CHAPTER 1

INTRODUCTION

1.1 GENERAL

Environmental pollution includes air pollution, water pollution and land pollution. It is unfair to classify solid waste as being deleterious to a single part of the environment rather solid waste problem transcend traditions environmental boundaries and contribute to air, water pollution as well as land pollution. The improper disposal of solid waste is one of the factors for the pollution. Since long back, with rapid growth of urban area and with explosion of industrial revolution, pollution is being increasing year after year at a faster rate.

1.2 SOLID WASTE

Solid wastes can be defined as unwanted materials in simplest term and it can also be termed as waste in the wrong place implying that a specific owner ceases to have use for it. Uncontrolled dumping of domestic solid waste on land results in health problems. Scarcity of space in urban cities creates difficulty in disposing of solid waste. Still this technology widely accepted option for solid waste management for most of the municipal corporations and other local bodies. The adverse effects of such landfills are contamination of underlying soil, groundwater and health hazards to the workers, waste pickers and neighboring communities, proliferation of the
vermin and poor air quality around landfill site due to the intentional burning of waste. Percolation of the leachate from uncontrolled land filled site into the soil aquifer is the serious problem of the water pollution. Complex biological, chemical and physical process occurring at dumpsite governs the leachate quality and hence, large variations on chemical composition are reported.

The primary objective of the solid waste management plan is to ensure efficient and economic collection, handling, utilization and disposal of solid wastes with minimum acceptable environment impacts. Since, such a plan as to be investigated on a longer time frame work. It is often desirable to include wastes arrangement in the urban development master plan. While implementing such a master plan, we have many constraints to overcome because of the quantity and diverse nature of the wastes and also due to sprawling urban areas, funding limitations for public services, impact of technology and limitations in both energy and materials.

1.2.1 Sources and Types of Solid Waste

The solid wastes arise in association with almost every activity of man as per IS: 9622-1980 report. The composition and properties of these waste reflects the diversity of main action characterization of waste is usually associated with broad description of the source of waste and is shown in Table 1.1 and Figure 1.1.
Figure 1.1 Classification of solid waste
Table 1.1 Sources and Types of solid waste

<table>
<thead>
<tr>
<th>SL. No</th>
<th>Source</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Residential</td>
<td>Sweepings, Fuel residue, Empty contained packages, waste, broken glass, cloths, vegetable matter etc.,</td>
</tr>
<tr>
<td>2</td>
<td>Commercial</td>
<td>Packaging materials such as fiberboards, containers, papers, plastics, wooden crates and paper packaging and office refuse such as paper, carbon paper, typewriter ribbon and fraction of food waste.</td>
</tr>
<tr>
<td>3</td>
<td>Institutional</td>
<td>Waste from schools, colleges, markets, hotels, hospitals.</td>
</tr>
<tr>
<td>4</td>
<td>Municipal</td>
<td>Waste from street and lane cleaning park and beach operation, leaves, landscaping, house gully, catch basins, sewer cleaning, repairs and dead animals.</td>
</tr>
<tr>
<td>5</td>
<td>Industrial</td>
<td>Building construction waste, factory waste and trade waste also waste from mineral extraction such as colliery waste, waste from metallurgical industries, waste from automobiles garages and garments.</td>
</tr>
<tr>
<td>6</td>
<td>Agricultural and animal husbandry</td>
<td>Poultry Waste, urine storage refuse, straw husk etc.,</td>
</tr>
</tbody>
</table>

1.2.2 Natural composition of solid waste

In general solid waste will have various characteristics, type and source of origin. It could be organic or inorganic, wet or dry, combustible or compostable. Patterns of composition, characteristics and quantities of solid waste are shown in Table 1.2.
Table 1.2 Patterns of composition, Characteristics and Quantities

<table>
<thead>
<tr>
<th>Composition (percent by weight)</th>
<th>Low income countries</th>
<th>Middle income countries</th>
<th>High income countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal</td>
<td>0.2 – 2.5</td>
<td>1 – 5</td>
<td>3 – 13</td>
</tr>
<tr>
<td>Glass, Ceramics</td>
<td>0.5 – 3.5</td>
<td>1 – 10</td>
<td>4 – 10</td>
</tr>
<tr>
<td>Food and Garden Waste</td>
<td>40 – 65</td>
<td>20 – 60</td>
<td>20 – 50</td>
</tr>
<tr>
<td>Paper</td>
<td>1 – 10</td>
<td>15 – 40</td>
<td>15 – 40</td>
</tr>
<tr>
<td>Textiles</td>
<td>1 – 5</td>
<td>2 – 10</td>
<td>2 – 10</td>
</tr>
<tr>
<td>Plastics/ Rubber</td>
<td>1 – 5</td>
<td>2 – 6</td>
<td>2 – 10</td>
</tr>
<tr>
<td>Miscellaneous Combustible</td>
<td>1 – 8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Miscellaneous Incombustible</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Inert</td>
<td>20 -50</td>
<td>1 – 30</td>
<td>1 – 20</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>250 – 500</td>
<td>170 – 330</td>
<td>100 – 170</td>
</tr>
<tr>
<td>Moisture Content (percent by weight)</td>
<td>40 – 80</td>
<td>40 – 60</td>
<td>20 – 30</td>
</tr>
<tr>
<td>Waste Generation (kg/cap/day)</td>
<td>0.4 – 0.6</td>
<td>0.5 – 0.9</td>
<td>0.7 – 1.8</td>
</tr>
</tbody>
</table>

Source: Holmes managing solid waste in developing countries.

1.2.3 Composition of Municipal Solid Waste

The total number of separate source on municipal refuse is very large which results in diverse characteristic of wastes as stated in IS: 9622-1980. The following constituents are found almost everywhere and though the proportion remains constant from day to day for any one source and difference among sources may be considerable. The general composition of municipal refuse contain dust, cinder, vegetable, fruits, and putrescible matter, textiles, paper, metals, glass bones, combustible matters such as wood, non combustible materials such as stones and crockery pieces. The typical
compositions of municipal solid waste are highlighted in Table 1.3 which shows the classification of materials comprising municipal solid waste.

**Table 1.3 Classification of materials comprising Municipal Solid Waste**

<table>
<thead>
<tr>
<th>SL No.</th>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Food Waste</td>
<td>The animal, fruit or vegetable waste from residence (also called garbage) resulting from handling, preparation, cooking and eating of foods. Because food wastes are putrescible they will decompose rapidly, especially in warm water.</td>
</tr>
<tr>
<td>2</td>
<td>Rubbish</td>
<td>Combustible or non – Combustible solid wastes excluding food waste or other putrescible materials. Typically combustible rubbish consists such as paper, cardboard, plastic textiles, leather wood, furniture and garden consists of such as glass, crockery, tin causes; aluminum causes dust and construction waste.</td>
</tr>
<tr>
<td>3</td>
<td>Dirt and Residue</td>
<td>Materials remaining from burning of wood, coal, coke and other combustible waste. Residues from power plants are normally composed of fine powdery materials, cinder, clinker and small amounts of burnt and partially burn materials.</td>
</tr>
<tr>
<td>4</td>
<td>Demolition and Construction</td>
<td>Waste from raged buildings and other structures are classified as demolition waste. Wastes from construction, remodeling and repairs of residential buildings and similar structures are classified as construction wastes.</td>
</tr>
<tr>
<td>5</td>
<td>Special Waste</td>
<td>Waste such as street sweepings, roadside litter, catch basin debris dead animals and abandoned vehicles are classified as special waste.</td>
</tr>
<tr>
<td>6</td>
<td>Treatment Plant Waste</td>
<td>The solid and semi solid wastes from water, waste water and industrial waste treatment facilities are included in this classification.</td>
</tr>
</tbody>
</table>
1.2.4 Quantity of Municipal Solid Waste

Quantity of municipal refuse generated is normally between 500 to 600 gm per capita per day in India. However under certain circumstances it may go up considerably. However, the range of volume is greater. The Table 1.4 below represents the typical densities of various components of solid waste.

Table 1.4 Typical densities for solid waste

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Item</th>
<th>Density (kg/m$^3$)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>Typical</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Food waste</td>
<td>120-480</td>
<td>290</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Paper</td>
<td>30-130</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Card Board</td>
<td>30-80</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Plastics</td>
<td>30-130</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Textiles</td>
<td>30-100</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Rubber</td>
<td>90-200</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Leather</td>
<td>90-260</td>
<td>160</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Garden Trimmings</td>
<td>60-225</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Wood</td>
<td>120-320</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Miscellaneous Organics</td>
<td>90-360</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Glass</td>
<td>160-480</td>
<td>195</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Tin Cans</td>
<td>45-160</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Non Ferrous Metal</td>
<td>60-240</td>
<td>160</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Ferrous Metals</td>
<td>120-1200</td>
<td>320</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Dirt, Ash, Bricks, etc.,</td>
<td>320-960</td>
<td>480</td>
<td></td>
</tr>
</tbody>
</table>

Source: George Tehobanoglous, Hillary Theisen and Rolf Eliassen (1977)
1.3 MUNICIPAL SOLID WASTE MANAGEMENT

Municipal solid waste is a heterogeneous mixture of various constituents (components). Uncontrolled decomposition of organic constituents of the waste results in various environmental problems. Certain components of the waste have the value of recycling potential and recycled besides reducing the pollution also yield some financial returns. Various processing technologies have been developed which decompose, stabilize the waste so that load on disposal site is reduced and some returns also occur.

The composition of the solid waste like Paper, Rubber, Leather and synthetics, Glass, Metal, Total combustible matter, inert are critically evaluated. It seems that, it contains nearly 30-50% organics, about 4-6% recyclable and certain constituents having calorific values. The choice of processing technology is accordingly based on mainly the proportion of their constituents.

The recyclable constituents of the Municipal Solid Waste are often removed by the owner and remaining by persons in the un-organized sector namely rag-pickers. They recover the Paper, Plastics, Metals, etc… reducing their proportion reaching the disposal site.

Some of the constituents of Municipal Solid Waste like paper, plastics and glasses indicate the value of the recyclable constituents as measured at the sources and as measured at the disposal site. Figure 1.2 shows the flowchart of generalized MSWM Process.

The organic constituents of Municipal Solid Waste have inherent calorific value and can also be converted to manure. The processing of the waste is to reduce the pollution and also to recover some value can be achieved either by biological route or thermal route.
Figure 1.2 Generalized flow diagram for the composting process
1.3.1 Storage

Storage of waste at some is the first essential step of Solid Waste Management. Every household, shop and establishment generates solid waste on a daily basis. The waste should normally be stored at the source of waste generation till collected for its disposal. The types of presently used for storage equipments are given below,

Containers/Storage bins

The design of an efficient waste collection system requires careful consideration of the type, size and location of containers at the point of generation for storage of wastes until they are collected. The containers may fall under either of the following two categories.

- Stationary containers
- Hauled containers

Collection Vehicles

Almost all collections are based on collector and collection crew, which move through the collection service area with a vehicle for collecting the waste material. The collection vehicle selected must be appropriate to the terrain, type and density of waste generation points.

1.3.2 Collection of solid wastes

George Techobanoglous, studied the functional element of collection, which includes not only the gathering of solid waste and recyclable material, but also the transport of these materials to the location where the
collection vehicle is emptied. This location may be a material processing unit, a transfer station, or a landfill disposal site.

The system of collection mainly depends on the method of storage, provided for keeping the household and commercial refuse, depending on the facility available for storing the refuse.

1.3.2.1 Methods of collection

i. Dump to Dump Collection

ii. Block to Block Collection (standing lorry system)

iii. Kerb Side Collection

iv. House to House Collection.

1.3.2.1.1 Dump to Dump collection

Garbage is deposited by private sweepers who clean the private premises like garden, public building etc., and dump them in the dust bin, refuse shells, vats etc. Such community points should be judiciously located to minimize the nuisance of pollution to the environmental and also to reduce long distance walking to the depositor. Four per kilometer length of the road could be considered reasonable, but actual site condition of layout premises, density of population, etc., should also be taken as a guiding factor.

1.3.2.1.2 Block to Block collection (Standing Lorry System)

In this system, the garbage collection vehicle travels at regular route at prescribed intervals and stops and pre-determined points, where householders and street sweepers bring their garbage cans or buckets for emptying into the vehicle. It is also known as “Standing lorry system”. The
arrival of the vehicles to a locality is announced by ringing of a bell or other convenient means.

1.3.2.1.3 Kerb side collection system

In this system, garbage cans are left outside the premises of the road kerb on the day the garbage van is to visit that area. The crews of the van empty the cans and leave them back at the kerb that is later collected by their owners at their convenience. This system can be successful only in developed areas, where is no danger of rag pickers and stray animals.

1.3.2.1.4 House to House collection

This is a door to door collection similar to block to block collection, but the garbage is not brought by the resident. Depending upon the type of houses i.e., low rise dwellings and high rise dwellings the collection system can be notified as follows:

1.3.2.1.5 Low rise dwelling

There are buildings with not more than two floors (ground and first floor). Following types of collection services are practiced in low rise dwelling areas. Curb Service, Alley Service. Set out – Set back, Set out Service, Dockyards Carry Service.

1.3.2.1.6 High rise buildings

Buildings having more than seven storey’s.

(i) Waste are picked up by building maintenance personnel or porters from the various floors and taken to the basement or service area.
(ii) Wastes are taken to the basement or service area by tenants.

(iii) Wastes usually bagged are placed by tenants in specially designed vertical chutes (usually circular) with openings located on each floor.

1.3.3 Transfer and Transport

The functional element of transfer and transport involves two steps: (i) the transfer of wastes from the smaller collection vehicle to the larger transport equipment and (ii) 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.

IS: 9622-1980 reported that depending upon the development, quantity of waste and distance to be carried, and various methods used. Some of these are carrying on head or on animal back, use of hand carts or animal driven carts. Refuse collection and transportation is a costly service. Every system for a particularly city will need evaluation both for the type of vehicles and the methods of collection to be adopted to find a system most appropriate to local conditions, in terms of quality and service. The Table 1.6 details show the various types of vehicles and their advantages and disadvantages.

The main considerations which need attention while adopting a particular system of transport are layout and condition of roads, methods of storage, method of collection and pay load per collection. Further, it is necessary to know the following factors to decide the types of vehicle.

(i) Number of shifts and duration of the shifts per day.

(ii) Number of trips per shift, distance from transport the point of collection to the disposal.
(iii) Pay load per trip that can be collected that that carried in each trip

(iv) Method of loading and un-loading.

(v) Regional transport authorities requirement and

(vi) Requirements from the print of view of hygienic and aesthetic demand of the citizens.

Table 1.5 Advantages and Disadvantages of transportation vehicles

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Types of Vehicles</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hand cart</td>
<td>Suitable for single person operation, for removal of street sweeping and in small leaves for house to house collection.</td>
<td>Use limited for short distance operation, slow movement.</td>
</tr>
<tr>
<td>2</td>
<td>Pedal Tricycle</td>
<td>Fast moving with silent operation and suitable for wider area than covered by band cart</td>
<td>Load cannot be tipped</td>
</tr>
<tr>
<td>3</td>
<td>Animal Tricycle</td>
<td>No fuel needed low cost of operation, driver can assist in loading, living vehicle unattended and load can be tipped</td>
<td>Suitable for small distance only</td>
</tr>
<tr>
<td>4</td>
<td>Auto Tricycle</td>
<td>Faster than pedal, tipping possible</td>
<td>Useful for short distance only</td>
</tr>
</tbody>
</table>
Table 1.5 (Continued)

<table>
<thead>
<tr>
<th></th>
<th>Tractor and Trailer</th>
<th>Cheapest mode of transport, universal operation for any road, layout, case of generation either alone or as composite vehicle</th>
<th>Slow moving, not suitable for longer distance movement, hitching problem if there are traffic abstractions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Truckers (Commercial Vehicles)</td>
<td>Cheap and study readily and easily available good ground clearance.</td>
<td>Full pay load capacity cannot be utilized. Loading height not convenient.</td>
</tr>
<tr>
<td>6</td>
<td>Compacting Vehicles</td>
<td>More pay loads capacity, easy in loading meet and clean operation</td>
<td>High capital and maintenance cost, special operation metal to operate the unit’s compaction may not be necessary for composting.</td>
</tr>
</tbody>
</table>

In developing countries, about 75 percent of the cities are having 100 to 400 m$^3$ of transport volume vehicles, per million populations served. The vehicles normally make about 2 to 4 trips per day and the average trip distance is less than 20 km. however in a large number of cases, open trucks are being used. They are kept uncovered during journey, and frequent halting and stopping the materials tend to fell on the roads. In India, metropolitan cities like Delhi, Mumbai, Calcutta, Chennai and Bangalore authorities are partially privatizing solid waste collection. Because of the fact that maintenance of vehicles and labour are becoming too costly. In addition, these authorities are finding very difficult to extract the quantity of work from these labour.
1.3.4 **Pre-treatment of solid waste**

After collection of solid wastes and before subjecting final disposal, the solid waste management system may if feasible be modified to improve efficiency in operation by using the following technique as listed in IS: 9622-1980.

This will help to recover resource of usable materials and also conversion products and energy. The suggested techniques are listed as follows:

a) Mechanical Volume Reduction.

b) Chemical Volume Reduction.

c) Mechanical Size Reduction.

d) Components Separation and

e) Drying and Dewatering.

These pre-processor will help in efficient handling in subsequent stages of solid wastes processing in disposal and recycling. By volume reduction solid waste is compacted in incineration volume of solid waste is reduced effectively.

Mechanical sized refuse may be shredded to a size convenient for handling. Component separation can be done both manually as well as mechanically.

Hand sorting, air separation optical sorting, electrostatic separation and screening are some of the methods generally adopted for sorting of solid wastes.
1.3.5 Processing of MSW

Processing techniques are used in Solid Waste Management system to improve the efficiency of Solid waste disposal system, to recover resources (usable materials), to recover conversion products and energy. This processing techniques used in Municipal Solid Waste system are includes, Compaction, Incineration, Shredding, Manual and Mechanical separation and Drying and Dewatering in these, the first to have been used for the processing of solid wastes since the turn of the century. The later three techniques do not have a long history of application the processing of solid wastes.

1.3.5.1 Recycling

Recycling is perhaps the most positively perceived and desirable of all the waste management practices. Recycling will return raw materials to market by separating reusable products from the rest of the municipal waste stream. Recycling saves precious finite resources; lessens the need for mining of virgin materials, which lowers the environmental impact for mining and processing; and reduces the amount of energy consumed. It can also cause problems if it is not done in an environmentally responsible manner.

There are three main methods that can be used to recover recyclable materials from municipal solid waste management,

1. Collection of source–separated recyclable materials by either the generator or the collector, with and without subsequent processing.

2. Commingled recyclables collection with processing at centralized materials recovery facilities (MRFs).
3. Mixed MSW collection with processing for recovery of the recyclable materials from the waste stream at mixed-waste processing or front-end processing facilities.

1.3.5.1.1 Collection of source-separated materials

The separation of recyclable materials into individual components, either by the generator or at curb side by the collector, is known as source separation. The separated materials can be collected individually in single-compartment trucks, or more commonly, they are collected at the same time in a specially designed multi-compartment recycling vehicle. The segregated components are then transported to a consolidation site for further processing and subsequent shipment to markets.

1.3.5.1.2 Collection of commingled recyclable materials

Recyclable materials set out at curb side for commingled collection. The generator only needs to separate recyclable materials from non-recyclables. The recyclable materials are transported to an MRF (Material recovery facilities) where they are segregated into each recyclable component. Processing operations at MRFs can vary from facilities with relatively mechanization, depending primarily on the sorting of waste materials, to highly mechanized automated sorting processes.

1.3.5.1.3 Collection of mixed MSW

In the third approach to recycling, there is no segregation of recyclables from other waste materials. Mixed wastes (including recyclables) are set out at curb side, as would be done for land filling or incineration. The mixed waste then transported to a central processing facility, which employs a high degree of mechanization, including separation equipment such as
shredders, trammels, magnets and air classifiers to recover the recyclables. Mixed waste processing of recyclables is also known as front-end processing or refuse-derived fuel (RDF) processing of MSW.

1.3.5.2 Composting

Composting is a controlled process by which, Biodegradable wastes (organic composition) gets decomposed through micro-organisms. Therefore only bio-degradable wastes can be composted, like vegetable wastes, green wastes, agricultural leaves etc.

Decomposition of the organic solid waste may be done either aerobically or an aerobically. Aerobic includes even vermicomposting where earthworms are used to digest the wastes. Composting can be carried out at the local level, though compost pits and heaps and at the central level through composting plants.

The organic content of municipal solid waste tends to decompose leading to various smell and odour problems. It has led to pollution of the environment. To ensure a safe disposal of the MSW it is desirable to reduce its pollution, potential and several processing methods are proposed for this purpose. Composting process is quite commonly used and results in production of stable product compost which depending upon its quality can be used as a low grade manure and soil condition. The process results in conversation of natural resources and is an important processing method, especially in agricultural and horticultural areas.

Compost is humus like materials that results from microbial action and degradable fraction of solid waste. It is stable, odour free and not attractive to yields, compositing is accelerated bio oxidation of organic matter through a haemophilic stage (45°C to 65°C) where microorganisms (mainly
bacteria, fungi and actinomycetes) the heterogeneous organic material is transferred into homogeneous and stabilized humus-like product through turning or aeration. The process of composting can be either aerobic or anaerobic.

Compost is mainly used as a soil conditioner. It is used to increase organic content of soils and so improve the soil structure. The addition of compost makes the soil take the form of crumbs, rather than fine powder, so that the soil is more resistant to wind and water erosion, able to retain more water and easier to till. Compost also provides trace nutrients and small quantities of the basic plant nutrients—nitrates and phosphates. Compost also used as a filter medium to remove odour.

Generally, successful composting depends on a number of factors that have both direct and indirect influence on the activities of the microorganisms. They include the type of raw material being composted, its nutrient composting, moisture content, temperature, acidity or alkalinity and aeration. The micro-organisms that do most of the work need high temperatures, plenty of oxygen and moisture, in the traditional method of composting, (Afr Birtechnol). It has therefore become highly imperative to develop an alternative technique for the needed good quality compost in a shorter period and identify the specific micro-organisms involved in the degradation with the aim of improving the biodegradation process. Any composting method that does not allow for adequate aeration and building up of relatively high temperatures will not allow the relevant microflora to colonize and degrade the wastes.

Composting of solid wastes deserves special attention even though it is a lower value form of recycling. In industrialized countries, 50 percent of households waste is containing organic materials. For restaurants and hotels, it could be as high as 75 percent. Residential wastes in developing countries,
the food waste becoming high over 50 percent because less processed and packaged food products are used in the world. (Ramesh Kumar Jalan 1999).

The method of utilization of organic material for land filling and traditional composting are inefficient. Hence, a viable and efficient alternative method of solid waste management by applying vermicompost is suggested by many scientists. The potential of earthquake has been used to convert sugarcane trash into manure (Ramalingam and Thilagar 2002) conversion of sludge from distillery into organic manure (Seenappa et al 1995).

The municipal solid waste is experimented as source of vermicompost which recorded higher average yield in the tomato field than the recommended dose of chemical fertilizer (Goswami et al 2001). The concentration of macronutrients like N, P, K were increased after vermicomposting. (Lakshmi Bai et al 2000). Assessment of vermicompost and compost on seedlings growth revealed that increased growth of seedlings was observed in vermicompost than in compost (Pulikhesi Biradar et al 2005).

As a result of composting process, the waste volume can be reduced to 50 to 85 percent (Taylor A et al 1988). Composting is best suited in Indian conditions because waste from Indian towns and cities contain chiefly organic matter (Bhide et al 1975). Humus makes the soil structure attain a crumb, like tendency which improves the water retention capacity of the soil. Humus also increases the ability of the soil to adjust to rapid changes in pH of the soil. Compost, however, is a poor fertilizer (Piali Chakrabarty et al 1995). Table 1.7 shows salient features of major composting plants in India.

When there are a number of dumps that need rehabilitation and only limited resources are available, higher priority may be assigned to dumpsites with high health environmental risk, maximum environmental impacts, minimum rehabilitation costs and maximum public concerns. A rapid risk
assessment tool has been developed by the research group (Kurian Joseph et al 2005).

Composting of fruit and vegetables was quite slow as compared other composting set up. Compost produced from municipal solid waste generally contains approximately 1 percent of NPK where these components were released gradually for plant uptake. The composting was generally contributed by high moisture content in the compost mixture at the initial stage. Factors that affect the rate of composting are the nutrient balance, surface area, moisture content, supply of oxygen and

Co-digestion is the combined treatment of different kinds of solid and semi solid biodegradable organic wastes that can range from the organic fraction of municipal solid wastes, to animal wastes, to municipal sludge’s, to concentrated organic wastes from industrial and agro-industrial processes. The final objective of the co-digestion would be to produce a compost to be recycled as a soil conditioner (Van Lier et al 2001).

Table 1.6 Salient features of major composting plants in India.

<table>
<thead>
<tr>
<th>City</th>
<th>Capacity (tonnes/day)</th>
<th>Area (hectare)</th>
<th>Operated by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangalore</td>
<td>200</td>
<td>7.20</td>
<td>Karnataka compost development corporation.</td>
</tr>
<tr>
<td>Baroda</td>
<td>150</td>
<td>3.50</td>
<td>Baroda municipal corporation.</td>
</tr>
<tr>
<td>Jaipur</td>
<td>200</td>
<td>5.00</td>
<td>Rajasthan state agro industries corporation ltd.</td>
</tr>
<tr>
<td>Kanpur</td>
<td>350</td>
<td>12.00</td>
<td>Baroda municipal corporation Ltd.</td>
</tr>
<tr>
<td>Kolkatta</td>
<td>300</td>
<td>2.00</td>
<td>Kolkatta municipal corporation</td>
</tr>
<tr>
<td>Mumbai</td>
<td>300</td>
<td>4.00</td>
<td>Mumbai organic manures ltd.</td>
</tr>
<tr>
<td>Delhi</td>
<td>200</td>
<td>4.00</td>
<td>New Delhi municipal committee.</td>
</tr>
</tbody>
</table>

Source: CPCB Central Pollution Control Board reference manual.
1.3.5.2.1 Advantages of composting

The advantages of composting are, the process involve Recycling of the waste materials and thus reduces the load on disposal sites. The product contain, essential plant nutrients N P K as well as some of the trace metals (magnesium, Iron etc), which are important for the plant growth. The process is quite rugged and simple to operate. The process does not require highly skilled labour to operate it. When compared to other techniques or technologies, the capital cost and also net operating cost is less. It is environment friendly; it can be located on city outskirts.

1.3.5.2.2 Disadvantage of composting

The disadvantages are, it requires comparatively larger land space as compared to other methods. If the plant is not properly operated, the smell & odour problems and as well as leachate from the yard may leads environmental problems. The inorganic which cannot be recycled have still to be disposed off at land fill. As the process is carried out in the open it is adversely affected by heavy rain & precipitation etc. The produced compost is larger volume of the same nutrient content and hence it may lead marketing and transport problems.

1.3.5.3 Vermicomposting

Vermicomposting is a process of degradation of organic matter by microbes and consumption of organic material by earthworms. Only selected species of earthworms like Eisenia foetida, Eudrilus eligeniae, Perionyx excavates, Lampito maturi, etc., are suitable for vermicomposting process. These earthworm acts as crusher and aerator during the process. The microbe’s capacity associated and makes the final product odourless. Vermicompost can be used as good fertilizer. The concentration of macronutrients like N,P,K were increased after vermicomposting (Lakshmibai etal 2000)
1.3.5.4 Aerobic digestion

Mainly aerobic processes are used to convert bio waste into compost. In these conditions, the bio waste is aerated during several weeks up to several months by forced suction or blowing, in order to remove moisture and heat and to create an optimal environment for the aerobic merophilic and thermophilic micro organisms performing the biodegradation (Haug, 1986).

Composting guidelines (Canadian Council of Ministers of the Environment, 1996) examined that finished compost should contain $<\log_{10} 3.0$ cells g$^{-1}$ dry weight of fecal coliforms, which is a subset of total coliforms (Francis Larney et al 2003).

In composting food wastes in aerobic bio-conversional cell, (Nikolas J. Themelis 2002) assumed that under controlled moisture, air, temperature conditions, the composting reaction proceeded as a quasi–first order reaction.

1.3.5.5 Incineration

Incineration is a technology where waste is burned in specially engineered machines. It is popularly linked primarily with hospital waste, because the use of incinerator is crucial need for the disposal of the pathological stream of Bio-medical wastes which includes body parts etc.

Incineration is a process of controlled combustion for burning solid, liquid and gaseous combustible wastes to gases and residue containing non-combustible material. Heat can be recovered by incineration, which can be used for heating water and generating electricity, (Khan 1994). Though incineration is not a complete method of disposal, its main advantage is that produces a residue that is substantially reduced in volume and may be relatively inert (Suess 1985).
The most attractive feature of the incineration process is that it can be used to reduce the original volume of combustible solid waste by 80 to 90 percent. In some of the new incinerators designed to operate at temperatures high enough to produce a matter material before cooling, it may be possible to reduce the volume to about 5 percent less. Incineration routinely emits dioxins and polychlorinated biphenyls, which are deadly toxins, causing cancer and endocrine system damage. Although the technology of incineration has advanced in the past two decades, air pollution control required may have been met through the use of existing developing technology. Design of on site incineration varies with the type of service and local air pollution control requirements. Incineration on smaller scale with or without energy recovery will continue to be a viable option in a number of locations and specially for hospital wastes (Jain et al 1994).

In developing countries including India, incineration cannot be widely used due to low calorific value of wastes (Bhide et al 1975). In Singapore and Hong Kong, incinerators are being used mainly because of high calorific value of wastes (Thanh et al 1978). The size of the on site incineration facilities ranges from 25kg/hr to 2000 kg/hr. On site incineration reduces the weight by 50 to 80 percent and volume by 70 to 85 percent (Ramesh Kumar Jalan 1999). A well designed incinerator emits about 788kg of CO$_2$, 1352kg of oxygen and 6603kg of nitrogen per tonne of refuse (Victor 1972). The amounts of particulate matter emitted from incinerators depend on the fine ash content of the refuses and the incinerator design.

Incineration is effective with organic wastes, slurries and sludges. Pathological wastes can be completely detoxified (Ahsan 1999). The combustion of solid wastes is can reduce its volume by 70 to 90 percent depending upon composition (Hershkowitz 1986). It can be applied to a wide range of wastes: solid sludge, liquid waste or gasses waste (Buekens et al 1985).
Nath 1984 estimated the relative cost of solid waste disposal by sanitary landfilling, manual composting, mechanical composting and incineration to be in the ratio of 1:2.5:5:25.

1.3.5.5.1 Advantages of incineration

The advantages of incineration are, residue is only 20-25 percent of original weight. The clinker can be used after treatment. It requires very little space. Cost of transportation is not high as incinerators, location within the city limits, safest from hygienic point of view.

1.3.5.5.2 Disadvantages of incineration

The few disadvantages are high capital and operating costs are that it needs skilled personnel and may cause air pollution.

1.3.6 Disposal methods of Municipal Solid Waste (MSW)

Ultimately something must be done with solid waste that are collected and of no further use. The residual matters after solid wastes have been processed and the recovery of conversion products and energy has been accomplished. There are only two alternatives available for the long term handling of solid waste and residual matter, First one is disposal on or in the earth’s mantle and second one is disposal at bottom of the ocean. Disposal on land is by far the most common method.

Land disposal is the form of sanitary landfill is proved to be most economical and acceptable method for the disposal of solid wastes. A land fill is a properly designed area used for the disposal of MSW. Only non-bio degradable and non-recyclable waste should go to a landfill site. Municipal and hazardous waste should not be mixed by putting them in the same landfill.
At present, different disposal practices are being followed in the local bodies, which include composting, recycling of recyclable material and dumping in municipal dump sites. It results in a situation where there is no economic utilization of garbage as an asset and there is simultaneously unnecessary occupation of dump sites leading to health hazards and inconvenience to citizens.

**Figure 1.3 Disposal methods of solid waste**

1.3.6.1 **Sanitary Landfilling**

The term sanitary landfill means an operation in which the waste to be disposed off are compacted and covered with a layer soil at the end of each day’s operation. When the disposal site has reached its ultimate capacity, the final layer of MSW is covered with a plastic sheet. The land disposal method in the form of sanitary landfill has proved to be the most economical and acceptable method of disposal of solid wastes. The planning, analysis and design of modern land disposal systems involve application of variety of scientific, engineering and economic principles. Final selection of a disposal site is usually based on the results of preliminary site survey, results of engineering design and cost studies, and an environmental impact assessment.
Sanitary land filling is a method of disposing of refuse on land without creating nuisance to public health or safety to confine the refuse to smallest practical area, to reduce it to the smallest practical volume and to cover it with a layer of earth at the conclusion of each day’s operation or at such more frequent intervals as may be necessary. In our country, over 90 percent of the solid wastes are disposed of in landfills. However, in most of the towns, crude dumping is done rather than sanitary land filling (Khan 1994).

Salvats (1992) suggests 2 types of land fill–trench method and area method. Trench method is used when the groundwater is low and the soil is more than 6 feet deep. This method is best suited for flat terrain. The area method will be suitable for most topography and will be often used if large quantities of solid wastes are needed to be disposal off.

The most significant environmental hazards associated with this method of solid waste disposal are the problem of water pollution. Ground as well as surface water can become highly polluted on coming into contact with the solid waste. Solid wastes in a land fill decompose biologically as well as chemically to produce solids, liquids and gases. The ground and surface water moving through the sanitary landfill pick up dissolved as well as suspended solid matter and microbial waste products to form a solution termed Leachate (Mantel 1975).

1.3.6.2 Advantages of Sanitary Landfilling

The advantages of sanitary land filling are as follows highly skilled personal are not required. Low lying, marshy wasteland can be reclaimed into use full area; natural resources can be returned to soil and recycled.
1.3.6.3 Disadvantages of Sanitary Landfilling

The main disadvantage of sanitary land filling is that it requires large area of land. Heavy transportation cost and it may cause fire hazards due to formation of methane gas in wet weather.

1.4 INTEGRATED SOLID WASTE MANAGEMENT (ISWM)

Integrated solid waste management (ISWM) can be defined as the selection and application of suitable techniques, technologies and management programs to achieve specific waste management objectives and goals.

Planning, development and implementation of ISWM is essentially a local activity that involves the selection of the proper mix of alternatives and technologies to meet changing local waste management, flexibility in meeting future changes and the need for monitoring and evaluation. A wide variety of proper mix of alternative programmes and technologies are available for the management of solid wastes some questions arises from this, what is the proper mix. 1) The amount of wastes separated for reuse and recycling. 2) The amount of waste that is composted. 3) The amount of waste that is combusted. 4) The amount of waste to be disposed of in landfills. What technology should be used for collecting wastes, separating waste components for composting the organic fraction of MSW, site feasibility selection for compacting wastes at a landfill and what is the proper timing from the application of various technologies in an ISWM system and how should decisions be made etc. Fig 1.4 shows the process of integrated solid waste management system.

In the development of ISWM system, it is very necessary to adapt waste management practices to changing conditions some important factors to
be considered are, 1) Changes in the quantities and composition of the waste system. 2) Changes in the specification and markets for recyclable materials and 3) Rapid development in technology if the ISWM system is planned and designed with this factors the local community will be protected from unexpected changes is local, regional and larger scale conditions. Therefore the Hierarchy of ISWM can be considered as, source reduction Recycling, waste transformation and land filling.

Figure 1.4  Process of Integrated Solid Waste Management (ISWM)

1.5  INDIAN PERSPECTIVE OF MUNICIPAL SOLID WASTE MANAGEMENT

With Indian population crossing one billion mark (census of India 2011) and combined unplanned development and urbanization is a thing for certain an enormous amount of waste is going to be generated. The situation
is no better at present, the urban population was 217 million in 1991 and the total quantity of solid waste generated in urban areas was estimated at 20.71 million tons per year. This is expected to cross 56 million tons during this year 2011.

Municipal solid waste is a part of public health and sanitation and is entrusted to the government for execution. Presently, the systems are assuming larger importance due to population explosion in municipal areas, legal intervention, and emergence of newer technologies and rising public awareness towards cleanliness (Kumar et al 2004). The municipalities in India, therefore, face the challenge of reinforcing their available infrastructure for efficient MSW management and ensuring the scientific disposal of MSW by generating enough revenues either from the generators of by identifying activities that generate resources from waste management (Singhal and Pandey 2001).

In India, unfortunately solid wastes management has received very little attention which resulted in unsanitary conditions in almost all cities and towns of the country. The main reason behind this could be attributed towards of lack of awareness and responsibility of both concerned authorities as well as citizens. Most of the citizens carelessly throw away solid waste generated within their house into the street as well as into public places.

The concerned authorities in all most all cities and towns are not adopting proper solid wastes management schemes. Combinations of all these have resulted in spreading many diseases, pollution and unhygienic conditions. Most of Indian cities and towns are not adopting proper solid wastes management schemes.

To plan effectively for solid waste management, information and data on the expected (future) composition of the solid wastes are important.
1.6 SOLID WASTE MANAGEMENT IN HOSUR TOWN

An investigation has been undertaken to study the present scenario of solid waste management in and around Hosur town of Tamil Nadu, Hosur is an industrially renowned town in Tamil Nadu and is located on the Krishnagiri-Bangalore National Highway at 12º44’N latitude and 77º50’ E longitude, which is popularly known as Industrial town, since major industries are situated like T.V.S, Ashok Leyland, Titan, SIPCOT-I, SIPCOT-II etc., it receives annual rainfall of 644mm. The projected population of the town is about 2.44 lakhs and floating population of about 35,000/day. It is having good connectivity by road and rail. It is also an important educational, administrative and trade centre, transportation network, influence of market and commercial activities, increased floriculture activities due to favorable climate conditions etc., The Hosur new town plan extends over an area of 76.2 sq. km. The entire area is divided into six zones for the different land use. The entire town is divided into three sanitary zones for effective management of MSW covering all 45 wards current management practices.

1.6.1 Method of Collection & Transportation of MSW at Hosur

The primary collection of MSW is being carried out by 136 sanitary Workers from house to house from 45 wards collected by using push carts. Secondary collection were done through transporting vehicles, the wastes were collected in 8 autorikshaws, 6 trucks and 3 tractors. The collected wastes are transported to the dumpsite at Thasepalli village which is 15 km away from Hosur, consisting of 7.9 acres of land area. At present from 45 wards, garbage is collected by local door to door and street sweeping and mopping method. Autos and tippers are used for primary collection in some zones and push cart, bins are used in other parts. The collected waste is dumped in the existing dump yard.
The characterization study has revealed that the solid waste contains composting material are in larger quantities 63.10 % when compared to other constituting parameters. Plastics, paper, combustible clothes were also analyzed and they constituted 10.50 %, 13.59 %, 4.89 % and respectively of the total MSW generated.

1.7 INSTITUTIONAL, FINANCIAL & ECONOMIC ASPECTS OF SWM IN THE TOWN.

In the year 2011-2012, for the scheme of integrated urban development mission granted an amount of Rs 1.56 lakhs for MSWM. This amount was used to develop the compost yard, compound walls and segregation units and others. During 8th Jan 2012 the Titan Industries limited, organized clean Hosur project visualizing a citizen based programme to keep Hosur clean. It was inspired by a volunteer based National clean-up drive in Estonia in Northern Europe and also by a similar programme in Kulithalai, Tamilnadu. Clean Hosur joint action group is being constituted with the sub collector as the chairman and representatives of Government Municipality, Principal of Adhiyamaan college of Engineering, Hosur industries and business men, NGOS, Eminent/ Influential persons of Hosur and subject experts as members, multiple stake holders etc.,

The objectives, strategies, plan and activities for the cleanliness drive are

- To provide a sustainable solution to the problem of garbage clearance and management in Hosur.
- To ensure a clean Hosur this becomes a model for the other urban settlements.

To achieve this objective two pronged approach was envisaged.

- A long term sustainable solution aiming at zero waste management.
• A onetime cleanliness drive involving nearly 12000 volunteers on Jan.8th 2012.

The discussions includes,

• Multiple stake holders
• Resource mobilization through monthly maintenance fee and earnings from recyclable waste(NGO activity)
• Awareness and Training
• Review garbage segregation leading to zero waste management
• Design of new ‘User Friendly’ garbage bins
• Adequate and strategically located clearance dumps
• Enzyme based plants for quick conversion of organic waste into organic manure to be located in high waste generating areas like Bus stand, Ullarar santhe etc
• Declaration of “Litter free zones “ and plastic Free zones”
• Incentive based plastic and other recyclable waste clearance for local rag pickers
• Dedicated garbage clearance teams for high waste generating areas
• Dignity of human labour to be stressed through out
• Timely and ongoing garbage removal mechanism, local rag pickers to be trained
• Dedicated monitoring teams Area leaders
• Modern and high tech waste management solutions.

1.8 ROLE OF PUBLIC PARTICIPATION IN SWM FOR HOSUR TOWN

Previously a private organization, Srinivasa Services Trust (TVS group) was collecting garbage in the bus stand and segregates the waste for producing vermicompost and being stopped. Titan Company organized a
Citizen-based programme to keep Hosur clean in the year 2012 by joining hands with Adhiyamaan College NSS students. Fig 1.5 shows Photographic view of public participation by the Adhiyamaan College NSS students.

The major activities involved in that programme are:

- A One-day Citizen’s led clean Hosur project, possibly involving about 12,000 Citizen of Hosur working together and cleaning up the town on 8th January 2012.

- The publics of various parts of Hosur came together to continue the good work and keep their localities clean.

The main objective of that programme is to provide a sustainable solution to the problem of garbage clearance and management in Hosur in a spirit of employee and Citizen volunteering and ensure a clean Hosur which becomes a model to other urban settlements. To clean up the Hosur town is a difficult task, but not impossible. All we require is a coming together of the entire community for this common purpose with uncommon zeal.

Figure 1.5 Public participation by NSS students of Adhiyamaan College
1.9 THE RELAVANCE OF THE PALACODE MODEL

The relevance of the “Palacode model studied as an example for MSWM”

A case study on SWM for clean Palacode a special scheme on solid waste management has been visited and studied. The different methods of collection, transportation, & disposal of SW have been studied generally to take up the SWMS for Hosur as a case study. Clean Palacode special model scheme on SWM during the study period 2004-2005 was considered to avoid environmental pollution due to rapid increasing of SW generation.

The main objective and aim of the special scheme on SWM of Palacode model is for

- The primary objective of this study of SWM is to ensure economic and efficient collection, handling, utilization and disposal of solid waste.
- To manage the solid waste arising in and around Palacode and to provide a clean environment over the entire area.
- To educate the people and to create public awareness for managing the waste.
- To prove it to be a role model for the future implementation in other places.

The highlights of the scheme are

- Door to door collection of the waste.
- No fee is collected from the public for the scheme’s activities.
- The waste is collected for all the seven days in a week without any holidays even during the festival period.
- Public co-operation.
- Clean /pure streets and roads.
- Extra income to the Town panchayat.
- Production of best quality manure.
- Absence of waste and waste bins in the streets.
- Formation of green belt along the street sides
- Achievement of wealth from waste concept.

To fulfill the above requirement, there is an immediate need for efficient and orderly SWM system which includes the study of

1. Accurate data analysis and the testing of SW characteristics and quantities.
2. Storage, collection, handling and Transport.
3. Utilization, recovery and recycling.
5. Disposal options including identification of suitable sanitary landfill sites.
6. Organization, management and implementations.

The various activities associated with the SWM from generation to final disposal have been grouped into six functional elements to solve a particular solid waste problem; the various functional elements are combined in what usually known as SWMS. One of the goals of SWM is the optimization of this system to provide the most efficient and economic solution.

Palacode before the implementation of scheme was studied. From the statistical details the amount of SW generated in the area was about 2.5 t/day. Waste was collected once in two days and dumped at road sides, empty areas and ditches. People were not aware of managing the SW in a proper way and even the drainage was also cleaned once in fifteen days and no proper management plan was introduced in the town for the past days.
To achieve proper solid waste management system, women were chosen for collecting the wastes from houses because they will have better interactions with the public, taking this in to account, a special hand driven cart was been designed by the officials so that it will be easy for them to handle. The cart is capable of carrying four specially designed containers along with an alarming bell and a lever to change the direction, the size of the designed cart is as follows.

The material of the bin has been made of plastic which is specially designed by the Sintex company for collecting the waste. One is green is colour for collecting the biodegradable wastes, and the other in black colour to collect the non-biodegradable waste. Safety equipments are provided to workers with safety materials like rubber, hand gloves, cap, uniform shirts, slippers, and with nose masks.

1.9.1 Collection of Waste

The entire town panchayat has been divided into 30 zones, in that, each zone comprises of 150 houses. Each zone is provided with one, three wheeler cart and one person has been appointed for supervision. They are instructed to collect the waste from each and every houses early in the morning between 7:00 am to 8:00 am. They have been advised to follow the same route daily to maintain good understanding with that people. The cart is also fixed with one alarming bell to call the households for delivering the waste bins.

The wastes are collected in two separate bins, green colour for bio degradable and black colour for non-biodegradable wastes. This work will continue for all the seven days in week without any holidays even in the festive periods. Alternatives are also made by themselves for the absentees (due to unavoidable reasons). After collecting the waste from each and every house, the carts are driven to one common point (in such points are chosen for entire 30 zones).
The town panchayat vehicle (lorry) will collect the biodegradable wastes and it is transported to the compost yards. The non-biodegradable wastes are segregated based on their nature and it is handed over to the officials for recycling. After disposing the wastes the bins are cleanly washed by the same workers.

The collective participation of women’s self help group were motivated to involve due to insufficiency of existing workers. Suggestion were made to tempt the house wives and other women to take active part in this scheme this was the key success.

The continuous event of this scheme maintained the town to be clean. This encouraged the public to give full support and to take active part. The non-biodegradable items like cardboards, vegetables wastes, egg shells and some plastic items are recycled without handing over it to the town panchayat. The commercial business centres pay for the collection of wastes without any hesitations. The garbage from markets are collected in separate baskets and sent to the town panchayat vehicles. No wastes are dropped in open areas or roadsides.

The hatcheries are advised to collect their wastes in a separate vessel and to dispose it to the town panchayat lorry and the general vendor’s are asked to collect their waste separately and hand it over to the town panchayat lorry.

Common collection point one is at Mandavilli and second one is at bus stand. Wastes collected from the houses are brought to the common point and waiting for the truck to unload the wastes and delivering the wastes into the truck at the common collection points and cleaning the bin’s in nearby bore pump at Mandavalli and water tank nearby bus stand. After disposing the biodegradable wastes, the self help group women segregate the non-biodegradable wastes according to their nature and it is stored in the office
premises for recycling. Action was taken to clean the roads, streets and ditches etc.

1.9.2 Transportation

Both empty and loaded weight is taken for the truck daily and proper records are maintained for it separate weight is measured for both biodegradable and non –biodegradable wastes .The truck is then transported to the compost yard. The compost yard located at Ernahalli village 4.70 km away from Palacode Town panchayat and total area of 4 acres which is away from residences separate disposing area for different categories of wastes and odor free zone were maintained and also the compost yard consisting of leachate collection tank Rain water harvesting, compost store room, gardening and completely fenced.

Open pit Aerobic composting process is carried out in compost yard. The compost yard is been designed. In compost yard consists of 30 no’s of composting pits (conc. pits, 15 no’s in each row) to carry out the composting process. The size of existing compost yard is 50 m x 5.0 m x 6 m. The pit has its dimensions of 3 mx1.5 mx1.2m. Two days waste is emptied in one pit so that for 60 days the pit can be engaged. At the end of 60th day the wastes in the first pit will become manure, it will be collected and once again the cycle follows for the next 60days.

During the composting process, after complete filling of the pit, water is sprinkled from the top to maintain certain moisture content in the pit The pit is turned up and down for better aeration in the alternate days ,cow dung is sprayed over the pit to enhance the process, and it is frequently monitored for temperature (maximum temp raised in the composting pit is 70ºc during the 1st two days after loading the waste into the pit) The pit is frequently turned for better aeration along with the special provision of holes in the side surface
of the pit’s. The compost is finally sieved before it transported to the compost store room.

The workers in the compost yard are provided with necessary safety equipments to prevent any health hazards. The obtained manure is stored in a separate store room, provided inside the compost yard.

The compost yard provided with water supply arrangement, chain link fencing yard with lockable gate, drying of 2000 Sq.ft for drying the composted materials and sorting of recyclables, store room of 250 Sq.ft to store bio-manure, recyclables and valuables, mechanized sieving machine to sieve the dried composted waste, pulverize to broken the larger sized remaining from the sieving machine, Weighing scale of 100 kg capacity to measure the weight to bio-manure for packing green belt of width 6m around inside the fencing as buffer zone, Cow dung slurry mixed while unloading the waste and adding of panchayat to enhance the property of bio-manure according to the std.

1.9.3 Economics at a glance for Palacode Model.

<table>
<thead>
<tr>
<th>Sl.no.</th>
<th>Particulars</th>
<th>Amount</th>
</tr>
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<tr>
<td>1.</td>
<td>Door to Door collection (35x800/month)</td>
<td>Rs.28000</td>
</tr>
<tr>
<td>2.</td>
<td>Compost yard Maintenance</td>
<td>Rs.2000</td>
</tr>
<tr>
<td>3.</td>
<td>Power &amp; others</td>
<td>Rs.2000</td>
</tr>
<tr>
<td>4.</td>
<td>Panchagavya and cow dung</td>
<td>Rs.5000</td>
</tr>
<tr>
<td>5.</td>
<td>Miscellaneous</td>
<td>Rs.3000</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Rs.40,000</td>
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### Table 1.8 Income/ Month

<table>
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<th>Sl.no</th>
<th>Particulars</th>
<th>Amount</th>
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<tbody>
<tr>
<td>1.</td>
<td>Sale of Recyclables</td>
<td>Rs.5000</td>
</tr>
<tr>
<td>2.</td>
<td>Collection charges from commercial</td>
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<tr>
<td></td>
<td>Establishments (500 x20)</td>
<td>Rs 10,000</td>
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<tr>
<td>3.</td>
<td>Sale of Bio-manure (30 t/month x 2000)</td>
<td>Rs 60,000</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>Rs.75,000</strong></td>
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</tbody>
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### Table 1.9 Net income / Annum

<table>
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<th>Sl.no.</th>
<th>Particulars</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Net income (75000 - 40,000 per month)</td>
<td>Rs 35000</td>
</tr>
<tr>
<td></td>
<td>For 12 months (Rs 35,000 x 12)</td>
<td>Rs 4,20,000</td>
</tr>
</tbody>
</table>

Payback period for the investment made -3 years

So it was concluded, that, this scheme is very successful one, where the wastes are made to a useful product that is end product obtained is manure which gains money and ultimately a better profit to the town panchayat .This scheme must be implemented in all the areas like town & cities so that all the roads and streets are always clean where nuisance and many health hazards can be avoided to a very great extent.
1.10 NEED FOR THE PRESENT STUDY

Solid waste management (SWM) involves managing activities associated with the generation, collection, transportation and disposal of solid waste in environmentally compatible manner, adopting principles of economy, aesthetic, energy and conservation.

One of the most important environmental problem faced by urban cities in solid waste management are increasing population, unplanned urbanization, scarcity of resources and limited alternative solutions make the problem serious. Due to rapid increase in population and industries, increase in agriculture and floriculture activities and exporting of fruits and vegetables has led to increase in generation of MSW.

At present, the town is not having proper solid waste management system; the collected waste is simply dumped in the open dumpsite at Thasepalli without any treatment, which is situated 15 km away from town. These contaminate the surface water, groundwater and soil. The place becomes a source for breeding for flies and mosquitoes causing many communicable diseases. It is also noticed that the pigs and other domestic animals cause further nuisance.

Keeping all these factors in view, an investigation is undertaken to study the various component of managing the solid waste and to suggest a scientific approach for proper solid waste management system for Hosur town.
1.11 OBJECTIVES

The research work has been undertaken to design the municipal solid waste management system for Hosur town and surroundings.

The detailed objectives of the present study are,

- To study the current status of solid waste management in Hosur town.
- To study the characteristics of municipal solid waste by analyzing physical, chemical and biological parameters.
- To study the possibility of recovery of materials from the solid waste.
- To study the feasibility of vegetable waste management by Vermicomposting Method.
- To study the feasibility of mango waste management by composting Method.
- To study the quality of ground water and soil in and around dumpsite.
- To design the integrated solid waste management system for Hosur town.
- To provide operational guidelines for efficient municipal solid waste management system.
• To identify the feasible site for landfill by using GIS and RIAM.

1.12 ORGANISATION OF THE THESIS

Chapter 1 Envisages causes and effects of environmental pollution in general and due to solid waste in particular. The characterization of the waste causing pollution is emphasized.

Chapter 2 Review of literature is made where in, state of art measures on solid waste management scenario with reference to Indian context is depicted, quantifying the collection and disposal measures.

Chapter 3 Materials and methods were discussed for different types of waste. Qualitative and quantitative characterization of solid waste in the study area being done. The composition and material characterization and its quantification are made to analyze the solid waste to understand the appropriate adaptability of vivid measures to dispose the solid waste. The work includes characterization of municipal solid waste, market waste and mango waste, followed by formulation of suitable treatment techniques. Study the effect of municipal solid waste on water and soil and identification of feasible land filling site using remote sensing, GIS and RIAM tools.

Chapter 4 Results and discussions on the parameters elicited to understand material characterization, remote sensing methodology and design alternatives are discussed elaborately.

Chapter 5 Site suitability analysis using GIS and RIAM is being carried out. Remote sensing and GIS tools are used to prepare the different thematic maps viz., land use, land cover maps, contour maps, slope map,
hydro-geomorphology map along with the creation of digital elevation model. The identified location for land fill is cross verified with the Rapid Impact Assessment Matrix (RIAM).

**Chapter 6** The design of Solid Waste Management system depicting the means of solid waste segregation, design of landfills, multiple chamber incinerators for the various of solid waste are discussed.

**Chapter 7** Presents the summary and conclusions with scope for further works are drawn out of the study. The list of references is furnished at the end of the thesis.

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