperative to make a MSW Management plan effective and successful that all the stakeholders and especially the public are aware of the importance of all stages of plan i.e. planning, execution, and later monitoring of operation and maintenance. Unless the inhabitants of the city feel that they have been involved and their views are heard, their problems will be taken care of, they feel alienated and no matter how well the plan has been conceived and executed, it does not achieve its objective.

It is important to make people realize that keeping a city clean and healthy involves continuous efforts and expenditure. Furthermore, it is not the responsibility of the administrative authorities of the city alone but also the inmates to actively get involved in keeping the city clean. They should clearly understand and appreciate that it is economical to pay a little to the authorities who provide and maintain the amenities for keeping their surrounding clean then to live in unhygienic conditions and run the risk of being sick. The inmates should not therefore take it as an additional burden but as merely a cost effective alternative for keeping good health and living in pleasant surroundings.

### 4.2 Public awareness and participation

Chandigarh is one of the major tourist destinations of India. Moreover resident population is also increasing year after at a rapid rate. This means more generation of waste but as we all know land cannot be increased its limited so it's the duty of municipal corporation to make some plans in coping with the ever growing population of this city. One of the most effective method to cope with the generation of waste is that many awareness programs could be conducted in order to make people aware of the **ill** effects of the solid waste generated. Help of many NGO'S can be taken in order to organize the programs. People should be made to participate in large numbers and should be made aware of various methods of handling the waste in their homes and vicinity.

## Chapter 5

## PROPOSED SOLID WASTE MANAGEMENT OPTIONS

### 5.1Proposed System of Solid Waste Management

For any good solid waste management system all the four functional elements i.e. storage and collection, transfer and transport, processing and disposal have to be attended. Theproposal for the system has the focus on the following points:

- Segregation of the waste at source/transfer station in the bio-degradable, non- biodegradable fractions and in other components if possible before sending the waste for disposal.
- Proper collection and storage of the waste.
- Processing and treatment of the collected waste.
- Minimizing the waste for the disposal in the sanitary landfills.
- Most effective technology for the treatment of waste.
- Revenue earning from the recyclable, reusable materials and the compost as well as charging properly from public.
- More the waste produced more the charge to be paid to the authorities.
- The system shall be reviewed after five years as the management options should be flexible and life structural changes may affect it.
- Workers to be kept safe and healthy.

- Proper management system for the waste generated by the floating population.
- More work force in the core areas and areas with large population so as to minimize the waste scattering.

## 5.2 Proposals of Solid Waste Management at Different Levels

(A) **Storage:**

Chandigarh is a city with a moderate level of population. The waste produced in Chandigarh per day is about 80MT per day The present system of storage of waste is observed carefully. MC Chandigarh offered two bins to every household and shop so that waste can be' collected properly. Green bin is for bio- degredable waste and yellow bin is for non-biodegradable waste. But due to negligence of the municipal corporation authorities this scheme has failed. Very less amount of houses are using these bins for the storage of waste. This is due to lack of awareness in the people. MC Chandigarh should organize programs at various levels so as to to make people aware of the serious consequences that they can face because of the waste. MC Chandigarh has placed community bins at different places. The size of the bins range from 1 cum to 6 cum. Most of the bins are in perfect condition but bins located at many places are not cleaned frequently. Some of the bins are full of waste and extra waste is scattered outside them. Thus they pose a threat to the local population of that areas because this watse can generate many types of diseases some of which may be life taking. So these bins should be cleaned regularly so as to reduce the pollution caused due to waste. Some bins are located at isolated places and at some crowded places there are no bins at all. So the people throw wastes in the open.

**(B) Collection route optimization:**

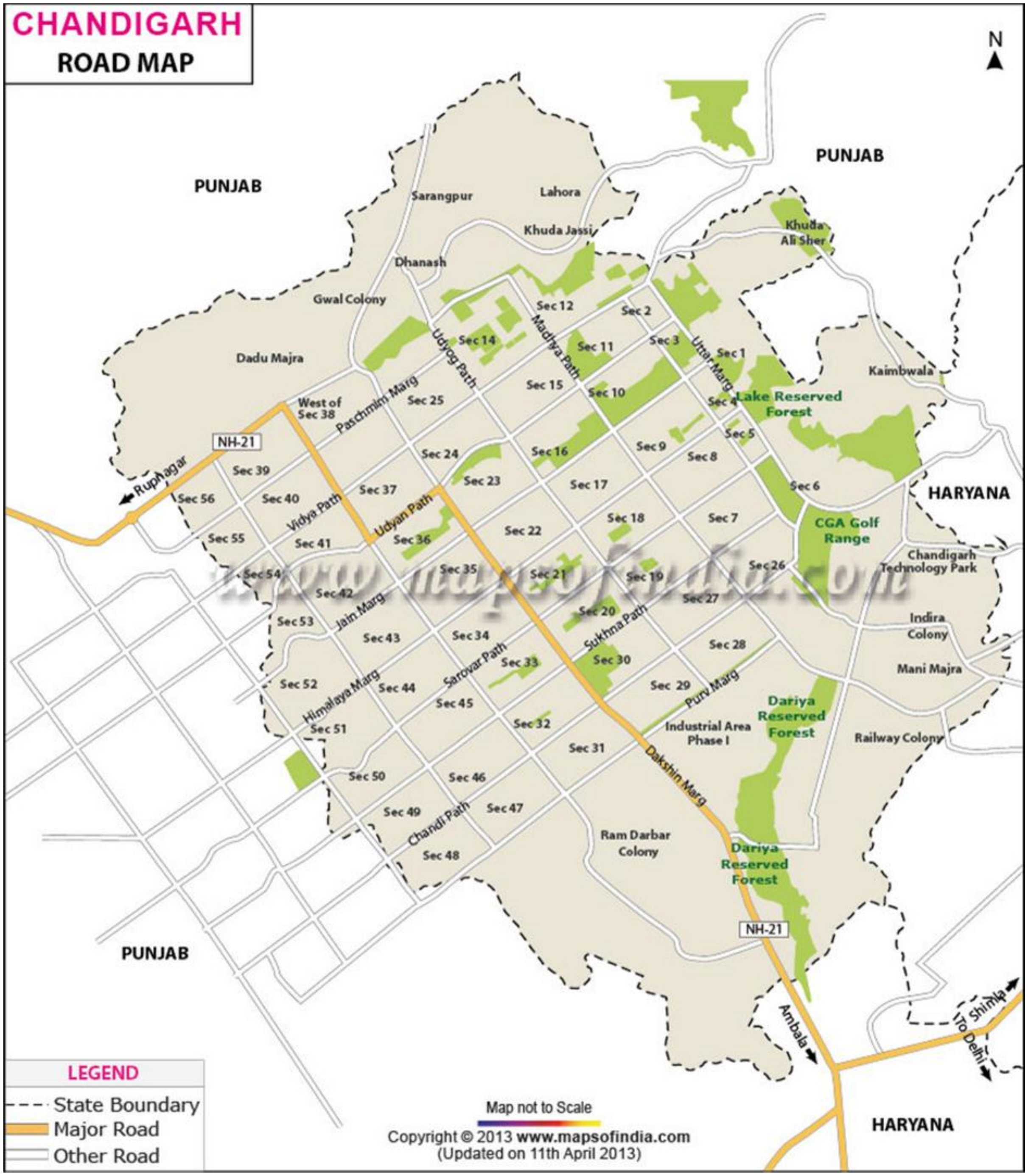


**Figure 7 : Chandigarh map showing route network for waste transportation**

1) Sec 1,2,3 – Sec 12 – Paschim Marg – Dadu Majra
2) Sec 4-10,28 – Udyan Path – Dadu Majra
3) Sec17 – Sec 22 – Udyan Path – Dadu Majra
4) Sec 43 – Dadu Majra

(C)**Transfer and transport**

The transfer process deals with the carrymg of waste from storage containers to the place where that can be segregated and processed or transferring from smaller vehicles to larger vehicles. Mostly pickups are used to to transport the waste to the site. There is no problem regarding the transfer and transport of the waste. It is done efficiently but there are some places which are neglected. At some places bins are not cleared regularly, they should be attended regularly because MC Chandigarh has fair quantity of vehicles. All the vehicles are covered during transportation. The one thing that MC Chandigarh can do that is to use large vehicles so as to reduce the number of trips per day and by this they can collect more and more waste because population of Chandigarh is growing at a very fast rate. Moreover the floating population is also increasing year after and the waste generated by floating population is in a large number so some additional number of vehicles should be added in the present fleet and more and more tippers should be added.

(D) **Waste Processing and Treatment:**

Waste processing shall be aimed at minimization of the waste to be landfilled and ensure reduction in landfill space for final disposal applying the principle reuse and recycling of waste. It is done at the new site but its not done efficiently. Segregation is must.

**5.3Treatment techniques**

There are many different techniques which are suitable to be applied in the area. Few of these techniques are described below

(a) **Incineration:**

In the process of incineration there is combustion under controlled condition to achieve conversion of waste material to harmless end products. Incineration is found to be successful method of treatment of solid waste having high calorific value for wastes like wood, paper, coconut, plywood, card board, bamboo etc. The solid waste having calorific value above 2500 kcak/kg is found to be most suitable fuel in incinerators.

In this method of waste treatment either incineration is carried out or the waste is converted into briquette for subsequent use as fuel. The suitability of this treatment option can be evaluated for MSW treatment of the area. However, this method is not only capital intensive but also requires skilled supervision and operation. Though this treatment is expensive, yet it is mandatory for treatment of infectious biomedical waste. Incorrect design and operation of the method would lead to environment pollution and other adverse affects. This option of treatment is unsuitable for treatment of large volume of MSW. Failure of incinerator plant in the year 1989 at Timarpur in Delhi has amply demonstrarted the unsuitability of this option.

(**b) Anaerobic Digestion:**

This process which is generally referred to as bio- methanation, the organic fraction of waste is segregated and fed to a closed container (biogas digester) where under anaerobic conditions the organic waste undergo biodegradation producing methane rich biogas and effluent/ sludge. The biogas thus produced can be used for cooking/ heating applications or through dual fuel engines or gas/ steam turbines for generatin electricity.

In particular case ofthe study area, the municipal solid has an average organic content up to

70% by weight. The waste after being after being segregated from the other inorganic oart like plastics, sand, ash, debris etc. can be used as feed stock to anaerobic digesters for conversion of organic material into methane, hydrogen sulfide etc.

The main steps followed for anaerobic treatment of MSW are:

**Pre- treatment:** To remove inert and non- biodegradable materials upgrade and homogenize the feed stock for digestion and to promote downstream treatment process.

**Anaerobic Digestion:** To produce biogas for energy to de- odorize, stabilize and disinfect the feedstock.

**Post treatment:** To complete the stabilization of the digested material and to produce a refined product of suitable moisture content, paricle size and physical structure for the proposed end- use as organic manure.

**Effluent treatment:** To treat the liquid effluent to specified standards before final disposal so that this cannot harm the environment.

**C) Plasma Arc Technology:**

Plasma gasification is a process which converts organic matter into synthetic gas, electricity, and slag using plasma. A plasma torch powered by an electric arc is used to ionize gas and catalyze organic matter into synthetic gas and solid waste (slag). **It** is used commercially as a form of waste treatment and has been tested for the gasification of biomass and solid hydrocarbons, such as coal, oil sands, and oil shale.

A plasma torch uses an inert gas such as steam. The electrodes vary from copper or tungsten to hafnium or zirconium, along with various other alloys. A strong electric current under high voltage passes between the two electrodes as an electric arc. Pressurized inert gas is ionized passing through the plasma created by the arc. The torch's temperature ranges from 4,000 to 25,000 of (2,200 to 13,900 0C). The temperature of the plasma reaction determines the structure of the plasma and forming gas. This can be optimized to minimize ballast contents, composed of the byproducts of oxidation: C02, N, H20, etc.

At these conditions molecular dissociation can occur by breaking down molecular bonds. The resulting elemental components are in a gaseous phase. Complex molecules are separated into individual atoms. Molecular dissociation using plasma is referred to as "plasma pyrolysis.

Pure highly calorific synthetic gas consists of CO, H2, CH, etc .. The conversion rate of plasma gasification exceeds 99%. Non-flammable inorganic components in the waste stream are not broken down. This includes various metals. A phase change from solid to liquid adds to the volume of slag.

Plasma processing of waste is ecologically clean. The lack of oxygen prevents the formation of many toxins. The high temperatures in a reactor also prevent the main components of the gas from forming toxic compounds such as furans, dioxins, NOX, or sulfur dioxide. Water filtration removes ash and gaseous pollutants.

The production of ecologically clean synthetic gas is the standard goal. The gas product contains no phenols or complex hydrocarbons however circulating water from filtering systems is toxic. The water removes toxins (poisons) and the hazardous substances which must be cleaned.

Metals resulting from plasma pyrolysis can be recovered from the slag and eventually sold as a commodity. Inert slag is granulated. This slag grain is used in construction. A portion of the syngas produced feeds on-site turbines, which power the plasma torches and thus support the feed system. This is self-sustaining electric power. This process can be used in Shimla for the treatment of MSW.

(D) **Pelletization:**

Pelletization of municipal solid waste involves the processes of segregating, crushing, mixing high and low heat value organic waste material and solidifying it to produce fuel pellets or briquettes, also referred to as Refuse Derived Fuel (RDF). The process is essentially a method that condenses the waste or changes its physical form and enriches its organic content through removal of inorganic materials and moisture. The calorific value of RDF pellets can be around 4000 kcal/ kg depending upon the percentage of organic matter in the waste, additives and binder materials used in the process. The calorific value of raw MSW is around 1000 kcal/kg while that of fuel pellets is 4000 kcal/kg. On an average, about 15-20 tons of fuel pellets can be produced after treatment of 100 tons of raw garbage. Since pelletization enriches the organic content of the waste through removal of inorganic materials and moisture, it can be very effective method for preparing an enriched fuel feed for other thermochemical processes like pyrolysis/ gasification, apart from incineration. Pellets can be used for heating plant boilers and for the generation of electricity. They can also act as a good substitute for coal and wood for domestic and industrial purposes. The important applications of RDF are found in the following spheres:

Cement kilns

RDF power plants

Coal-fired power plants

Industrial stearnlheat

boilers Pellet stoves

The conversion of solid waste into briquettes provides an alternative means for environmentally safe disposal of garbage which is currently disposed off in non-sanitary landfills. In addition, the pelletization technology provides yet another source of renewable energy, similar to that of biomass, wind, solar and geothermal energy. The emission characteristics of RDF are superior compared to that of coal with fewer emissions of pollutants like NOx, SOx, CO and C02.

RDF production line consists of several unit operations in series in order to separate unwanted components and condition the combustible matter to obtain the required characteristics. The main unit operations are screening, shredding, size reduction, classification, separation either metal, glass or wet organic materials, drying and densification. These unit operations can be arranged in different sequences depending on raw MSW composition and the required RDF quality.

Various qualities of fuel pellets can be produced, depending on the needs of the user or market. A high quality of RDF would possess a higher value for the heating value, and lower values for moisture and ash contents. The quality of RDF is sufficient to warrant its consideration as a preferred type of fuel when solid waste is being considered for co-firing with coal or for firing alone in a boiler designed originally for firing coal.

**(E) Composting:**

Composting is an organized method of producing compost by adopting decomposition and stabil-

ization of organic waste matter. Compost is organic manure which contains plant nutrients as well as micronutrients which can be utilized as soil conditioners. It is useful for plant growth also when used along with the chemical fertilizers. Composting can be carried out in two methods- aerobic and anaerobic composting. In aerobic compo sting micro-organisms oxidise organic compounds to C02 and nitrate. Carbon from organic compounds is used as a source of energy whereas nitrogen is recycled. During aerobic co mposting compo sting process, temperature rises up to

65-70 degrees due to exothermic reaction. The aerobic composting normally takes 30-45 days to complete by repeated turning and aeration. Though aerobic composting is most effective in segregated waste, yet it is also suitable in case of mixed wastes. It is currently used by the treatment plant but the operations are not carried out efficiently, moreover temperature is not controlled properly there compost produced is not of good quality. In the anaerobic composting process, micro-organisms metabolize the nutrients and break.

**Table 10: Design and Operational conditions of Aerobic Composting Process**

| S.No | Aspects | Pref erable standards and specifications |
|---|---|---|
| 1. | MSW characterstics | Sort ed organic fraction of MSW, preferable with same rate of decomposition. |
| 2. | MSW particle size | Between 25- 75 mm for optimum results. |
| 3. | C/N ratio | Between 25- 50 initially. Release of ammonia and imp eding of biological activity at lower ratios. |
| 4. | Blending and seeding | Addition of partially decomposed matter (1-5% by weight) reduces composting time. |
| | | 55% (optimum). |
| 6. | Windrow size | 3m length, 2m width and 1.5 m height (optimum). |
| 7. | Mixing/turning | Every four or five days, until the the temperature drops |

| | | |
|---|---|---|
| | | Celsius or less. Alternate days under typical operating conditions. |
| 8. | Temperature | 50-55 degree Celsius for first few days and 55-60 degree activity reduces significantly at higher temperature C). |
| 9. | Pathogen control | Maintenance of temperature between 60-70 C for 24 hours. |
| 10. | Air requirement | Air with at least 50% of initial oxygen concentration reach all parts of composting material. |
| 1l. | PH control | 7-7.5(optimum). Not above 8.5 to minimize nitrogen in the form of ammonia gas. |
| 12. | Inoculums | Not desirable, except in special cases. |
| 13. | Degree of decomposition | Determine by COD test or from Respiratory Quotient (RQ) |
| 14. | Area requirement | Nearly equal to 25 m2 for 1 ton of MSW. Area for machinery, packing and storage extra. |
| 15. | Post treatment care | Facility for effluent recycling and treatment and landfill of rejects. |
| 16. | Nutrient recovery | 2- 4 kg N/ton; 1-2 kg Piton; 1-2 kg K/ton. |
| 17. | Product recovery | 18-25% of waste input. |
| 18. | Residuals for disposal | 2- 20% sieving overflow (plastic, metal, glass, stones, uncomposted matter) |

Detailed computation of windrow composting:

Considering the shape as trapezoidal, with the top width as 2 m., bottom as 3 m. and height as

2m.

*CIS* area of windrow = 5 square meters

Daily waste expected = 70 tons

Required length of windrow = 7015 = 14 metres.

Length of windrow required for one week = 6* 14 = 84 metres. Since the waste is to be kept for three weeks

Therefore the length of the windrow required = 84*3 = 252 metres

So we are providing 3 windrows each 252 metres long at 14m. c/c Width of the windrow area = 3*3 + 14*2 = 37 metres. Windrow platform may be laid at a slope of 2%.

**Table 11: Factors essential for composting process**

| S.No | Factor | Desirable ranges |
|---|---|---|
| 1. | Moisture content | 50 to 60 % |
| 2. | *C/N* ratio | 26 to 31 |
| 3. | Mixing | Adequate oxygen throughout |
| | | |

Other types of composting which have been in practice are:

**Mobile composting:**

It is another type of composting known as tumbleweed composter, having function of rotating on a solid stainless steel axis. In this type of composting kitchen, lawn and garden scrap can be used producing earthy compost in 21 days. It is 116 em high, 66 cm wide, 86 em deep with weight 10 kgs. Its all components are recyclable.

**Drum composting:**

This is a on-site composting facility for food waste in which drums of various sizes can be used. The typical size is 1.5 m in diameter and 2.5 to 4.8 m in length. Drums are generally oriented horizontally and kept at the time of need. They tumble material slowly either continuously or intermittently. Feedstock is loaded at one end and compost is removed at the other. The tumbling material mixes, agitates and generally moves materials through the drum. The reason is to get exposed to air. Retention time varies from 2 to 20 days.

**(F) Vermi- composting:**

Vermicompost is the product or process of compo sting using various worms, usually red wigglers, white worms, and other earthworms to create a heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and vermicast. Vermicast, also called worm castings, worm humus or worm manure, is the end-product of the breakdown of organic matter by an earthworm. [1] These castings have been shown to contain reduced levels of contaminants and a higher saturatt, nutrient-rich organic fertilizer and soil conditioner. This process of producing vermicompost is called vermicomposting.

Making vermi- compost

Step l:Cover the bottom of the cement ring with a polythene sheet. (Or use the sheet to cover the ground of the area you're using).

Step 2: Spread a layer (15-20 ems) of organic waste on top of the sheet.

Step 3: Sprinkle rock phosphate on top of the organic material (2kgs).

Step 4:Prepare cowdung slurry (1Skgs) and add the slurry as a layer on top of the mixture.

Step 5:Fill the ring completely and evenly with the layered material.

Step 6:Paste cowdung or soil over the top of the material.

Step 7:Allow the material to decompose for 20 days. After 20 days, put the earthworms on top. They will find the cracks and enter the material.

Step 8:Cover the ring with wire mesh or gunny bags to prevent birds from eating the worms.

Step 9: Sprinkle water over the whole mixture at 3-day intervals for 2 months, to maintain

adequate moisture and body temperature of the worms.

Step 10: After 2 months, (or when the compost is ready), remove the ring and heap the material in a cone shape on the floor. Leave the heap undisturbed for 2-3 hours, to let the worms move slowly to the bottom.

Step 11: Separate the upper portion ofthe heap.

Step 12: Sieve the lower portion of the heap to separate the worms. They can be used again for preparation of more vermicompost.

Step 13: Pack the compost in bags and store them in a cool place.

**Table 12 : Design and operational conditions of Vermi composting process**

| S.no. | Aspects | preferable standards and specifications | | |
|---|---|---|---|---|
| 1 | MSW characteristics | Any organic waste which are not appreciably oily,spicy, salty or hard and that do not have excessive acidity and alkanity. | | |
| 2 | MSW particle size | Between 25- 50 mm for optimum results | | |
| 3 | Worms | Eudrilluseugineae. | | |

| | | | | |
|---|---|---|---|---|
| 4 | C/N ratio | 30:1 (preferred). Brown matter (wood products, saw dust, paper etc) is rich in carbon and green matter (food scraps, leaves etc) in nitrogen. Overabundance of green matter generates ammonia. Correction by application of brown matter. | | |
| 5 | Ph | Slightly alkaline state preferable. Correction by adding small dose of calcium carbonate. | | |
| 6 | temperature | 20- 30 degree centigrade | | |
| 7 | Moisture content | 40- 55 % preferable; cover the tank with wet sack and sprinkle water as required. | | |
| 8 | Base layer | Coconut husk of one or two layers with cow- dung powder. | | |
| | | | | |
| 9 | Placing MSW | Waste layer thickness in the tank to be less than 15 cm at a time; introduce fresh waste at consecutive portion of the tank on successive days. | | |
| | | | | |
| 10 | Blending | Sprinkle cow- dung powder along with waste. | | |
| 11 | Aeration | Regular removal of the composted material, adding holes to the bin, or using a continuous- flow bin. | | |
| | | | | |
| 12 | Physical protection | Wire mesh protection from mouse, ants and other pests; avoid exposure to direct sunlight or rainfall. | | |
| 13 | Leachate collection | 500 litres leachate collection tank for 250 kg/day plant. | | |
| | | | | |
| 14 | Area requirement | Tank size of 4m x 1m x O.5m for waste input of 10kgj/day of semi decomposed waste. | | |

**Mobile verrni- composting:**

This arrangement is good for farmers and households with a movable unit. Drum with stand hands and wheel barrow for easy movements and tap allows free flow of vermi wash.

**(G) Microwave Pyrolysis:**

The use of microwaves for heating is well established in society, being used in domestic and some industrial processes. However, there is potential for this technology to be introduced and applied to many other industrial heating processes, which offers unique advantages not attained with conventional heating. In this sense, microwave technology is being explored as one method to assist in waste management.

Currently, significant quantities of hazardous wastes are generated from a multitude of products and processes. The increase in both the quantity and of the diversity of waste production is now posing significant problems for their effective management. New technologies are being investigated to develop systems which shall support the safe handling, transportation, storage, disposal and destruction of the hazardous constituents of this waste. The recent interest in microwave technologies appears to offer the best solution to waste management, whereby a variety of microwave systems can be designed, developed and tailored to process many waste products. It is possible that microwave technologies

shall provide for: (i) a reduction in waste volume, (ii) rapid heating, (iii) selective heating,

(iv) enhanced chemical reactivity, (v) the ability to treat waste in-situ, (vi) rapid and flexible processes that can also be controlled remotely, (vii) ease of control, (viii) energy savings, (ix) overall cost effectiveness, (x) portability of equipment and processes, (xi) cleaner energy source compared to some more conventional systems, etc.

From existing processes for the harnessing of energy and raw materials from waste, thermochemical conversion routes are suitable candidates for the application of microwave technology. One of the thermochemical processes which is rapidly gaining in importance in this field is pyrolysis.

The term "pyrolysis" is defined as a thermal degradation in the absence of oxygen, which converts a raw material into different reactive intermediate products: solid (char), liquid (heavy molecular weight compounds that condense when cooled down) and gaseous products (light molecular weight gases). The understanding of the pyrolysis process is a complicated one since many factors have to be considered, such as raw material composition and experimental conditions. **It** is generally accepted that there are two possible steps in any pyrolysis process (Conesa et al., 1998): (i) primary pyrolysis, which comprises the devolatilization of the material where different reaction zones can appear corresponding to the thermal decomposition of the main constituents; and (ii) secondary pyrolysis, which covers the secondary decomposition reactions in the solid matrix, as well as secondary reactions between the volatiles release (homogeneous reactions), or between the volatiles and the carbonaceous residue (heterogeneous reactions). The first stage mainly involves dehydration, dehydrogenation, decarboxylation or decarbonilation reactions. The second comprises of processes such as cracking (thermal or catalytic), where heavy compounds further break into gases, or char is also converted into gases such as CO, C02, CH4 and H2 by reactions with gasifying agents, as well as partial oxidation, polymerization and condensation reactions.

**Table 13: Specification for microwave pyrolysis reactor**

| S.No | Parameter | Specification |
|---|---|---|

| | | |
|---|---|---|
| 1. | Microwave distribution diffuser for homogeneous system | Multiple magnetron with microwave distribution. |
| 2. | Microwave Power | 10 KW, 2450 MHz |
| 3. | Delivered microwave minimum to maximum power | User selective from |
| 4. | Pyrolysis reactor capacity, made SS304 capacity and material Of construction | 500 L |
| 5. | Safety interlock | Safety interlocks are provided to prevent microwave leakage |
| 6. | Microwave leakage | Less than 0.005W/cm2 |
| 7. | Temperature Specially designed thermocouple measurement | |
| 8. | Control panel | Microprocessor based control |
| 9. | Cooling system for exhaust blowers magnetrons | Air cooling |
| 10. | Power supply | 3 Phase |

**Table 14: Product and by- product for microwave pyrolysis reactor**

| Primary Products | Yields ( wt. %) | Content | Secondary |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Products | | | |
| Pyro- gas | 10-30 | Pyro- gas Hydrogen, C02, CO, CH4, C2H6, C3H8, C4HIO, Propene, other hydrocarbons | Electricity |
| Oil | 30-45 | High Mol wt. Aromatics, Alkanes, Alkenes, Ketones, Aldehydes | Furnace oil |
| Carbon | 30-50 | | >15% of Ash |

The yields shown as above are approximate and depend on the nature of waste. Pyro- gas can directly be used for cooking or electricity generation. Carbon and oil are marketable commodities and can generate revenue. Carbon black can be converted to activated carbon and sold. Alternatively, both these products can be used as fuels to produce steam and generate electricity.

### 5.3.1 Plastic waste pyrolysis

Pyrolysis is the thermal degradation of waste in an oxygen-starved environment in which the oxygen content is low for gasification to take place. Pyrolysis liquefaction is a non-combustion heat treatment that catalytically (chemically) decomposes waste material by applying heat, directly or indirectly to the waste material in an oxygen free environment. **It** is an endothermic reaction which requires an input of energy that is typically applied indirectly through the walls of the reactor in which the waste material is fed into. Pyrolysis liquefaction occurs under pressure and at operating temperatures above 4300C. Industrial Oil (Pyrolysis oil), Charcoal and Syn-gases are produced.

## CONVERSION EFFICIENCY

The output of a plant with input capacity of 10,000 Kgs mixed plastic wastes/day is as follows;

Pyrolysis Oil (Diesel: 85%, Kerosene: 7% & Petrol: 8%): 6500 to 9000 lit

Hydrocarbon Gas: 500 to 1000 Kg

Carbon Black: 500 to 700 Kg

## WASTES RECOMMNDED

Waste plastic, Electronic scrap, Mixed Plastic (LDPE, LLDPE, HDPE, PP, Nylon, Teflon, PS, ABS, FRP), Multilayered Plastic, Waste tyres, Rubber

## WASTES NOT RECOMMENDED

Agricultural waste

**Table 15: Merits and Demerits of Various Treatment Process ofMSW**

| S.No | Item | Incineration | Pelletisation | Bio-methanation | Landfill gas |
|---|---|---|---|---|---|
| 1. | Requirement | High | Very high | High | High |
| | For | | | | |
| | Segregation | | | | |
| 2. | Energy | Around 14 | Around 14 | Around 11 times | About 11 |
| | Recovery | waste stream | times waste | waste stream | times waste |
| | | | stream | | stream |
| 3. | Direct energy | Yes | No | No | No |
| | Recovery | | | | |
| 4. | Overall | Low | Low | High | Low |
| | Efficiency | | | | |
| 5. | Efficiency in | Very low | Very low | Moderate | Moderate |
| | case of high | | | | high |
| | Moisture | | | | |
| 6. | Land | Low | Low | Low to moderate | High to |
| | Requirement | | | | high |
| 7. | Transportation | Moderate | High | High | Very high |
| | Costs | | | | |
| 8. | Ability to | Yes | No | No | No |
| | tackle bio- | | | | |
| | medical and | | | | |
| | low-hazardous | | | | |
| | Wastes | | | | |
| 9. | Concern for toxicity of | High | NA | NA | Moderate to |
| | Product | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 10. | Leachate | None | None | High | High |
| | Pollution | | | | |
| 1l. | Concern for | High | Moderate | Low | Moderate |
| | Atmospheric | | | | |
| | Pollution | | | | |
| 12. | Sustainability | Moderate | Low | Low | High |
| | of source/ | | | | |
| | waste stream | | | | |
| 13. | Capital investment | High | Very high | Very high | High |

## 5.4Comparison and Recommended Methods

Different types of methods have been studied and their merits and de- merits are summarized below. Recommendation of the treatment process has been done after considering the physical, chemical characters tics and types of waste available, capital cost, operation and maintenance cost involved.

**Table 16: Recommended treatment processes of MSW**

| S.No. | Treatment process | Merit/Demerit of process |
|---|---|---|

| | | |
|---|---|---|
| 1 | Incineration | The calorific value of solid waste is generally in the range of 1000 kcal/kg of waste. Quantity of combustible material is about 10% by weight. The low calorific value MsW cost contains lot of debris, ash,sand etc. and thus is not suitable for treatment by incinerator |
| 2 | Anaerobic Digestion | It requires segregation of solid waste at the source and suitable arrangement for transportation of segregated waste or arrangement for segregation near the landfill site. Hence the process is not suitable at this stage. |
| 3 | Plasma Arc technology | It is generally used for the treatment of hazardous waste and Chandigarh has no history of any hazardous wastes |
| 4 | Pelletization | It requires high capital, operation and maintenance costs. Needs a strict quality control to ensure toxicity free waste pellets so that air pollution [problems are avoided. It needs trained, skilled manpower and that is easily available in Chandigarh |
| 5 | Pyrolysis | This technology can be used since it provides clean energy and it also produces oil which can be used in various industries but it requires large amount of plastic |

| | | |
|---|---|---|
| | | waste products. |
| 6 | Vermi-composting | The compost produced will not be of good quality in summer because ideal temp for bacterias to be active is 10-30 degree celcius and temp of chandigarh is >30 degrees. |

**Table 17: Comparison of various composting processes**

| S.No | Item | Aerobic composting | Anaerobic composting | Vermi-composting |
|---|---|---|---|---|
| l. | Foul odor in the Process | Yes | Yes | No |
| 2. | Quality of end Product | Good | Moderate | Moderate to Good |
| 3. | Time for | 2-3 weeks | 6-8 months | 6 months |
| 4. | Use for methane production | No | Yes | No |
| 5. | Attracts rodents, pests, dogs | Yes | No | No |
| 6. | Need for constant monitoring | Low | High | Very high |
| 7. | Storage capacity of end product | Low | Low | High |
| 8. | Market demand | Moderate | Moderate | High |
| 9. | Power requirements | Yes | No | Yes |
| 10. | Skilled labour requirement | Low | Moderate | High |
| 1l. | Land requirement | Low | Moderate | High |
| 12. | Quality of waste segregation | Moderate | High | Very high |
| 13. | Leachate pollution | High | High | Low |
| 14. | Contamination of Aquifers | High | Moderate t high | Low |

| | | | | |
|---|---|---|---|---|
| 15. | Capital investment | Moderate | Moderate | High |
| 16. | O&M costs | Moderate | Moderate | High |

**5.5 Selection of Landfill Site**

In almost any document on landfill site selection, the general objectives are to ensure that the site to be developed is environmentally and socially acceptable, and thus sustainable. Specialist consultants are often used for this purpose. These are technical, but often include environmental consultants. Early considerations in the technical process are the size (land area) and the strategic location of the proposed site, to ensure that the facility meets the disposal need. While the size depends on the waste stream over the predicted site life and provision for sufficient buffer zones, strategic location is determined by the waste generation areas to be served and transport routes. It is economically sound practice to establish the proposed facility as close to the generation areas as possible, with a view to minimising transport costs. Often an "economic radius" is determined, based on the existing or proposed mode of waste transport. This will define the initial area of investigation.

Once the "economic radius" or "study area" has been identified, a Public Participation Process (PPP) should be initiated and maintained throughout the site selection process. This may, however, be controversial, as making the public aware too early can compromise the results. It may stir up public and political resistance, i.e. the "not in my back yard" or NIMBY syndrome. It might also lead to land speculation and soaring land prices, or losing a competitive edge in the case of a private sector contractor. On the other hand, not to inform the public early on, or presenting then with a fait accompli is guaranteed to generate mistrust and even more resistance. Unless dictated by local regulations, therefore, informing the public is a case-specific issue. Once working in the study area, the next phases are the elimination of all areas with associated Fatal Flaws. In this instance, Fatal Flaws are defined as phenomena that prohibit the development of an environmentally or publicly acceptable waste disposal facility except at excessive cost. In the South

African Minimum Requirements 1998, eighteen such fatal flaws are listed, including sensitive environments, water resources, development and unsuitable geological and soil conditions.

Once all areas with associated Fatal Flaws have been eliminated from the study area, a number of candidate sites have to be identified. This process is based on numerous economic, environmental and public acceptance criteria, and ensures the due consideration of alternatives, which represents a fundamental element of any Environmental Impact Assessment (EIA) process. Once all the candidate sites have been identified, they must all be compared and technically evaluated. Unsuitable sites must be eliminated and the best sites must be short listed for further consideration. The short listed sites are then ranked in order of suitability. The ranking process is, however, controversial and is often open to criticism because it may be seen as subjective, which in some instances is the case.

The top-ranking site is then subjected to a more detailed investigation by means of a Feasibility Study, to confirm that it has no Fatal Flaws and is environmentally and publicly acceptable. The Feasibility Study may comprise many administrative and technical aspects, which depend on local legislation. It should, however, include a preliminary Geohydrological Investigation, as well as a preliminary Environmental Impact Assessment (EIA). If Fatal Flaws emerge in the investigations the site is discarded and the next best site is investigated. Otherwise, a conceptual design is drawn up, which addresses any critical factors associated with the site, and this, together. with the investigation results, is submitted to the authorities and usually to the public.

In the event that the authorities find the site feasible, further detailed investigations must be undertaken. These should involve detailed Geohydrological Investigations, a detailed Environmental Impact Assessment (EIA) and a detailed design. If Fatal Flaws emerge in the investigations the site is discarded and the next best site is investigated. If the site is sound, however, it may be developed. Depending on local legislation, sophistication and know-how of the authorities or fund donors, the generic landfill siting process may vary. Some countries have permitting systems in place, which require landfill site permitting before development, while others have nothing. Any professional working in the latter environment should work according to suitable guidelines, such as the South African Minimum Requirements or USEP A Guidelines for landfilling in developing countries.

### 5.5.1 Some Technical Aspects of Landfill Site Selection

#### 5.5.1.1 Negative mapping

Negative mapping is a preliminary tool used in the identification of Candidate Landfill sites. It is used early in the study to eliminate the unsuitable areas in a study area and to identify "positive window areas" for further investigation. This can be done on a small or large scale and makes use of overlay technology to exclude the unsuitable areas. Such unsuitable areas are often associated with the Fatal Flaws and unsuitable conditions, termed "exclusion criteria". Some of these appear below:

- Existing land use, development and population density (current and future).
- Unsuitable topography, drainage areas and areas of vulnerable to water pollution.
- Unsuitable geology (e.g. dolomites in South Africa) and soils.
- Existing and potential agricultural land use .
- Identified areas of environmental sensitivity (e.g. nature conservation areas).

Initially, manual overlays were used with a high degree of success. However, this methodology was slow and tedious. Notwithstanding this, it remains the appropriate technology in developing countries where normal and digitized maps are often scarce. In countries where digitized maps are available, Geographical

Information Systems (GIS), for which overlay technology is the ideal application, is now the state of the art. When using GIS and digitised data for negative mapping, however, one must proceed with caution, as there are at least two associated pitfalls, as follows:

- The quality of the result depends on the quality of the input data used. Much of the soils and geological data for instance is mapped on a scale of 1:250 000, whereas one really needs to work on a scale of 1:50 000, particularly in the remaining positive "window areas". If the scale is not sufficient to provide detail, certain aspects can be overlooked.

- Another possible pitfall is when GIS specialists, (who can achieve spectacular presentations on the computer, but have little or no insight into science of landfill site selection) carry out he GIS negative mapping. There are examples of studies that, based on this and a lack of field validation, have resulted in erroneous conclusions, sometimes with far reaching implications.

To ensure better accuracy and a good understanding of actual conditions on ground,therefore, negative mapping must always be carried out in parallel with field validation,involving direct observation. Since field validation in effect provides a scale of 1. It is always more conclusive than GIS data in this context. For example, the type and depth of soil observed in a road cutting, is far more reliable than information obtained off a 1: 250 000 or even a 1: 50000 soil map. This "ground truthing" has sometimes resulted in areas ruled out by GIS negative mapping, yielding prime Candidate Landfill sites. Conversely, it often reveals that the remaining positive "window areas" are not that good after all. It has been found that excellent results can be obtained with GIS when done in conjunction with ground trothing.

#### 5.5.1.2 The due consideration of alternatives

Since the due consideration of alternati ves is a fundamental principle in Integrated Environmental Management (IEM) and the EIA process, and is also a fundamental principle in landfill site selection. By presenting numerous alternatives and comparing them, the approach goes a long way towards providing objectivity and a defensible approach.

One mistake that has frequently been made by the consultant (the author included) is that one tends to view "alternatives" as Candidate Landfill sites. As soon as the lAPs become involved, however, it soon becomes evident that (as indicated in the EIA section), "alternatives" also mean other waste management solutions. These will include composting, recycling and possibly even the latest "black box" technology that has been "sold" to the politicians. These issues have to be addressed and the necessity of a new landfill confirmed, before the process can proceed. Similarly, the lAPs may present alternative Candidate Landfill sites. While these are usually intended to move the proposed landfill away from the area under consideration, they must be taken seriously and considered on the same basis as the other Candidate Landfill sites. In a landfill site selection exercise, generally the more alternatives identified, the better. In the recent project to identify a new regional landfill site for the City of Cape Town, some 75 potential sites in total were considered. These were reduced to about 30 Candidate Landfill sites, of which only 4 were short-listed and ranked. This example possibly represents an extreme case, on account of it being a high profile project in an extremely sensitive environment. Regarding the Cape Town project, it is of interest to note that, notwithstanding the number of alternatives considered, the EIA process dictated that the top two sites both be considered for further investigation. This was based on an interpretation of the National Environmental Management Act of 1998 and is contrary to the South African Minimum Requirements approach and that of many developed countries, including the USA, which require specialist studies to be carried out on only the top ranked site. This approach has significantly increased the complexity, size and cost of the project and delayed the process, which at the time of writing had been going for five years.

While in most site selection processes, one should endeavor to identify as many alternatives as possible, few will result in the number of Candidate Landfill sites considered in the Cape Town project. For sites in South Africa, the number has ranged from 15 to 30, while in other African countries, where transport distances are usually restricted by vehicle type, this has ranged between 12 and 15. Examples are SekondiTakaradi in Ghana, Soyo in Angola and Jwaneng in Botswana. There are also situations where the due consideration of alternatives may not always represent the most logical approach. Such situations could result when existing factors and/or historical planning may strongly favor a given site. In such instances, the situation should be made known to the authorities from the start, and a directive obtained as to what would be considered to represent an appropriate approach. At this point, it is interesting to note the trends. Historically, it was land availability that counted. Basically, the nearest piece of vacant land would suffice for the "tip" or the "dump", whether in a wetland or a canyon, as in the cartoon. Then as we became more aware athescience of landfill site selection evolved, land suitability became the main criterion. For example, a landfill had to be situated on deep clays and had to have an adequate buffer zone around it. Now, with the NIMBY syndrome, environmental awareness and associated stringent constraints, the adequate buffer zone has become the key criterion. Availability of a site with a suitable buffer zone becomes a prime consideration. Consequently, even if a site is not ideal in terms of underlying geology and soils, provided it has the adequate buffer zone and is close enough to the waste generation areas, it will be considered, allowing for more costly liner engineering to overcome inherent site shortcomings.

### 5.5.2.3 Ranking of short listed Candidate landfill sites

Once Candidate Landfill sites have been identified, they must be evaluated to eliminate unsuitable sites and to help determine the top ranking or short- listed sites. If there are a number of sites, the "course screening" can usually be achieved by inspection and consensus, within an objective team of experts, in a process similar to a Delphi method. Alternatively, a simple matrix comprising the candidate sites on the one axis and selected criteria on the other may be used. The criteria must then be appropriately weighted to reflect their relative importance. Scores are assigned for each criterion for each site and added together to provide a site total. Thereafter, sites are ranked from the lowest to the highest, and the latter are compiled into the short-list for further consideration.

Once a short-list of the top ranking sites has been established, these must be compared with one another in a "fine screening" exercise. For this process the above simple site-ranking matrix may again be used. However, assigning numerical values is seen as very subjective, so at this level variations may be used. One is a more detailed matrix based on an ABC system, where for each criterion, the site rated best would receive an A, second best B and the worst, a C. This is fine for three sites, but not for more sites or close ranking criteria. Another variant is to use colours. While it was found that in some instances, the public would accept simple ranking matrices, this was not always the case, particularly with sophisticated lAPs. In such instances the ranking of Candidate Landfill sites can become a controversial issue, especially when using the simplistic methods described above. This is because different people have different perspectives. For example, whereas a waste manager will want to minimize transport costs, the lAPs are not concerned with transport costs and are (understandably) only interested in ensuring that their quality of life is not compromised. Frequently therefore, the objectivity of the ranking process is brought into question. Consequently, a more sophisticated methodology is required to rank the short-listed sites, to ensure defensible objectivity, especially in the face of public resistance and potential for litigation.

Various methods have been considered and the most successful methodology used to date is that based on the Analytic Hierarchy Process (AHP), a multi-criteria decision-making approach, (Saaty 1994). Using pair wise comparisons and the eigenvector, this facilitates the scientific evaluation of alternatives in terms of a set of difficult-to-quantify criteria, such as aesthetics, risk, social impact, etc. The method first determines the weight of importance of each criterion, and then the relative scores of the .alternatives under consideration for each criterion. To carry out this exercise in the Cape Town project, an objective multidisciplinary team of experts was selected. Although in this case, the team comprised only consultants, it may include fund donors, members of authorities and even members of the public, provided they are seen to be objective and to have a recognizable level of expertise in a given field. First, each team member was requested to submit his or her list of landfill site ranking criteria. These lists were then work-shopped with the client and various EIA consultants, before being consolidated into a single list. Since the criteria do not all have equal importance in the ranking process, AHP and pair wise comparison were used to assign a weighting to each criterion by the multi disciplinary team. Using the same pair wise method, each short-listed site was compared to its competitors for each criterion. The weighted criteria scores were then tallied for each site and compared to provide a ranking.

### 5.5.3 Landfill Liner

A landfill liner, or composite landfill liner, is intended to be a low permeable barrier, which is laid down under engineered landfill sites. Until it deteriorates, the liner retards migration of leachate, and its toxic constituents, into underlying aquifers or nearby rivers, causing spoiliation of the local water. Modem landfills generally require a layer of compacted clay with a minimum required thickness and a maximum allowable hydraulic conductivity, overlaid by a high-density polyethylene geomembrane.

#### 5.5.3.1 Leachate control system design

The leachate control system elements are the landfill cover, surface water control structures which prevent water from running into the site and, if installed the landfill liner, collection pipes, leachate detection systems, and leachate disposal system.

Percolation through the proposed cover is estimated with the water balance equation. Selection of the best alternative can be based on the cost and availability of the cover materials, the potential detrimental effect of leachate that drains from the base of the landfill, and leachate treatment cost. Regulatory constraints will also influence the alternative selected.

The slope and soil characteristics of the cover will establish the runoff characteristics of the site. Runoff quantities and peak flows can be predicted with standard drainage calculation techniques ("Urban Hydrology for Small Watersheds," 1975).

Water that percolates through the landfill cover is assumed to eventually reach the base of the landfill as leachate. A variety of decisions is necessary on how to best handle this leachate.

A small amount of leachate may not have a significant potential effect on groundwater. Making this determination is difficult; however, groundwater computer models are available to predict leachate flow and contaminant migration patterns. The difficulty arises in selecting the model's input parameters for leachate chemical characteristics, and in predicting the chemical reactions that will occur as the leachate moves through the soil.

The amount of leachate that drains from the base of the landfill will depend upon the type of liner, how successfully the liner is installed, and the procedures employed for removing leachate from the landfill. For soil liners, a liner efficiency can be calculated if data regarding soil permeabilities i s available.

The projected liner efficiency of 81% indicates that 19% of the leachate will eventually drain through the liner. If this quantity is determined to be potentially detrimental to groundwater quality, then a more efficient liner can be designed. One possibility would be to incorporate a geosynthetic membrane into the liner system. Implicit in the design of the soil liner with the efficiency calculation is the slope of the soil liner at the base of the landfill and the spacing of leachate collection lines. The leachate retained by the liner must be removed for treatment or a portion recycled.

Geosynthetic liners may complement or be used in place of clay liners. The typical geosynthetic lining material is 40-to 80-thousandths-of-an-inch-thick flexible sheets which can be bonded to adjacent sheets with thermal or chemical bonding equipment.

Many configurations are available for installing geosynthetic liners. Composite liners utilize a combination of geosynthetic and clay liners. The geosynthetic liner is placed immediately on top of the clay liner. Sand above the geosynthetic liner carries leachate to time collection system. Alternately the sand may be replaced by high-strength geosynthetic grid or mesh material which is less than one-half-inch thick and capable of transmitting large quantities of leachate to the collection pipes.

Double geosynthetic lined landfills utilize two layers of liners and leachate collection systems. The upper layer is the leachate collection liner. The lower layer acts as a leak detection liner, should the upper liner develop a hole.

Liner systems, clay, geosynthetic. or combination, cost hundreds of thousands of dollars per acre. An interesting design consideration is the reduced volume that a geosynthetic liner system occupies within the increased volume of the landfill, A 367-foot-thick clay liner system may, depending on regulatory controls, be replaced by a geosynthetic liner system that is less than one foot thick. The geosynthetic liner system will cost more per acre but the added cost may be more than offset by the additional revenue which results from having a larger volume available for landfilling. Similar considerations apply to landfill covers constructed with geosynthetics.

When the design concepts for the leachate control system are completed, laying out the landfill on maps and engineering plan-sheets can begin.

# CHAPTER 6

# CONCLUSION

After doing this study there are a few points which are crystal clear and needs attention. The following recommendations are made from this work:

1. From the study of present status of SWM in Chandigarh it was found that system does not need much changes.
2. MC Chandigarh have a fair number of sweepers and work is properly distributed among them.
3. Most of the people living in the study area are well educated and thus can be easily guided to make Chandigarh a waste free city. For this many awareness programs should be organized with the help of various NGO's.
4. At some places bins are not cleared frequently hence causing the overflowing of waste, so it is the duty of MC Chandigarh to clean these bins frequently.
5. All the bins are places at places which are easily viewable, so waste do not litter here and there.
6. Though MC Chandigarh has fair quantity of community bins but some of these are not placed in places of need. Bins should be placed in accordance to the population of concerned area.
7. Some of the bins do not have lids on them thus making these bins prone to monkeys and stray dogs which in return scatters the waste outside the bins. So these bins should be covered properly.
8. Currently aerobic composting is done in the treatment plant which is suitable due to the temperature of the city and the surroundings. Hence the compost produced is of good quality.
9. Waste is segregated properly into biodegradable and non-biodegradable components thus having proper treatment and proceesing of waste.
10. Landfilling is done at a site which is far from city and residents thus the surroundings are not prone to bacterias or any other diseases.

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