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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – I – INTRODUCTION – SCIA3004

NEED FOR SOLID WASTE MANAGEMENT:

Waste management is the process of treating solid wastes and offers variety of solutions for recycling items that don‘t belong to trash. It is about how garbage can be used as a valuable resource. Waste management is something that each and every household and business owner in the world needs. Waste management disposes of the products and substances that you have use in a safe and efficient manner.

Natural systems, there is no such thing as waste. Everything flows in a natural cycle of use and reuse.

Living organisms consume materials and eventually return them to the environment and it converted usually in a different form, for reuse.
Human activities create waste, and the ways that waste is handled, stored, collected, and disposed of can pose(create) risks to the environment and to public health. Solid waste

management (SWM) includes all activities that seek to minimize health, environmental, and aesthetic impacts of solid waste.

In urban areas, especially in the rapidly urbanizing cities of the developing world, problems and issues of municipal solid waste management (MSWM) are of immediate importance. Most governments have acknowledged the importance of MSWM

In India, a proper waste management system is urgent necessary for the following reasons:

- To control different types of pollution, i.e., air pollution, soil pollution, water pollution etc.;
- To stop the spread of infectious diseases.;
- To conserve all our environmental resources, including forest, minerals water etc.;
- To recycling of hazardous wastes for further production.

To implement proper wastes management policy, successful and safe disposal of solid and liquid wastes are very necessary.

In this connection, the government of any country has to follow the steps below:

- Collection
- Segregation
- Dumping
- Composting
- Treatment of Effluents before discharge

MUNICIPAL SOLID WASTE:

It commonly named as GARBAGE or TRASH, each household generates garbage or waste day in and day out.

- **Garbage is generally referred to "Waste" and is also termed as rubbish, trash, junk, unwanted or undesired material.**

Fig 1.1

Fig 1.2

PRINCIPLES OF MUNICIPAL SOLID WASTE MANAGEMENT – SOCIAL & ECONOMIC ASPECTS

Municipal Solid Waste Management involves the application of principle of Integrated Solid Waste Management (ISWM) to municipal waste. ISWM is the application of suitable techniques, technologies and management programs covering all types of solid wastes from all sources to

achieve the twin objectives of (a) waste reduction and (b) effective management of waste still produced after waste reduction.

Waste Reduction

It is now well recognised that sustainable development can only be achieved if society in general, and industry in particular, produces _more with less‘i.e. more goods and services with less use of the world‘s resources (raw materials and energy) and less pollution and waste. Production as well as product changes have been introduced in many countries, using internal recycling of materials or on-site energy recovery, as part of solid waste minimisation schemes.

Effective Management of Solid Waste

Effective solid management systems are needed to ensure better human health and safety. They must be safe for workers and safeguard public health by preventing the spread of disease. In addition to these prerequisites, an effective system of solid waste management must be both environmentally and economically sustainable.

- Environmentally sustainable: It must reduce, as much as possible, the environmental impacts of waste management.
- Economically sustainable: It must operate at a cost acceptable to community.

Clearly it is difficult to minimise the two variables, cost and environmental impact, simultaneously. There will always be a trade off. The balance that needs to be struck is to reduce the overall environmental impacts of the waste management system as far as possible, within an acceptable level of cost.

An economically and environmentally sustainable solid waste management system is effective if it follows an integrated approach i.e. it deals with all types of solid waste materials and all sources of solid waste.

A multi-material, multi-source management approach is usually effective in environmental and economic terms than a material specific and source specific approach. Specific wastes should be dealt within such a system but in separate streams. An effective waste management system includes one or more of the following options:

(a) Waste collection and transportation.

(b) Resource recovery through sorting and recycling i.e. recovery of materials (such as paper, glass, metals) etc. through separation.

(c) Resource recovery through waste processing i.e. recovery of materials (such as compost) or recovery of energy through biological, thermal or other processes.

(d) Waste transformation (without recovery of resources) i.e. reduction of volume, toxicity or other physical/chemical properties of waste to make it suitable for final disposal

Financial Aspects

The ultimate goal of municipal solid waste management is to improve the quality of life of people, especially the underprivileged, the ignorant and the poor who cannot exercise their right to human dignity.

The lack of attention given to human health, environment and safety issues cannot be attributed to cost factors. Suggested Investment Generally there has been a tendency to set up curative (Remedial) services to deal with problems created by a development project instead of setting in place appropriate preventive strategies as an integral part of the original development as has been amply (Sufficiently) demonstrated in the major development projects like irrigation and industrial projects which have propensity for creating malariogenic conditions. It is, therefore, recommended that generally about 1% of the project investment on MSWM may be considered for environmental and health impact assessment of Municipal solid management.

Environmental Factors

The community is exposed to the environment through location, occupation and behaviour. The environment is changed by the project. New health hazards may be introduced and old health hazards may disappear. The changes may take place immediately or over a timescale of ten or more years. Hot, humid and moist environment is congenial (friendly) for most of the disease causing organisms.

Various components like air, water, land, noise and socioeconomic are considered during environmental and health impact studies.

Environmental factors which have potential linkages with solid waste Management at its different phases and health are:

1. Temperature;
2. Rainfall;
3. Humidity;
4. Wind (speed and direction);
5. Air quality;
6. Water quality;
7. Physical and chemical properties of soil; (particularly for minimising leaching from landfill sites, soil-microbe activities for composting)
8. Land use
9. Noise
10. Aesthetics

EFFECTS OF IMPROPER DISPOSAL OF SOLID WASTE:

Introduction

There are potential risks to environment and health from improper handling of solid wastes. For the general public, the main risks to health are indirect and arise from the breeding of disease vectors, primarily flies and rats.

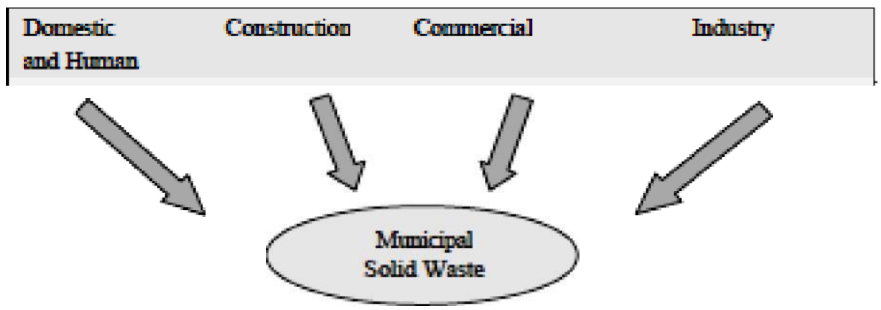
The most obvious environmental damage caused by municipal solid wastes is aesthetic, the ugliness of street litter and degradation of the urban environment and beauty of the city. Also transfer of pollution to water, ground water. Air pollution can be caused from the Inefficient burning of wastes, either in open air, or in plants that lack effective treatment facilities from the gaseous effluents.

Fig 1.3

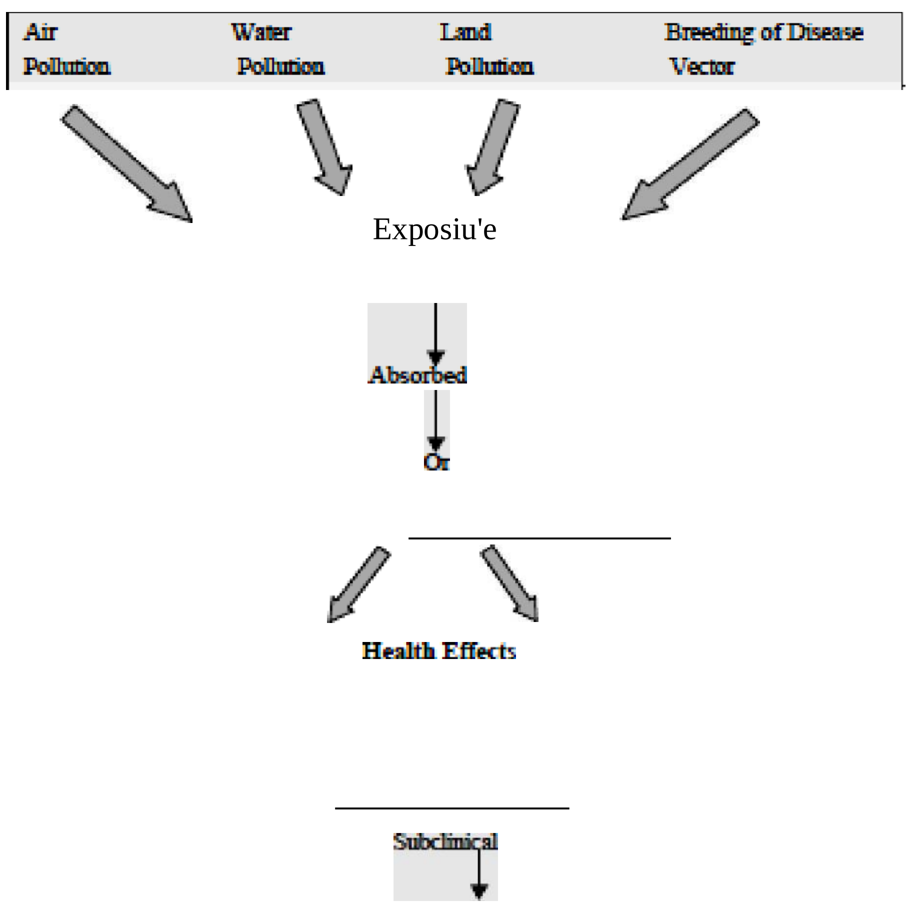
Fig 1.4

Fig 1.5

Actiiñties Generating= 3dunicipaI Solid Tt'aste



Environmental and Bealth Impact



Impact of municipal solid waste on Environmental & Health

Environmental and health identification of the following activities/components need to be carefully examined:

1. Design, storage methods of collection bins;
2. Frequency of collection particularly putrescible organic matter;
3. Environmental status of collection points and disposal sites;
4. Loading/unloading of wastes in the vehicles at the collection points and disposal sites;
5. Sorting out the recyclable materials;
6. Open burning of solid waste; (whether the practice leads to increase in concentration of suspended particular matter carbon monoxide, sulphur dioxide, hydrogen sulphide, nitrogen oxide, dioxins and furons in the surrounding area);
7. Design and operation of collection vehicles;
8. Design and operation of landfill sites
9. Compaction and coverage of solid wastes at the landfill site (to prevent escape of methane gas at the landfill site);
10. Breeding of flies, mosquitoes, cockroaches, rodents, pigs, stray dogs (they play important role in the spread of disease)
11. Activities generating odour and aesthetic problems;
12. Activities/components which are potential cause of injury, violence etc.
13. Activities/components which are likely source of air, water, soil and noise pollution. 14.Periodical Personal Protective Clothing's (PPC), Personal Protective Equipment (PPE) and health check-up of workers/staff engaged in various/activities of solid waste management.

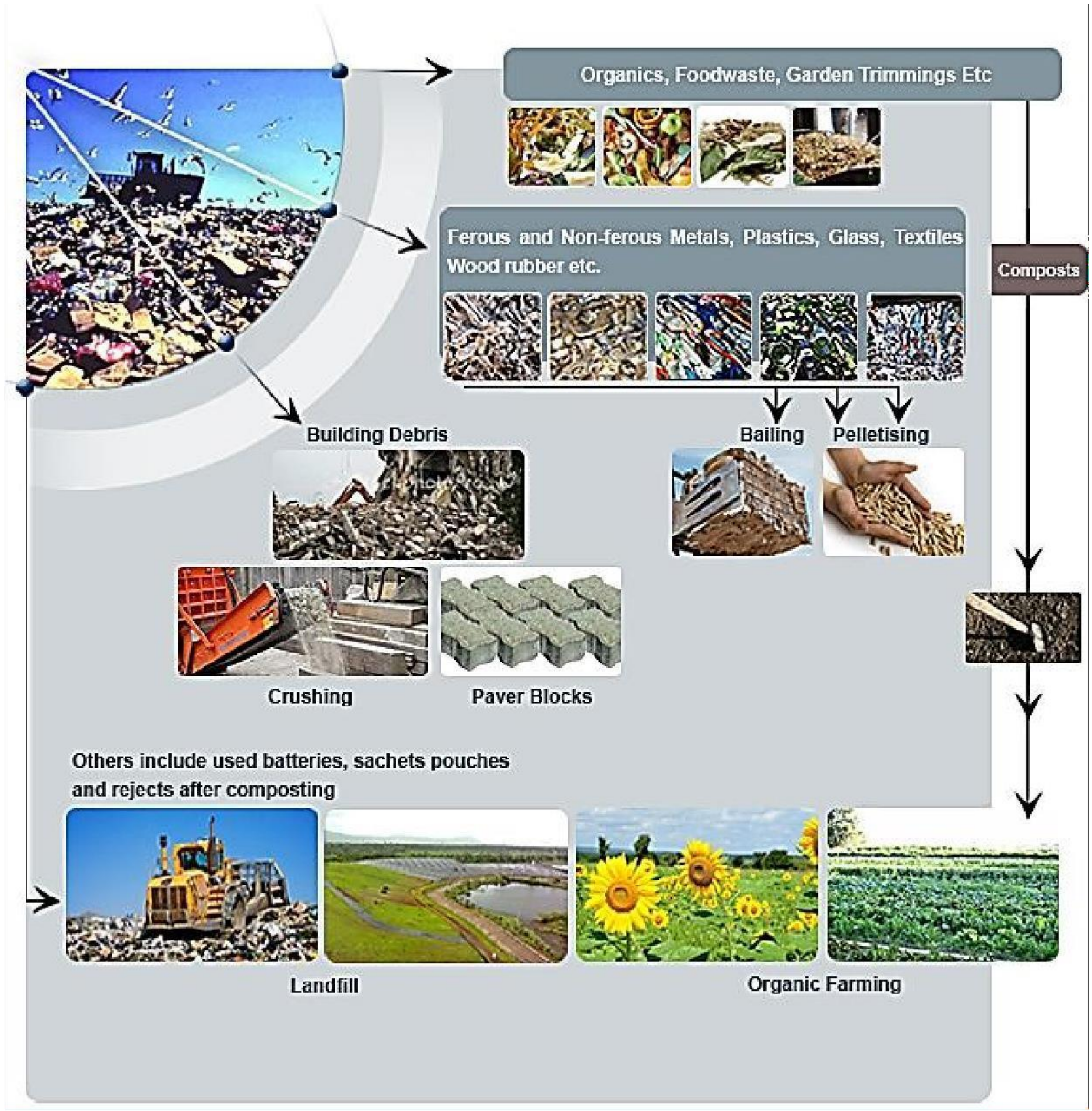


Fig 1.6 Pelleting: form or shape(a substance) into pellets

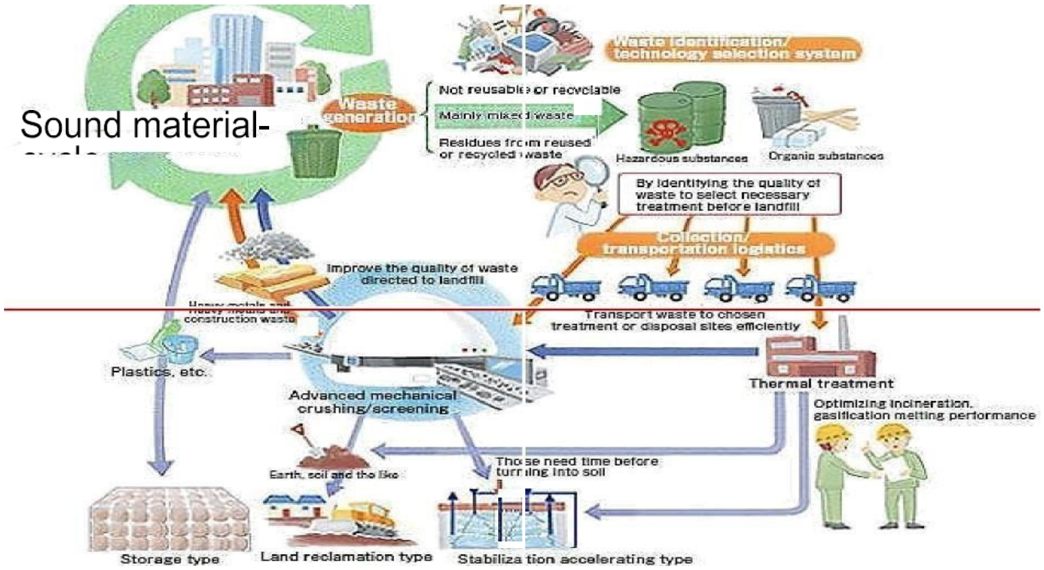

Sound material-
Waste identification/ technology selection system
Waste generation
Not reusable or recyclable
Mainly mixed waste
Residues from reused or recycled waste
Hazardous substances
Organic substances
By identifying the quality of waste to select necessary treatment before landfill
Collection/ transportation logistics
Improve the quality of waste directed to landfill
construction waste
Transport waste to chosen treatment or disposal sites efficiently
Plastics, etc.
Advanced mechanical crushing/screening
Thermal treatment
Optimizing incineration, gasification melting performance
Earth, soil and the like
Those need time before turning into soil
Storage type
Land reclamation type
Stabilization accelerating type

Fig 1.7

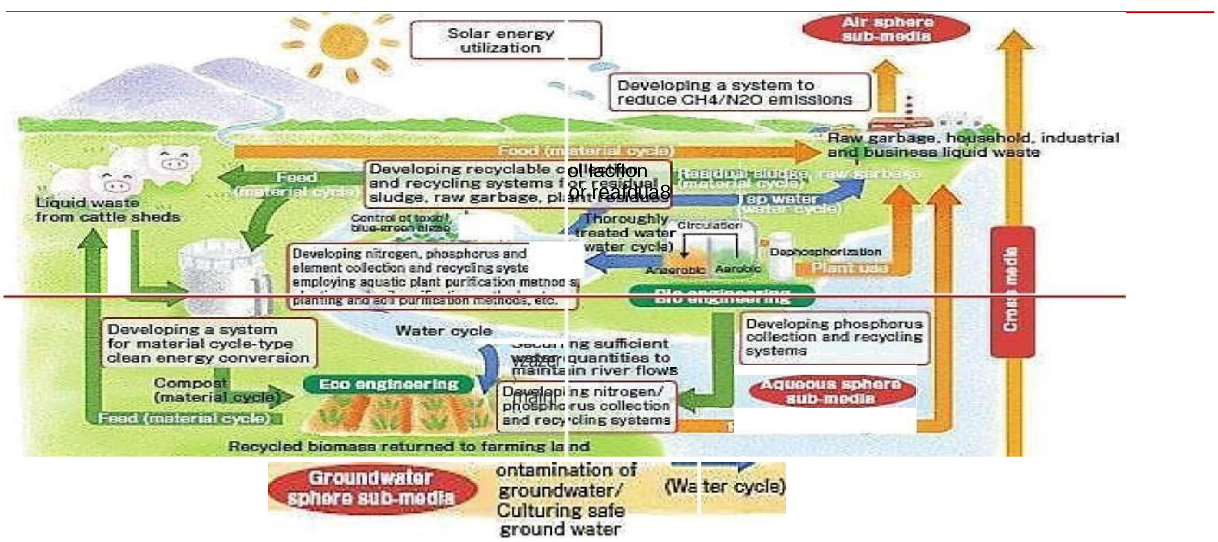
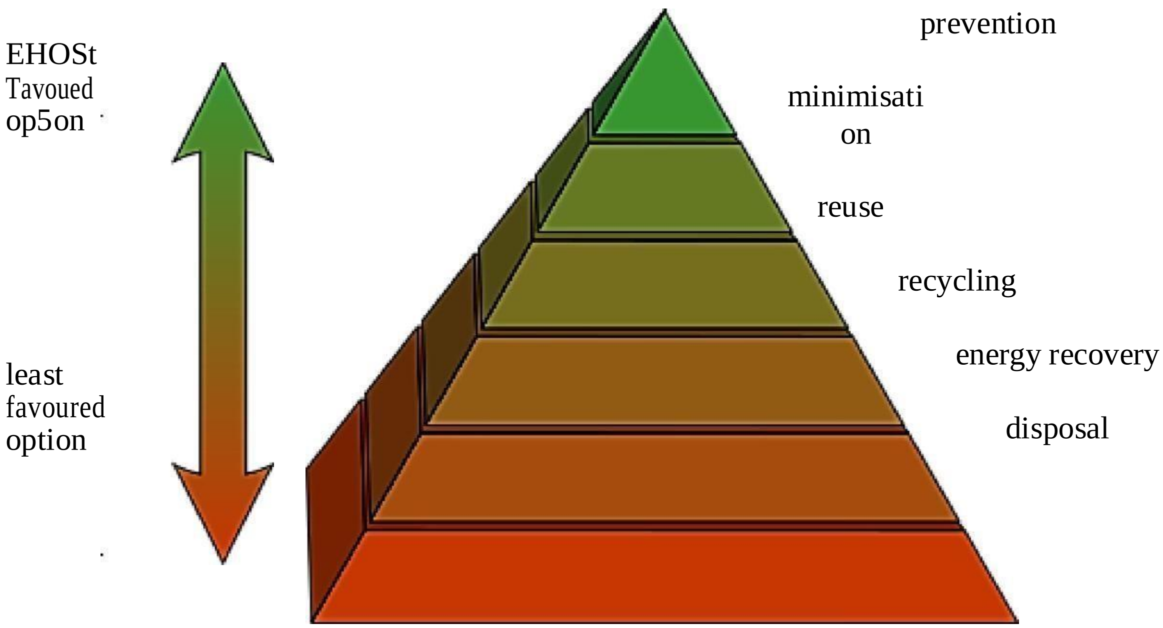

Solar energy utilization
Air sphere sub-media
Developing a system to reduce CH4/N2O emissions
Raw garbage, household, industrial and business liquid waste
Food (material cycle)
Feed (material cycle)
Liquid waste from cattle sheds
Developing recyclable collection and recycling systems for residual sludge, raw garbage, plant residues
Thoroughly treated water (water cycle)
Circulation
Anaerobic
Aerobic
Dephosphorization
Plant use
Developing nitrogen, phosphorus and element collection and recycling systems employing aquatic plant purification methods, planting and soil purification methods, etc.
Bio engineering
Cross media
Developing a system for material cycle-type clean energy conversion
Water cycle
Securing sufficient water quantities to maintain river flows
Developing phosphorus collection and recycling systems
Compost (material cycle)
Eco engineering
Feed (material cycle)
Developing nitrogen/ phosphorus collection and recycling systems
Aqueous sphere sub-media
Recycled biomass returned to farming land
Groundwater sphere sub-media
ontamination of groundwater/ Culturing safe ground water
(Water cycle)

Fig 1.8


EHOSt
Tavoued
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least
favoured
option
prevention
minimisati
on
reuse
recycling
energy recovery
disposal

Fig 1.9

GREEN HOUSE GASES EMISSION FROM SOLID WASTE:

MUNICIPAL SOLID WASTE AND GHG EMISSIONS:

What does MSW have to do with rising sea levels, higher temperatures, and GHG emissions? For many wastes, the materials in MSW represent what is left over after a long series of steps:

(1) extraction and processing of raw materials;

(2) manufacture of products;

(3) transportation of materials and products to markets;

(4) use by consumers; and

(5) waste management.

Virtually every step along this –life cycle‖ impacts GHG emissions. Solid waste management decisions can reduce GHGs by affecting one or more of the following:

(1) Energy consumption (specifically, combustion of fossil fuels) associated with making, transporting, using, and disposing the product or material that becomes awaste.

(2) Nonenergy-related manufacturing emissions, such as the CO_2 released when limestone is converted to lime (e.g., steel manufacturing).

(3) CH_4 emissions from landfills where the waste is disposed.

(4) CO_2 and nitrous oxide (N_2O) emissions from waste combustion.

(5) Carbon sequestration, which refers to natural or manmade processes that remove carbon from the atmosphere and store it for long periods or permanently.

The first four mechanisms add GHGs to the atmosphere and contribute to global warming. The fifth—carbon sequestration—reduces GHG concentrations by removing CO_2 from the atmosphere.

Forest growth is one mechanism for sequestering carbon; if more biomass is grown than is removed (through harvest or decay), the amount of carbon stored in trees increases, and thus carbon is sequestered.

Different wastes and waste management options have different implications for energy consumption, CH4 emissions, and carbon sequestration. Source reduction and recycling of paper products, for example, reduce energy consumption, decrease combustion and landfill emissions, and increase forest carbon sequestration.

THE IMPACT OF MUNICIPAL SOLID WASTE MANAGEMENT ON GHG EMISSIONS To measure the GHG impacts of MSW, EPA first decided which wastes to analyze. The universe of materials and products found in MSW was surveyed and those that are most likely to have the greatest impact on GHGs were identified. These determinations were based on

(1) the quantity generated;

(2) the differences in energy use for manufacturing a product from virgin versus recycled inputs; and

(3) the potential contribution of materials to CH4 generation in landfills. By this process, EPA limited the analysis to the following 21 single-material items:

Three categories of metal:

- Aluminum Cans;
- Steel Cans;
- Copper Wire;
- ***Glass;***
- ***Three types of plastic:***
- HDPE (high-density polyethylene);
- LDPE (low-density polyethylene);
- PET (polyethylene terephthalate);
- ***Six categories of paper products:***
- Corrugated Cardboard;
- Magazines/Third-class Mail;
- Newspaper;
- Office Paper;
- Phonebooks;
- Textbooks;

• ***Two types of wood products:***

• Dimensional Lumber;

• Medium-density Fiberboard;

• ***Food Discards;***

• ***Yard Trimmings;***

• ***Clay Bricks;***

• ***Concrete;***

• ***Fly Ash; and***

• ***Tires***.

EPA‘s researchers also included two products that are composites of several materials: • Carpet; and

• Personal Computers.

PUBLIC HEALTH EFFECTS:

EXTERNAL EXPOSURE:

Occurs when radiation (usually x-rays or gamma rays) penetrates the body.

ABSORBED DOSE:

The quantity of ionizing radiation absorbed by a body, measured (usually in grays) as the energy absorbed per unit mass.

TARGET ORGAN DOSE:

A tissue or organ that is affected by a specific hormone.

An organ intended to receive a therapeutic dose of irradiation, such as the kidney when high-energy x-rays or gamma rays are beamed to the renal area for the treatment of a tumor.

SUBCLINICAL:

Relating to or denoting (representing) a disease which is not severe enough to present definite or readily observable symptoms. (i.e., the disease not be indicate immediately).

MORBIDITY:

The proportion of sickness or of a specific disease in a geographical locality.

MORTALITY:

Death, especially of large numbers; heavy loss of life, i.e., Death Rate.

(OR)

The relative frequency of deaths in a specific population; death rate.

ENVIRONMENTAL and health impacts:

The organic fraction of MSW is an important component, not only because it constitutes a sizable fraction of the solid waste stream in a developing country, but also because of its potentially adverse impact upon public health and environmental quality. A major adverse impact is its attraction of rodents and vector insects for which it provides food and shelter. Impact on environmental quality takes the form of foul odours and unsightliness. These impacts are not confined merely to the disposal site. On the contrary, they pervade the area surrounding the site and wherever the wastes are generated, spread, or accumulated. Unless an organic waste is appropriately managed, its adverse impact will continue until it has fully decomposed or otherwise stabilized. Uncontrolled or poorly managed intermediate decomposition products can contaminate air, water, and soil resources.

PUBLIC AWARENESS:

Public Information and Participation for EHIA (Environmental Health impacts Assessment)

The public should be made aware on the following aspects for environment and health surveillance:

As far as possible faecal matter should not be allowed to mix with Municipal refuse

- Hospital and municipal wastes should be handled separately
- Burning of refuse should not be permitted
- Discharging of waste into drains and open areas should be prohibited by law
- Solid waste should be handled once and its contact with workers minimised as much as possible
- Efforts should be made to remove solid waste from habitations regularly
- Regular medical check up of personnel handling solid waste should be carried out
- Health records should be maintained for the areas served under municipal solid waste management programme.

SALIENT FEATURES OF INDIAN LEGISLATIONS ON MANAGEMENT & ROLE OF NGOs

Legal Framework Applicable To Municipal Solid Waste Management

Legislation concerning waste is usually differentiated according to the type of waste. International conventions (agreements) often cover nuclear and hazardous waste, whereas non hazardous waste, often called solid waste is usually more regulated at the national level.

From an environmental angle the following environmental rules, regulations and acts would be the most relevant for MSWM:

- Municipal Solid Waste (Management & Handling) Rules 2000, notified by the ministry of Environment and Forests, Government of India vide notification No. S.O.908 (E) dated 25th September 2000. The guidelines given in this law covers all the functional elements of municipal solid waste management.
- The Water (Prevention and Control of Pollution) Act, 1974. Two aspects have to be kept in mind of this law in regard to MSWM. Firstly, consent from the state pollution control board for establishment of a sanitary landfill site and compost plant is essential and secondly, no water pollution should be caused by the leachate that is emitted by the sanitary landfill site or a compost plant.
- The Water (Prevention and Control of Pollution) Cess Act, 1977 and amendments thereon. The only aspect that should be considered in this law in regard to MSWM is provision for levying and collection of cess on water consumed for the sanitary landfilling, composting and anaerobic digesters.
- The Air (Prevention and Control of Pollution) Act, 1981 and amendments thereon. The aspects to be considered in this law with respect to MSWM is the need for obtaining consent from the State Pollution Control Board for establishment of the processing and disposal site and from an environmental aspect would be the pollution caused by incineration plants, compost plants and landfill sites.

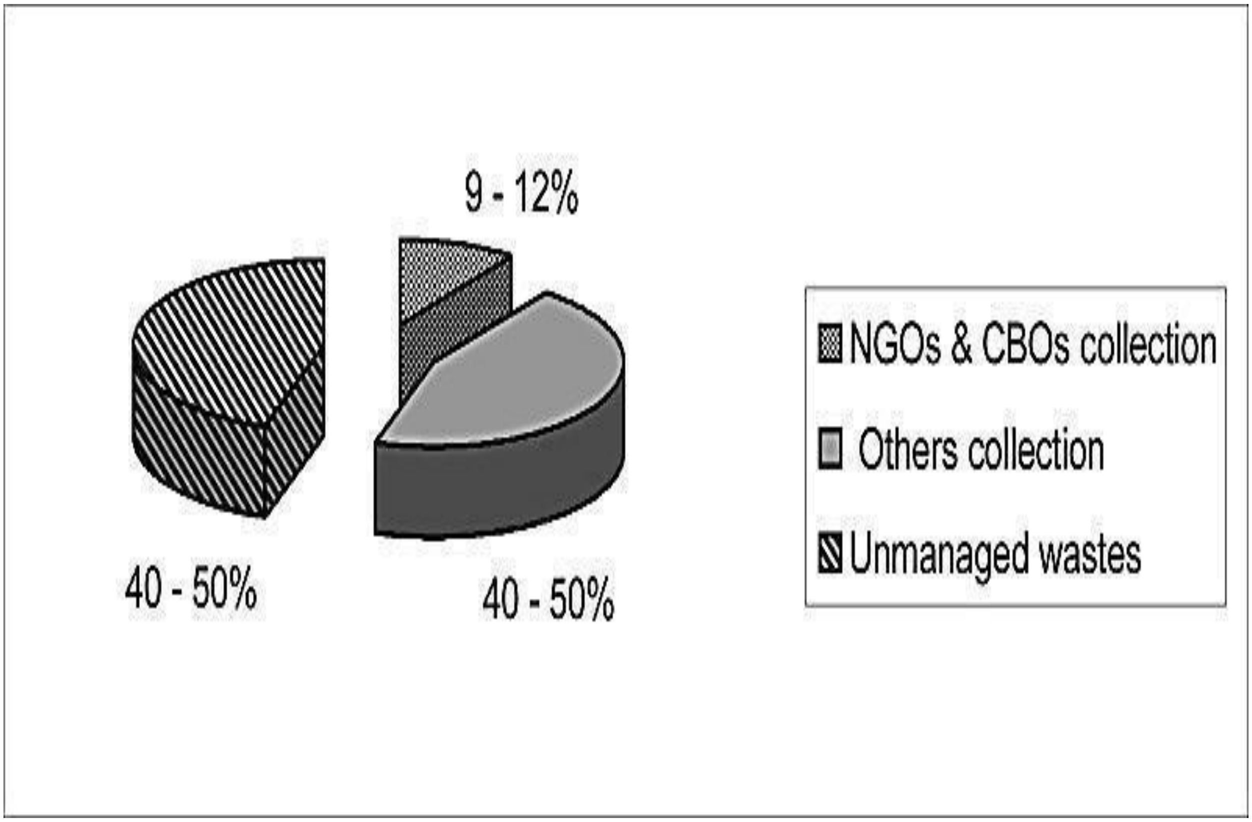
- The Environmental (Protection) Act, 1986 and its subsequent notifications. The aspect in regard to MSWM would be the EIA notification, 1944, which states that for any project to be authorized an EIA report should be submitted first.

Role of NGO's:

- NGOs are providing a prominent support to informal sector waste workers and enterprises to organize themselves to improve working conditions and facilities, increase earnings, and extend access to essential social services such as health care and schooling for children.
- first they should consult with the Commissioner of the respective ward.
- Then, they may obtain the permission from the conservancy department of the city corporation office.
- NGOs and CBOs are mainly involved in the collection of wastes from different generation sources, e.g. houses, markets, restaurants, and hotels.
- Then, they dispose the collected wastes to the nearest SDSs.

Role of NGO's - Collection system

- Collection of wastes from generation sources is mainly executed by NGOs and CBOs.
- Door-to-door collection systems are adopted for waste collection and then dispose major portion of it to the nearest SDSs.
- Some NGOs transfer the collected wastes to compost plants.
- Most of the NGOs collects waste from household and receive tiny payment from the dwellers as collection charge.
- Non-motorized rickshaw vans of NGOs to operate the collection system.
- A driver and a helper are assigned for each van and the collection generally occurs daily for 9 hours (8 am to 5 pm) from residential sources as well as some offices.



Role of NGO’s - Multi-dimensional Problems

- NGOs have been facing many multi-dimensional problems, which can be summarized as:

a. As the van pullers and helpers get tiny salary, there is a lack of sincerity and punctuality to perform the duty properly.

b. The service charge collection is a common problem for all NGOs.

c. On an average 20% of households is not paying or delaying the payment as per the agreement.

d. NGOs do not have any big vehicles to collect and transfer. They are not able to buy as well due to the financial constraint. The collected wastes are, therefore, usually disposed to SDSs, i.e. on roadsides.

e. In SDSs, waste is discarded outside of the bin due to lack of sufficient bin and due to few technical problems such as size, shape, location, and design aspects of bins.

The spreading of waste creates environmental pollution and reduces traffic passage

a. The marketing of compost product is a great concern of NGOs, as the market of compost is not yet fully established.
b. Non-motorized rickshaw vans require frequent repairing and finally out of service after 4–5 years.
c. A big amount of money is required to buy new vans to continue the service. Therefore, a continuous financial support is required for its operation and maintenance.
d. Sometimes an irregular and weak participation of city/ward authority with NGOs creates unwanted situation and terminate the MSW management system temporarily.
e. Due to lack of public awareness, motivation, and commitment, people do not cooperate as desired. Even the cooperation from some ward commissioners is not encouraging.
f. NGOs are only involved in a part of MSW management, therefore they may not be able to change the overall scenario as desired by city dwellers.

Comparison of different MSW management activities before and after participation of NGOs/CBOs in Khulna City in Bangladesh

MSW management activities	**Before participation of NGOs/CBOs**	**After participation of NGOs/CBOs**
MSW collection from sources and transfer to SDSs	Residents had to bring the waste to the nearest SDS	Mostly done by NGOs and CBOs. Door-to-door collection system was launched by them.
Composting of organic wastes	No composting plant was found	Six composting plants are now managed by NGOs

Medical/hospital waste management	This waste was not properly managed	Prodipan handles this waste to manage it properly. A burning unit and a concrete chamber have been constructed by Prodipan.
People awareness and motivation	Residents had no/little awareness to store the waste properly	NGOs and CBOs have been trying to motivate the residents to store the waste properly and to keep clean the premises. They have regular motivation activities, e.g. campaign, rally, demonstration, and visiting schools, slum and residential areas.
City authority/local government	The city authority was not very conscious to manage the MSW properly	NGOs and CBOs have succeeded to bring the full attention of the city authority in this sector. A large numbers of NGOs and CBOs involvements show the importance to manage it properly.

Recycling	Residents had no/little awareness to separate the waste for recycling	Nowadays residents are interested for recycling due to the movements of NGOs and CBOs. The numbers of dealers are increased as well who buy some items from houses, e.g. plastic, leather, newspaper, and glass bottle.

SOLID WASTE GENERATION:

Municipal solid waste (MSW) can be broadly categorized into five broad categories as-

- **Biodegradable waste:** food and kitchen waste, green waste (vegetables, flowers, leaves, fruits), paper (can also be recycled).
- **Recyclable material:** paper, glass, bottles, cans, metals, certain plastics, etc.
- **Inert (Sluggish) waste:** construction and demolition waste, dirt, rocks, debris.-[Slow moving materials].
- **Composite wastes:** waste clothing, Tetra Packs, waste plastics such as toys.
- **Domestic hazardous waste** (also called "household hazardous waste") & toxic waste: medication, e-waste, paints, chemicals, light bulbs, fluorescent (Incandescent) tubes, spray cans, fertilizer and pesticide containers, batteries, shoe polish.
- With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing.
- There are different categories of waste generated, each take their own time to degenerate (as illustrated in the table below).

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

Table 1: Sources of waste, waste generators & types of solid wastes can be tabulated as below:

Source	Typical waste generators	Types of solid wastes
Residential	Single and multifamily dwellings(residences)	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes.
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants.	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes.
Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Institutional	Schools, hospitals, prisons, government centres.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes, biomedical waste.
Construction and demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants.	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge.

Process (manufacturing, etc.)	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing.	Industrial process wastes, scrap materials, off-specification products, slay tailings.
Agriculture	Crops, orchards, vineyards, dairies, feedlots, farms.	Spoiled food wastes, agricultural wastes, hazardous wastes (e.g., pesticides).

QUANTITY:

The quantity of MSW generated depends on a number of factors such as food habits, standard of living, degree of commercial activities and seasons.

Indian cities now generate eight times more MSW than they did in 1947 because of increasing urbanization and changing life styles.

The rate of increase of MSW generated per capita is estimated at 1 to 1.33% annually.

MSW generation rates in small towns are lower than those of metro cities, and the per capita generation rate of MSW in India ranges from 0.2 to 0.5 kg/ day.

Figure-1 shown in below solid waste generated in Indian Top Ten Cities

Solid Waste Generated in India's Top Ten Cities

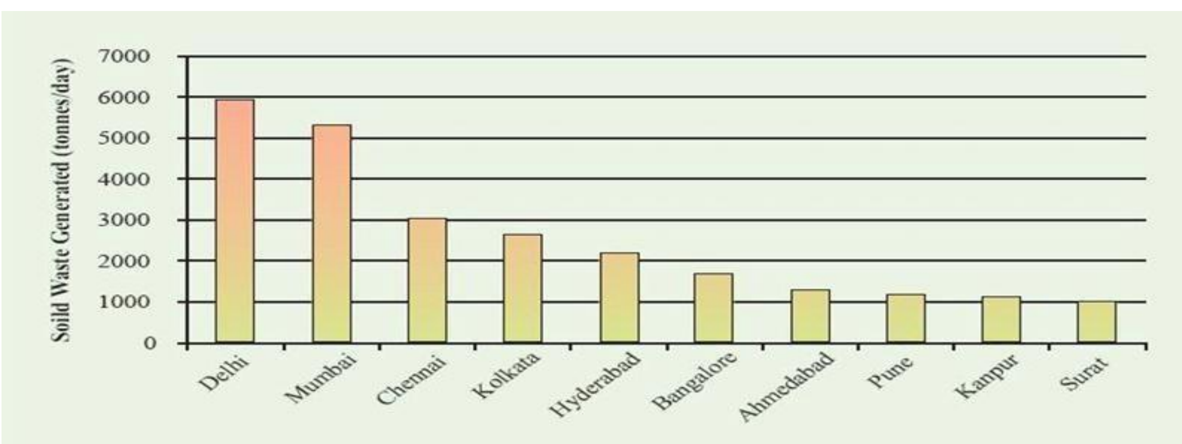


Fig 1: Source: Central Pollution Control Board, 2006-07

Quantity of Solid Waste

In the year 1947, cities and towns in India generated an estimated 6 million tonnes of solid waste; which rose in the year 1997 to about 48 million tonnes.

As per Annual Report on Environment (2009-10) CPCB estimated around 57 million tonnes per annum of MSW presently generated in the country.

FACTORS AFFECTING GENERATION OF SOLID WASTE:

1. The state of the national economy
2. The lifestyle of the people
3. The demographic profile of the population
4. The size and type of dwelling (House or Residence)
5. Age
6. Religion
7. The extent to which the 3Rs (Reduce, Refuse & Recycle) are carried out
8. Presence of pets and domestic animals
9. Seasonal variations
10. Presence of laws and ordinances governing waste management
11. Company buy-back guarantees for used containers, packaging.

CHARACTERISTICS:

GENERAL CHARACTERISTIC IN MSW (Municipal Solid Waste):

Compostable / Bio-degradable = 30% - 55% matter (Can be converted into manure)

Inert material = 40% - 45% (to go to landfill)

Recyclable materials = 5% - 10% (Recycling)

These percentages vary from city to city depending on food habits

CHARACTERISTIC IN MUNICIPAL SOLID WASTE:

- PHYSICAL CHARACTERISTICS
- CHEMICAL CHARACTERISTICS
- BIOLOGICAL CHARACTERISTICS

- **PHYSICAL CHARACTERISTICS**

Density:

The knowledge of density is important for the design of all elements of the solid waste management systems like storage, transport and disposal.

Example: For a known volume of the solid waste its density gives us the idea about the requirement of the truck in tonnage. Every truck or similar vehicle has a permitted load capacity say 12 tonnes.

The density varies significantly from source to the disposal site because of handling, change in moisture content, densification due to vibration of movement, disturbance by animals and birds (scavengers) etc

- Density of Municipal Solid Waste produced in some Indian Cities.

S.No	City	Density in Kg/m^3
1	Bangalore	390
2	Delhi	422
3	Hyderabad	369
4	Jaipur	537
5	Jabalpur	395
6	Raipur	405
7	Chennai	330-500

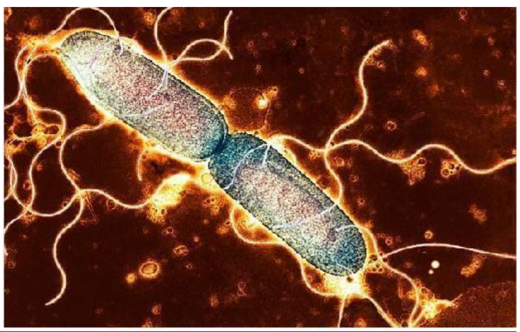
Moisture content:

Moisture content of the solid waste is expressed as the weight of moisture per unit weight of wet material. Moisture content varies generally from 20 to 45% depending upon the climatic conditions and level of city (income group) etc.

Calorific value:

Calorific value is the amount of heat generated from combustion (Burning) of a unit weight of a substance, expressed as kilo calorie per kilogram.

- **CHEMICAL CHARACTERISTICS**
  - Chemical quantities of solid waste in Indian urban Centre‘s are pH, nitrogen, phosphorus, and potassium (N-P-K), total carbon, carbon/nitrogen ratio.
  - Bio-chemical characteristics include carbohydrate, proteins, natural fiber, and biodegradable factor.
  - Toxic characteristics include heavy metals, pesticides, insecticides (Insect repellant or Fly Spray) etc
- **BIOLOGICAL CHARACTERISTICS:**
  - Bacteria: a very large group of microorganisms comprising (Including) one of the three domains (Areas)of living organisms. They are prokaryotic, unicellular, and either free-living in soil or water or parasites (Organisms or vermins) of plants or animals.



  - Fungi: organism that feeds (Foods)on organic matter.
  - Attracts flies,
  - Vermin: functioning as small animals collectively, esp. insects(Pests) and rodents, that are troublesome to man, domestic animals, etc.,
  - Rodents:

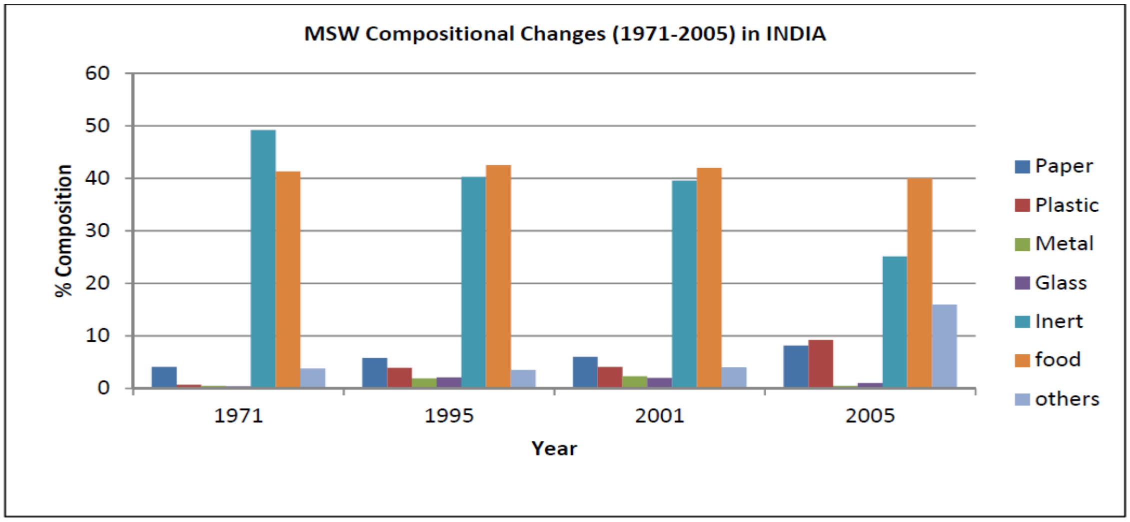
CHARACTERISTICS AND COMPOSITION OF MSW IN INDIA:

As compare to the western countries, MSW differs greatly with regard to the composition and hazardous nature, in India.

Many categories of MSW are found such as food waste, rubbish, commercial waste, institutional waste, street sweeping waste, industrial waste, construction and demolition waste, and sanitation waste.

MSW contains compostable organic matter (fruit and vegetable peels, food waste), recyclables (paper, plastic, glass, metals, etc.), toxic substances (paints, pesticides, used batteries, medicines), and soiled waste

(blood stained cotton, sanitary napkins, disposable syringes). MSW composition at generation sources and collection points ,determined on a wet weight basis, consists mainly of a large organic fraction (40–60%), ash and fine earth (30–40%), paper (3–6%) and plastic, glass and metals (each less than 1%). The C/N ratio ranges between 20 and 30, and the lower calorific value ranges between 800 and 1000 kcal/kg.



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ig 2: Source:Rajendra Kumar Kaushal et al. / International Journal of Engineering Science and Technology (IJEST)., Vol. 4 No.04 April 2012

As countries develop economically and become more urbanized, the waste composition undergoes a change as the increase in the paper, paper packaging, plastics, multi material packing items and _consumer products and decrease in the organic share.

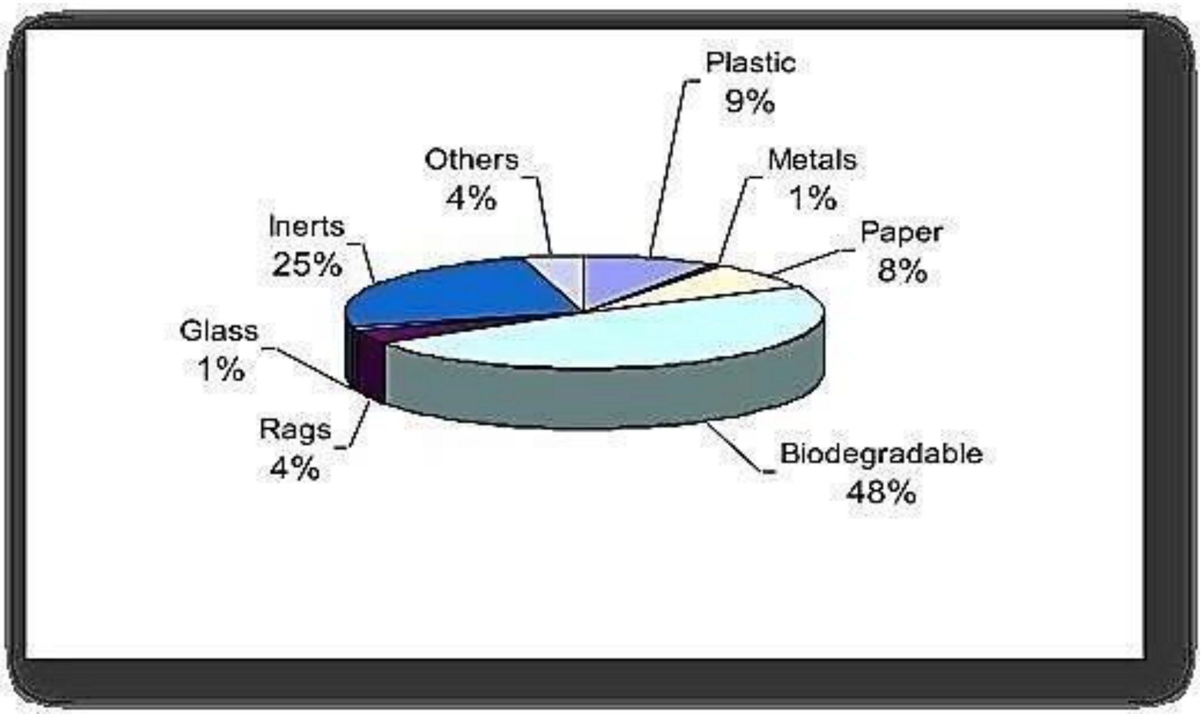
Compositional Changes Reported for India since 1971

Changes in the average composition of municipal solid waste for 1971-2005 have been shown in Fig.-2. It suggest that MSW components like Paper, Plastic, Glass are having the increasing trend from 4.1%, 0.7%

and 0.4% respectively in 1971 to 8.18%, 9.22% and 1.01 respectively in 2005, metals are also having the increasing trend during the same period while inert materials and compostable matter are having the decreasing trend from 49.2% and 41.3% respectively in 1971 to 25.16% and 40% in 2005. Increasing trend suggest that the establishment of the formal recovery and recycle facilities will be economically a viable option.

Composition of Municipal Solid Waste in India:

In India the biodegradable portion dominates the bulk of Municipal Solid Waste. Generally the biodegradable portion is mainly due to food and yard waste



METHODS OF SAMPLING AND CHARACTERISATION:

Methods of Sampling:

Quartering, random sampling, stratified sampling and cluster sampling methods are evaluated for precision and efficiency in the analysis of municipal solid wastes (MSW).

Characterisation:

The goal of a waste characterization study is to identify the sources, characteristics, and quantities of the waste generated.

Waste characterization studies are difficult to perform because of the large number of sources and the limited number of waste sample that can be analyzed.

The typical steps involved in a waste characterization study are as follows:

1. Gather Existing Information

   The use of existing information can save money, time and serve as a cross reference.

Existing information sources include,

-
- Previous solid waste management and planning studies and documents
- Waste collection company records (public and private)
- Processing facility records (e.g., composing facilities, incineration facilities, etc.)
- Landfill and transfer station records
- Previous waste disposal studies
- Information from comparable communities
- Department of public works
- Utilities
- Retail trade reports
- Community employment records (Chamber of Commence)

2. Identify waste generation sources and waste characteristics

✓ Sources

- Residential
- Commercial
- Institutional
- Construction and demolition
- Municipal services
- Water and waste water treatment plants
- Industrial
- Agriculture

3. Develop sampling Methodology

- Sample identification and

characteristics including Sources

Size of Sample

Number of Sample needed

- Duration of sampling period
- Time of year

4. Conduct Field Studies
5. Conduct Market Surveys for Special Wastes
6. Assess Factors Affecting Waste Generation Rates.

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – II – ON-SITE STORAGE & PROCESSING – SCIA3004

ON-SITE STORAGE METHODS

GENERAL

On-Site: (i) Taking place or located at the site;

(ii) A hazardous waste treatment, storage or disposal area that is located on the generating site.

Waste handling and sorting involves activities associated with management of wastes until they are placed in storage containers for collection.

Handling also encompasses the movement of loaded containers to the point of collection.

a) Sorting (categorization) is an important component of waste management and best-done onsite.
   However, there are various stages of sorting. These can be identified as the following:

   - At the source or house hold level
   - At the community bin (municipal bin)
   - At transfer station or centralised sorting facility
   - At waste processing site (pre-sorting and post sorting)
   - At the landfill site

b) Sorting Operations can be carried out in three ways:

   - Manual sorting
   - Semi-mechanised sorting
   - Fully mechanised sorting

c) Onsite storage is of primary importance because of public health concerns. Open ground storage, make shift containers should always be avoided and only closed containers should be used. Processing at the source involves backyard composting. Storage of wastes can be done at three levels:

- At source
- At community level
- At transfer stations

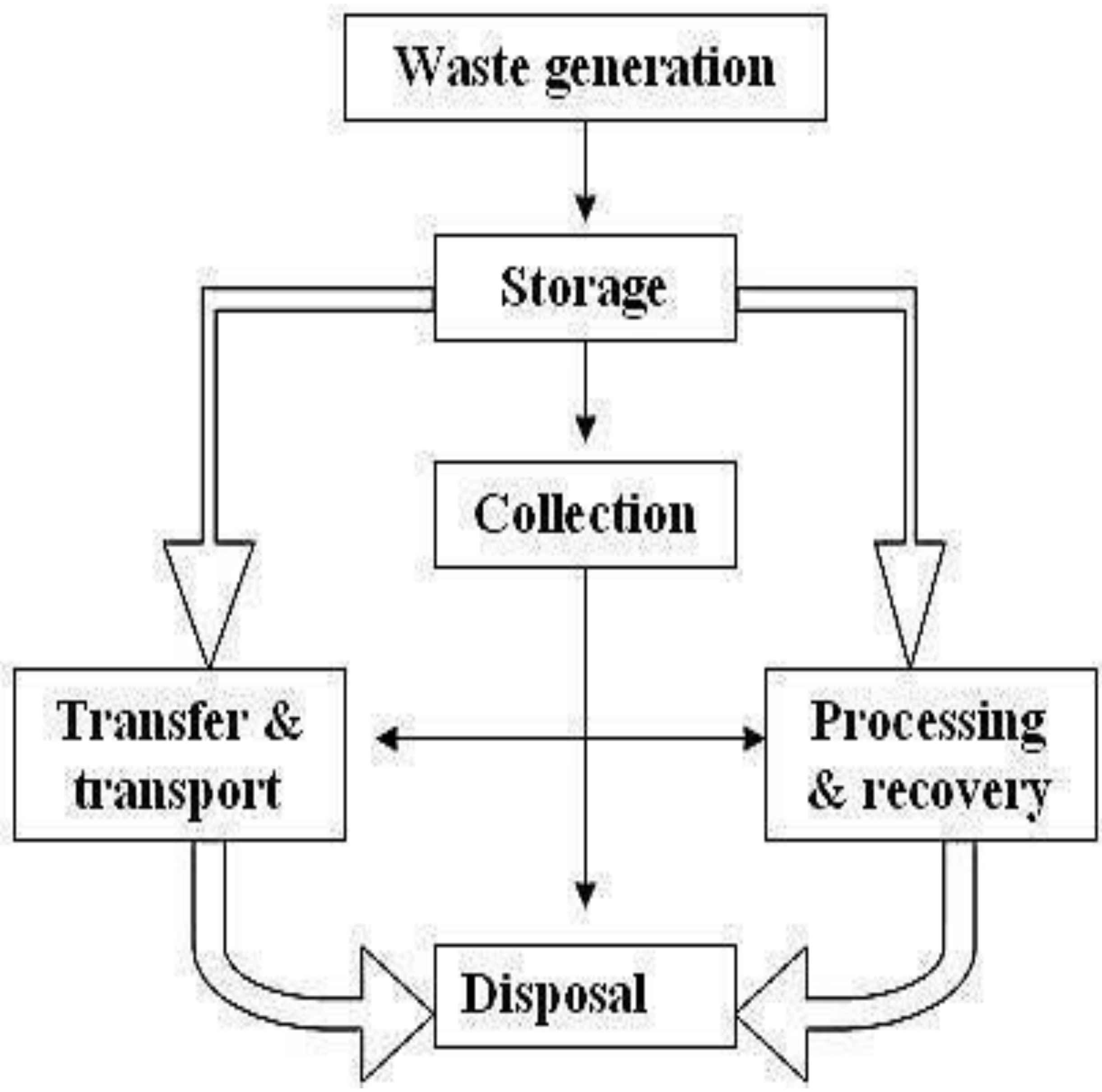
- *On-site handling* refers to the activities associated with the handling of solid wastes until they are placed in the containers used for their storage before collection.
- It may also be required to move loaded containers to the collection point and to return the empty containers to the point where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

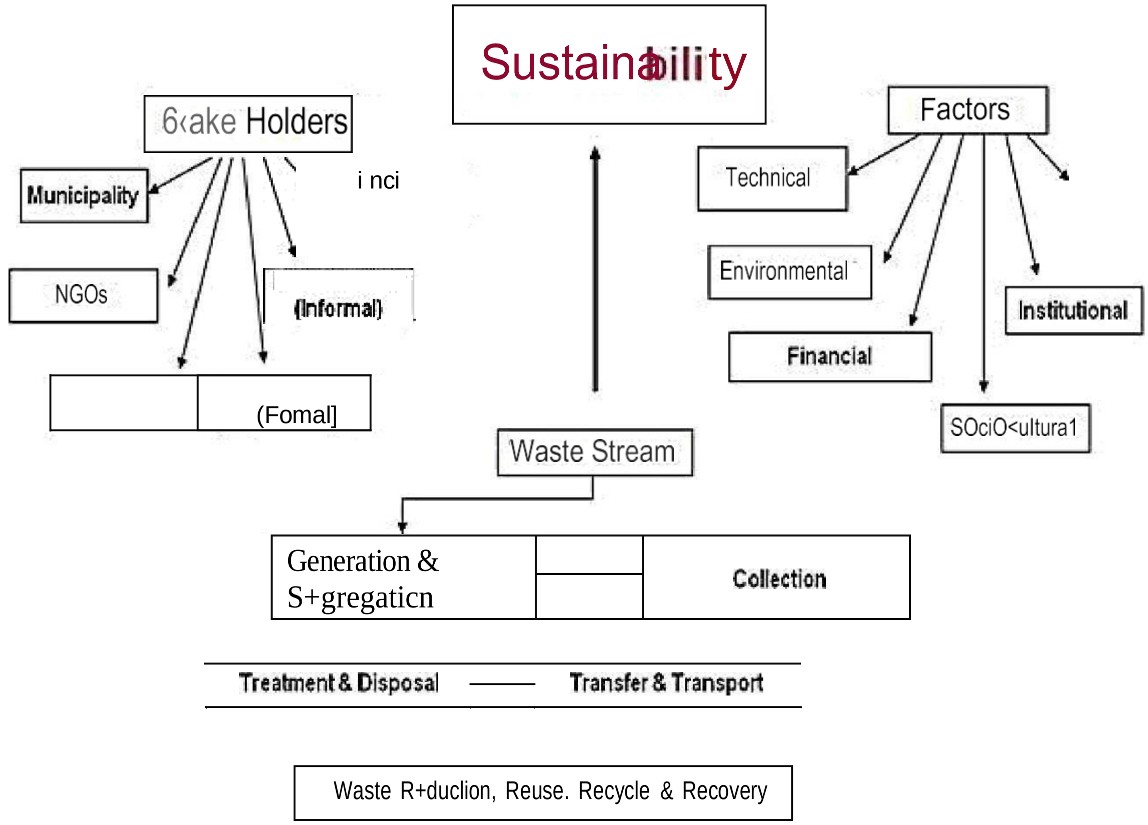
Methods:

In generally two types of storage bins are used-

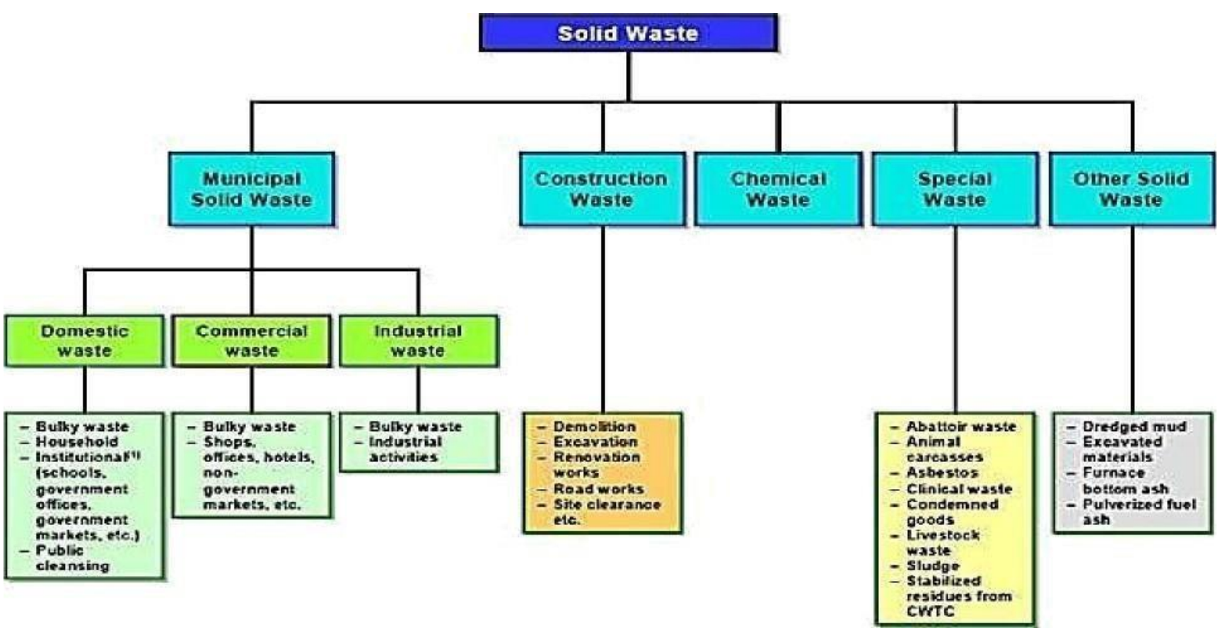
Movable bins and fixed bins.

The fixed bins are more durable but their positions cannot be changed once they have been constructed, while the movable bins are flexible in transportation but lacking in durability.





Sustainability
6‹ake Holders
Municipality
i nci
NGOs
(Informal)
(Fomal]
Factors
Technical
Environmental
Institutional
Financial
SOciO<ultura1
Waste Stream
Generation & S+gregaticn
Collection
Treatment & Disposal
Transfer & Transport
Waste R+duclion, Reuse. Recycle & Recovery



Solid Waste
Municipal Solid Waste
Construction Waste
Chemical Waste
Special Waste
Other Solid Waste
Domestic waste
Commercial waste
Industrial waste
– Bulky waste – Household – Institutional(1) (schools, government offices, government markets, etc.) – Public cleansing
– Bulky waste – Shops, offices, hotels, non-government markets, etc.
– Bulky waste – Industrial activities
– Demolition – Excavation – Renovation works – Road works – Site clearance etc.
– Abattoir waste – Animal carcasses – Asbestos – Clinical waste – Condemned goods – Livestock waste – Sludge – Stabilized residues from CWTC
– Dredged mud – Excavated materials – Furnace bottom ash – Pulverized fuel ash

While residential dwellings and building types can be classified in various ways, a classification based on the number of stories is adequate for the purpose of discussing the handling and separation of wastes at residential dwellings.

The three classifications most often used and adopted are:

- Low-rise – under four stories
- Medium rise – from four to seven stories
- High rise – over seven stories.

Table 2.1 Persons responsible for and auxiliary equipment used in the handling and separation of solid waste at the source

Source	**Persons responsible**	**Auxiliary equipment and facilities**
Residential Low-rise	Residents, tenants	Household compactors, large-wheeled containers, small- wheeled handcarts.
Medium rise	Tenants, building maintenance crews, janitorial services, unit managers	Gravity Chutes (waterfalls), service elevators, collection carts, pneumatic conveyors.
High-rise	Tenants, building maintenance crews, janitorial services,	Gravity chutes, service elevators, collection carts, pneumatic conveyors.
Commercial	Employees, janitorial (One who attends to the maintenance or cleaning of a building.) services	Wheeled or castered collection carts, container trains burlap drop cloths, service elevators, conveyors, pneumatic conveyors.

Industrial	Employees, janitorial services	Wheeled or castered collection carts, container trains, service elevators, conveyors.
Open areas	Owners, park officers, municipal employees	Vandalproof containers **(lock boxes on all containers which will allow you to securely lock your container with your own key**).
Treatment plant sites	Plant operators	Various conveyors and other manually operated equipment and facilities.
Agricultural	Owners, workers	Varies with individual commodity.

Storage of Solid Wastes at the Source

The following factors must be considered in the onsite storage of solid wastes include,

1. the effects of storage on the waste components
2. the type of container to be used
3. the container location
4. Public health and aesthetics.

Materials used for containers:

- Storage of waste at source is the first essential step of Solid Waste Management.
- The waste should normally be stored at the source of waste generation till collected for its disposal.

Some types of containers presently used for storage are as under:

- Buckets
- Plastic baskets
- Plastic bags
- Metal bins with or without lids (Tops or covers).
- By and large such bins used are without lids.

These are unsuitable for storage of food waste for 24 hours and more in the Indian conditions as waste starts stinking (Foul-smelling) very fast due to putrefaction. Containers for waste materials including solid waste & explosion-proof waste. Types include

1. drums & cans. Containers include
   - ash & trash containers,
   - decorative trash containers,
   - recycling containers,
   - hazardous materials containers,
   - battery containers,
   - trash containers,
   - packaging containers & utility containers.
2. Cans include garbage cans & collections,
   - safety cans,
   - oily waste cans.
3. Drums include
   - poly drums,
   - steel drums,
   - steel salvage drums & fiber drums.
4. Applications include
   - ash & trash handling,
   - facility marking,
   - drain protection,
   - material handling,

- storage & maintenance.

On-site segregation of solid waste :

Household Storage and Segregation of Waste Storage of waste at the source of its generationis the first essential steptoward appropriate SWM.

Most urban areas of the country have yet to take this step.

Most households, shops, and establishments throw their waste just outside their premises, on streets, in drains, in open spaces, in water bodies, and in other inappropriate places.

Because such waste contains high levels of biodegradable material, it attracts rodents and stray animals and thus contributes to the spread of Filth (smut) and disease.

Fig 2.1 Waste is discharged into drains.

Fig 2.2 Disposal of waste is onto streets and into open places.

Partial Segregation of Recyclables

Segregation of recyclable waste at source is not seriously practiced by households, shops, and establishments in India.

At least 15 to 20 percent of the country’s total waste could be conveniently segregated at its source for recycling if the practice of segregation of waste at source were adopted. Nevertheless, in all parts of the country, people by and large salvage reusable material—such as newspaper, glass bottles, empty tins, plastic bags, and old clothes— and then resell it.

This sector is low profile but well established.

Large numbers of waste buyers purchase recyclable waste from the doorstep and pass it on to a sub dealer or a dealer with a good margin, who, in turn, passes on the material to the recycling industry in bulk.

Other people are known as rag pickers.

Rag pickers are generally poor women and children who pick up discarded recyclables from the streets, bins (Baskets or Container), and dump yards; segregate various components; and sell them to a dealer for a small price to earn a living.

Those recyclables are often soiled with food waste, human excreta, and biomedical waste. Accordingly, the price of such waste is much lower than the dry and clean recyclable material that is picked up directly from households or shops. Furthermore, because rag pickers are very poor, they have little bargaining power to negotiate a higher price.

Fig 2.3 Paper is sold to a recycler.

Fig 2.4 Rag pickers work at the landfill.

A sizable amount of recyclable dry waste—such as wastepaper, plastic, broken glass, metal, and packaging material—is not picked up, because it is soiled substantially or is directly buried under a huge pile of waste in the bin or at the disposal site.

Quite often, rag pickers focus their search and recovery on a few varieties of recyclables that have good returns. Other materials are discarded.

Urban Indian cities generate 42 million metric tons of waste annually. Of that amount, around 4 million metric tons are retrieved (Saved) for recycling. Another 4 million metric tons are disposed of in uncontrolled dumps—a problem that needs to be prevented.

In the past 10 years, an increasing number of nongovernmental organizations (NGOs) have become active in improving the working and living conditions of rag pickers. Because the municipal waste service was until recently limited to waste collection from public bins, NGOs recognize the service gap and have started offering door-to-door collection services to households.

Most of these efforts are done on a private or nongovernmental basis. Hence, they lack further dissemination and have limited positive effects for the whole sector.

Waste recycling in India has many untapped potential opportunities that could benefit the entire Indian society.

Public health and economic aspects of storage :

Important considerations in the onsite storage of wastes are the effects of storage itself on the characteristics of the wastes being stored.

These effects of storing wastes include,

1. Biological decomposition
2. The absorption of fluids
3. The contamination of waste components.

4.

1. Microbiological decomposition

Food and other wastes placed in onsite storage containers will almost immediately start to undergo microbiological decomposition (often called *putrefaction*).

If wastes are allowed to remain in storage containers for expected periods of time, flies can start to breed and odour compounds can develop.

2. Absorption of fluids

The components that comprise solid wastes have differing initial moisture contents; re- equilibration takes place as wastes are stored onsite in containers.

Where mixed wastes are stored together, paper will absorb moisture from food wastes and fresh garden trimmings. The degree of absorption that takes place depends on the length of time the wastes are stored until collection.

If wastes are allowed to sit for more than a week in enclosed containers, the moisture will become distributed throughout the wastes.

If watertight container lids are not used, wastes can also absorb water from rainfall that enters partially covered containers.

Saturation of wastes to their field capacity is a common occurrence in tropical regions where it rains on most days.

3. Contamination of waste components

Perhaps the most serious effect of the onsite storage of wastes is the contamination that occurs. The major waste components may be contaminated by small amounts of wastes such as motor oils, household cleaners and paints.

The effect of this contamination is to reduce the value of the individual components for recycling.

While the contamination that occurs during onsite storage decreases the value of the individual waste components, one can also argue hat his contamination is beneficial with respect to the disposal of these wastes in a landfill.

That is the concentrations of the individual contaminations are reduced considerably when the contaminated waste components are spread out and compacted for landfilling.

Options under Indian conditions:

MSWM refers to the entire process chain, comprising seven steps:

(1) Waste segregation and storage at source,

(2) Primary collection,

(3) Street sweeping,

(4) Secondary waste storage,

(5) Transport of waste,

(6) Treatment and recycling options for solid waste, and

(7) Final disposal.

All seven steps are equally important and should be harmonized. Authorities need to consider specialized strategies for different waste generators (households, shops and commercial establishments, industries, hospitals, and so forth) and appropriate measures for the different levels in the SWM chain (household level, neighbourhood level, regional level, and so forth). They must also coordinate with the different actors in the management of waste throughout the waste management levels

Critical Evaluation of Options:

Estimation on the quantity and characteristics of municipal solid waste and its forecasting over the planning period is the key to a successful management plan. This study analyses the changing trend in the MSW quantities and characteristics in major urban agglomerations in India over last four decades.

The study critically reviews the present practices of estimating and forecasting of MSW and highlights their limitations.

- Due to population growth, industrialization, urbanization and economic growth, a trend of significant increase in municipal solid waste (MSW) generation has been recorded worldwide.

- MSW generation, in terms of kg/capita/day, has shown a positive correlation with economic development at world scale.
- India, with a population of over 1.21 billion account for 17.5% of the world population (Census of India 2011).
- 377 million people live in the urban areas of the country.
- This is 31.16 % of the Country's total population
- Due to rapid industrial growth and migration of people from villages to cities, the urban population is increasing rapidly.

Table 2.2 Population status in India

Cities	Population
Greater Mumbai UA	18.4 Millions
Delhi UA	16.3 Millions
Kolkata UA	14.1 Millions
Chennai UA	8.7 Millions
Bangalore UA	8.5 Millions

Source: censusindia.gov.in/2011-Documents/UAs-Cities-Rv.ppt

- Generally in India, MSW is disposed of in low-lying areas without taking proper precautions or operational controls.
- Therefore, municipal solid waste management (MSWM) is one of the major environmental problems of Indian megacities.
- SWM involves activities associated with generation, storage and collection, transfer and transport, treatment and disposal of solid wastes.
- In most Indian cities, the MSWM system comprises only four activities,

i.e., waste generation, collection, transportation, and disposal.

- Poor collection and inadequate transportation causes the accumulation of MSW at every nook and corner.
- The MSW amount is expected to increase significantly in the near future as India strives to attain an industrialized nation status by the year 2020.
- MSW management encompasses planning, engineering, organization, administration, financial and legal aspects of activities associated with generation, storage, collection, transport, processing and disposal in an
- environmentally compatible manner adopting principles of economy, aesthetics, energy-conservation and opportunities.

Table 2.3

S. No.	Name of the State	No. of cities	Municipal population	Municipal solid waste (t/day)	Per capita generated (kg/day
1	Andhra Pradesh	32	10,845,907	3943	0.364
2	Assam	4	878,310	196	0.223
3	Bihar	17	5,278,361	1479	0.280
4	Gujarat	21	8,443,962	3805	0.451
5	Haryana	12	2,254,353	623	0.276
6	Himachal	1	82,054	35	0.427
7	Karnataka	21	8,283,498	3118	0.376
8	Kerala	146	3107358	1220	0.393
9	Madhya Pradesh	23	7225833	2286	0.316
10	Maharashtra	27	22727186	8589	0.378
11	Manipur	1	198535	40	0.201
12	Meghalaya	1	223366	35	0.157
13	Mizoram	1	155240	46	0.296
14	Orissa	7	1766021	646	0.366
15	Punjab	10	3209903	1001	0.312
16	Rajasthan	14	4979301	1768	0.355
17	Tamil Nadu	25	10745773	5021	0.467
18	Tripura	1	157358	33	0.210
19	Uttar Pradesh	41	14480479	5515	0.381
20	West Bengal	23	13943445	4475	0.321
21	Chandigarh	1	504094	200	0.397
22	Delhi	1	8419084	4000	0.475
23	Pondicherry	1	203065	60	0.295
		299	128113865	48134	0.376

Source: Status of MSW generation, collection, treatment and disposal in class-I cities [23]

Tabel 2.4 Per capita Quantity of Municipal Solid Waste in Indian Cities

Table-3: Per Capita Quantity of Municipal Solid Waste in Indian Cities

SN	Population	Waste Generation Rate Kg/capita/day
1	Cities with a population < 0.1 million (8 cities)	0.17-0.54
2	Cities with a population of 0.1–0.5 million (11 cities)	0.22-0.59
3	Cities with a population of 1–2 million (16 cities)	0.19-0.53
4	Cities with a population > 2 million (13 cities)	0.22-0.62

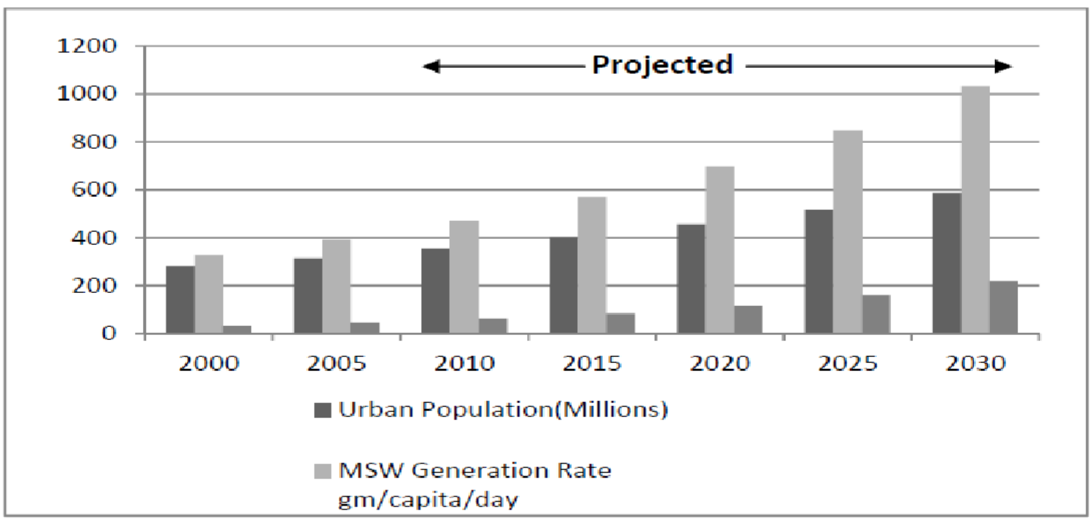


Figure 1: Projected Municipal Waste Generations for Urban Population in India

Source: Information from web site of CPCB

Fig 2.5 Projected municipal waste generations for urban population in India.

- Table-3 suggest the per capita quantity of municipal solid waste in Indian cities.
- It also suggests that average municipal solid waste production from 0.21 to 0.50 Kg per capita per day in India.
- The urban population of India is approx. 341 million in 2010. Fig.-1 suggest the projected MSW quantities are expected to increase from 34 million tonnes in 2000 to 83.8 million tonnes in 2015 and 221 million tonnes in 2030.
- It is also reported that per capita per day production will increase to

1.032 kg, and urban population as 586 million in 2030.

MSWM and Economy

- There is generally a correlation between the amount of municipal waste andthe Gross Domestic Product (GDP) of the country.
- Higher the GDP of a country, higher is the quantity of waste produced.
- Studies have indicated that for every Indian Rs. 1000 increase in incomethe solid waste generation increases by one kilogram permonth.

The growth of GDP for every decade since 1960 is given in Fig-3 which suggests that Indian GDP growing rapidly during last few decades

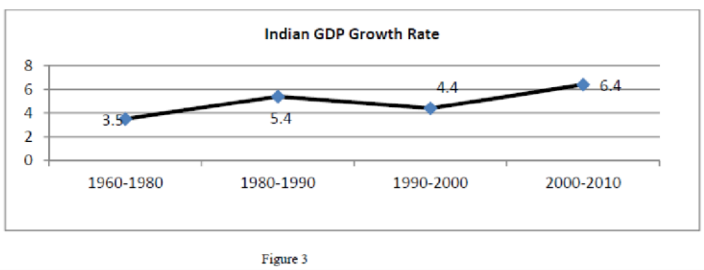


Fig 2.6

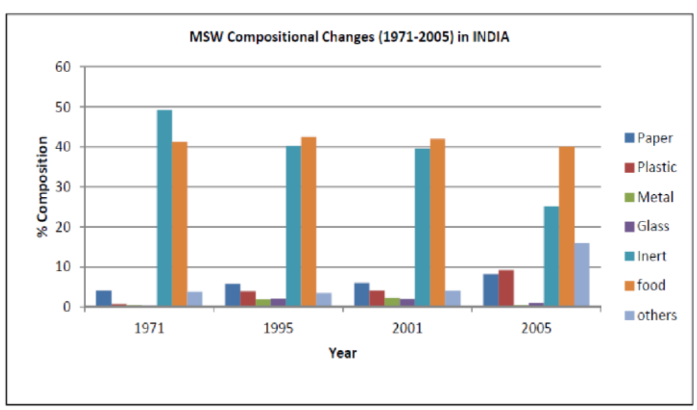


Fig 2.7

Collections and Storage of MSW

- In India most of the urban areas are lacking in MSW storage at the source, significantly. For both decomposable and non-decomposable waste common bins are used to collect the waste without any segregation, and disposed off at a community disposal centre.
- Two types of storage bins are used-
  - movable bins and
  - fixed bins.
  - The fixed bins are more durable but their positions cannot be changed once they have been constructed,
  - while the movable bins are flexible in transportation but lacking in durability.
  - Collection of MSW is the responsibility of corporations/municipalities. In most of the cities the predominant system of collection (through the communal bins) at various points along the roads, and sometimes this leads to the creation of unauthorized open collection points.

House-to-house collection is just starting in many megacities such as Delhi, Mumbai, Bangalore, Madras and Hyderabad with the help of NGOs.

Treatments and Disposal of MSW

- India is facing the lacking of resources or the technical expertise necessaryto deal with the disposal of MSW.
- The disposal method trend adopted in India has been shown in Fig. 11.
- For the years 2001 and 2005, waste dumps or open burning continue to bethe principal method of waste disposal.
- These methods causes several accidents are continuous source of emission of harmful gases and highly toxic liquid leachate.

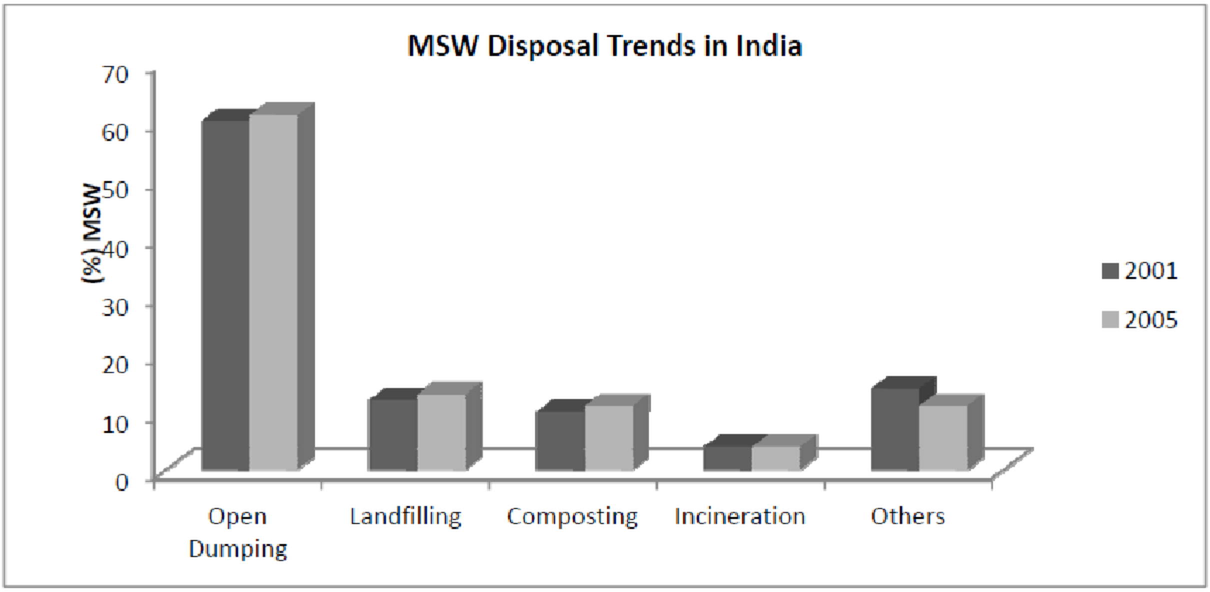


Figure 11

Fig. 2.8

Issues in MSW Management

- Source Segregation, Collection
- Treatment & Disposal
- MSW is usually disposed as it is without any treatment. Most of MSW is still disposed off in dumps causing
- severe environmental and health risks. The progress in moving towards sanitary landfills and/or disposing
- through well designed and well operated incinerators is rather slow.
- Resource Generation
- Technology Issues
- Financing Issues

Future Challenges in MSW Management

- In India some of the future challenges for the management of solid waste are:
- Increasing quantities and changing composition
- Increasing severity of adverse impacts
- Increasing cost of waste management
- Limited policy framework

- Policy framework to support resource recovery
- from waste is still inadequate in India

- Lack of political priority

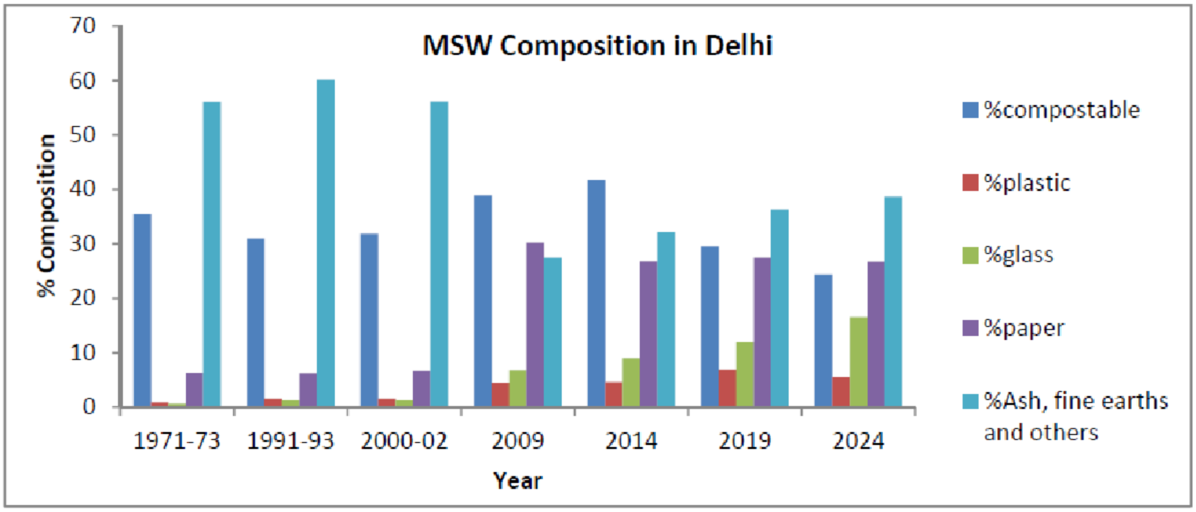


Fig. 2.9 MSW Composition in Delhi

SUCCESSFUL OPTIONS

- A successful long term planning depends on the characteristics of the solid waste and estimation of future quantities.
- Decisions related to treatment choices and disposal options for solid waste management will get affected by the composition of solid waste in the future.
- Researchers have been reported for innovative and forward-looking solutions to address the issue of forecasting the quantities of municipal solid waste.
- A long time Forecast will be more meaningful if it gives the most optimistic (Bright), most pessimistic (Negative) values and also the most likely values.

Most traditional statistical forecasting models, such as the geometry average method, saturation (Capacity) curve method, least-squares regression (deterioration) method, and the curve extension method, are designed based on the configuration (outline) of semi-empirical mathematical models

SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – III – COLLECTION AND TRANSFER – SCIA3004

Methods of Collection:

General:

Collection:

The process of picking up wastes from residences, businesses, or a collection point, loading them into a vehicle, and transporting them to a processing site, transfer station or landfill.

The functional element of collection includes not only the gathering of solid wastes and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a material processing facility, a transfer station, or a landfill disposal site.

India produces about 36.5 million tonnes of municipal waste every year. Municipal bodies spend approximately Rs. 500 to Rs. 1500 (US $ 12- 36) per ton for solid waste management (Disha et al. 2001).

About 60 - 70 % of this amount is spent on collection, 20 - 30 % on transportation and less than 5 % on final disposal (Disha et al. 2001).

Collection of Solid Waste

To prohibit littering (prohibiting) and to facilitate compliance (amenability), municipal authorities must take the following steps:

• Organize collection of MSW at household level by using methods such as door-to-door, house-to-house, or community bin service. Collection must be on a regular preinformed schedule or by acoustic (audible) announcement (without exceeding permissible noise levels).

• Give special consideration to devising (PLANNING) waste collection in slums and squatter areas, as well as to commercial areas such as areas with hotels, restaurants, and office complexes.

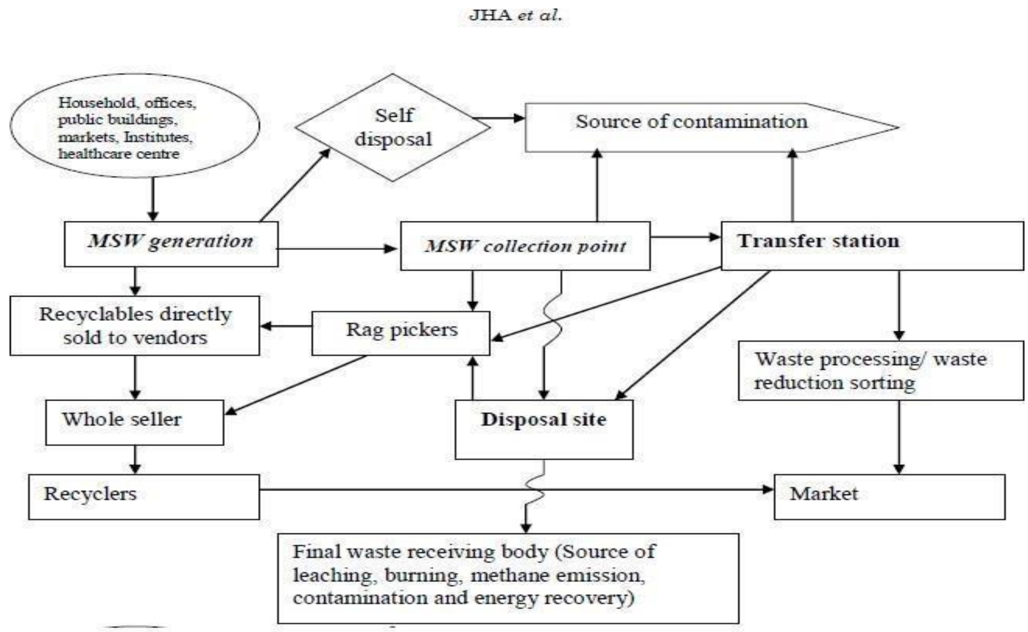


Fig. 1. Schematic flow chart of common MSW management process.

Fig.3.1

Figure.1 elaborately explains the process of Municipal solid waste management process and collection point has clearly showed.

• Segregate at the source all recyclable waste, as well as biomedical waste and industrial waste, to prevent special waste from being mixed with ordinary municipal solid waste.

• Collect separately all horticultural waste and construction or demolition waste or debris, and dispose of it following proper norms. Similarly, waste generated at dairies will be regulated in accordance with the state laws.

• Prohibit burning of waste.

• Do not permit stray animals at waste storage facilities.

<u>Collection Frequency</u>:

The number of MSW collections made from a specific location within a given time period.

METHODS OF COLLECTION SYSEMS:

Primary collection of MSW and its transfer to community bin or self disposal, care of transfer station.

Secondary collection and transport to the waste disposal site;

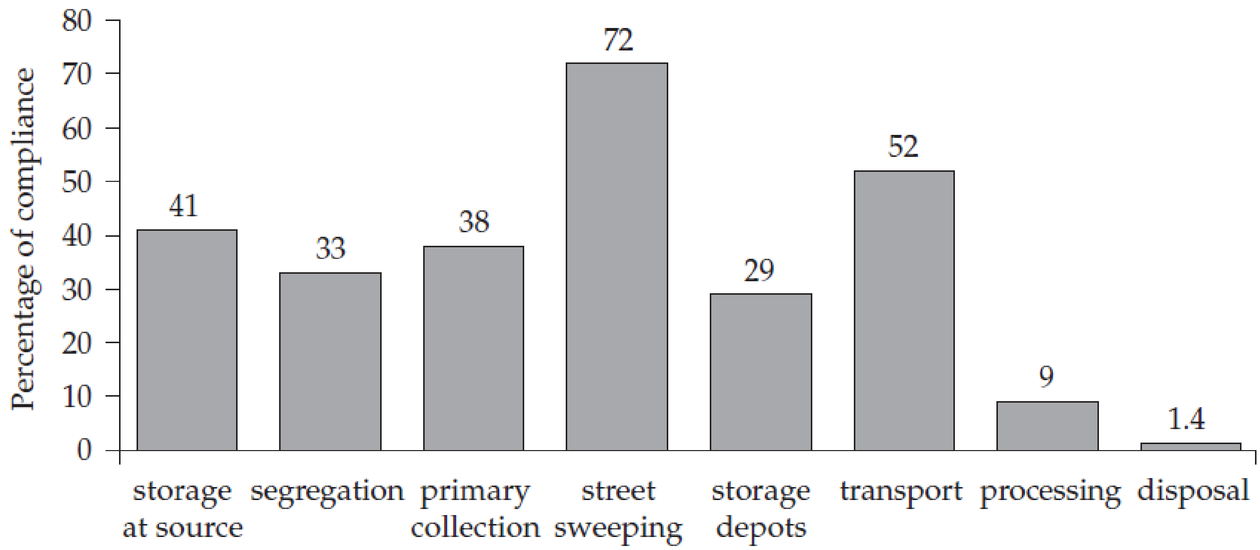


Fig.3.2

Secondary collection and transport to the waste disposal site.

i) Primary Collection

Primary collection is the most essential component of SWM service and is grossly neglected. Collection systems in India are primitive (Simple) and inefficient. Municipal authorities, by and large, do not provide the service of door-to-door collection of waste, nor do they contract for such services to be provided by the private sector.

- The principal reason for this deficiency in service is the mindset of the municipal authorities. Such authorities consider themselves responsible only for waste collection at street collection points and do not feel it is their job to provide doorstep collection service, even though such service is now mandated in the rules.

Colour Coding and Type of Container for Disposal of Biomedical Waste

Color code[a]	*Type of container*[b]	*Waste category*[c]	*Treatment options*
Yellow	Plastic bag	1, 2, 3, and 6	Incineration or deep burial
Red	Plastic bag	3, 6, and 7	Autoclaving, microwaving, or chemical treatment
Blue, white, or translucent	Plastic bag or puncture proof container	4 and 7	Autoclaving, microwaving, chemical treatment, destruction, or shredding
Black	Plastic bag	5, 9, and 10	Disposal in secured landfill

Source: Ministry of Environment and Forests 1998.

a. Per Schedule I, the color code of waste categories with multiple treatment options is selected depending on treatment option chosen.

b. Waste collection bags for waste types needing incineration cannot be made of chlorinated plastics. Category 8 and liquid types of category 10 do not require containers. Category 3, if disinfected locally, also does not need to be put in a container.

c. Category types are as follows: 1 = human anatomical waste, 2 = animal waste, 3 = microbiology and biotechnology waste, 4 = waste sharps, 5 = discarded medicines and cytotoxic drugs, 6 = soiled waste, 7 = solid waste, 8 = liquid waste, 9 = incineration ash, and 10 = chemical waste.

anatomical (STUCTURE)

- **clave (cleave) - slice**
- **Biotech (Brief study about the Biological substance)**
- **Cytotoxic (a type of Toxic agents)**

  -
  - The second reason is the lack of citizen involvement in the storage of waste at source, which would facilitate primary collection from the doorstep. Changing the habits of citizens, who are used to throwing waste on the streets and must instead learn to store it in domestic bins, will be a slow process.

In very few places does door-to-door collection exist. In such cases, it is provided by NGOs or the private sector with or without municipal initiative. **(**LACK OF COLLECTION)

The success of such efforts can be attributed to the concerted efforts of NGOs or, in some cases, a motivated municipal official or elected representative who is in a position to change the system.

Street Sweeping

Street sweeping is the most common method adopted in India for primary collection of wastes deposited in the streets. However, only important roads and markets are swept daily. Some streets are swept on alternate days or twice a week, and some are swept (irregularly) or not at all.

No planning is done to ensure that all streets are swept regularly.

Fig.3.3

Short-handled brooms cause fatigue and Backache, resulting in loss of sweeper's Productivity.

Fig.3.4

Inefficient handcarts require constant bending.

Summary of Drawbacks of the Current Street-Sweeping Practices towns.

- Street sweeping is not carried out on Sundays and on public holidays in many cities and
- All roads, streets, and lanes are not covered with daily street-sweeping operations.
- Citizens continue to throw waste on the streets throughout the day, even after cleaning of streets.
- There is a large variation in street-sweeping norms, which range between 250 meters per sweeper per day and 1 kilometre per sweeper per day.
- The time for cleaning of commercial streets is not synchronized.
- Sweeping tools are inadequate and inefficient.

(i) Secondary collection

Municipal authorities have designated several locations in cities and towns for the temporary storage of waste collected by street sweepers and for the deposition of the domestic or trade (Job) waste by the citizens.

Those sites are intended (planned) to facilitate the bulk transport of waste from such depots. The waste depots are called dustbins, vats (container), waste collection points, and so forth. Most of those sites are open and are located on the roadside. Some are constructed as cement or concrete bins, missionary bins, or large built structures. Is that collection is called secondary collection or secondary storage of waste.

Fig.3.5 Temporary storage bins frequently overflow

Fig.3.6 This handcart is not synchronized with secondary storage.

TYPES OF COLLECTION SYSTEMS:

These systems may be classified from several points of view, such as the mode of operation, the equipment used, and the types of wastes collected.

Collection systems have been classified according to their mode of operation into two categories:

1) Hauled container system (HCS)
2) Stationary container system (SCS)

In the former the containers used for the storage of wastes are hauled to the disposal site, emptied and returned to their original location or some other location.

1) Hauled container system (HCS)

Hauled container systems are ideally suited for the removal of wastes from sources where the rate of generation is high, because relatively large containers are used.

The use of large container reduces handling time as well as the unsightly accumulations and unsanitary conditions associated with the use of numerous smaller containers.

Another advantage of hauled container system is their flexibility, also container of many different sizes and shapes are available for collection of all types of wastes.

There are three main types of hauled container systems:

1) Hoist truck
2) Tilt-frame container
3) Trash-trailer.

2) Stationary container systems (SCS)

Stationary container systems may be used for collection of all types of wastes. The systems vary according to the type and quantity of wastes to be handled, as well as number of generation points.

There are two main types:

General:

System in which mechanically loaded collection vehicles

1) System in which manually loaded collection vehicles.

Types of Collection System

- Refuse Collection Systems - Household waste removed from the home
- Commercial Waste Collection - Commercial waste removed primarily using dumpsters
- Recyclable Material Collection - Collection of recyclable materials separated at the source of generation

Types of Vehicles:

Equipment

- Both Vehicles and Containers are required
- Average life of vehicles: 5-7 yrs
- Residential collection vehicles - Packer trucks
  - most have internal compactors
  - Rear loaders - larger hopper not as necessary with the elimination of larger, bulky items
  - Side loaders - 2 person crew (driver and loader)
  - Mechanically loaded
  - Front Loader, residential waste place in bin then cycled (Cal and western states)
- Commercial waste collection vehicle
  - Front Loader
  - Hoist truck; small operation, few pickup locations, bulky items

    - Tilt frame - large containers, widely used
    - Trash trailers - heavy rubbish (C/D)
- Recycling - compartmentalized truck

Automated Collection

Usually only one driver required works best:

- without on-street parking, low hanging wires, narrow streets
- Where commitment to preventative maintenance
- Where commitment to educating public
- 60-90 gal containers

Collection Options

City-Run Collection

- More control over collection
- City owns and operates all equipment
- City manages personnel
- Funded from property tax, user fees, or utility bill
- Advantages
- Disadvantages
    1. Municipalities tend to be less efficient than private companies
    2. Capital expenditures can be difficult
    3. May require passage of bond
    4. Tendency to minimize short-term spending without considering long-term implications
- Advantages
    1. Non-profit
    2. Centralized operation
    3. City maintains complete control over waste

Private Collection

City gives contract to firm(s) as a set fee based on bidding process, users are billed directly

Non-Exclusive Franchises

- Multiple contractors competing for service in community Exclusive Franchises

- One contractor is responsible for a given area
- Advantages
  - No capital expenditure for city
  - Long-term lower costs
  - Impose order on collection (exclusive franchise)
  - Regular pickup schedules (exclusive franchise)
  - Trash cans/trucks on street one or two days per week (exclusive franchise)
  - Lower costs due to improved routing and technology (exclusive franchise)
- Disadvantages
  - Difficult to compete with large haulers
  - Leads to domination by a few haulers (exclusive franchise)
  - Citizens provide a profit to waste hauler
  - City can become overly dependent
  - Requires oversight by city

Collection routes:

Once equipment and labour requirement have been determined, collection routes must be laid out so that both the collectors and equipment are used effectively.

In general, the layout of collection routes involves a series of trials.

There is no universal set of rules that can be applied to all situations. Thus collection vehicle routing remains today a heuristic (common sense) process.

Some heuristic (common sense) guidelines that should be taken into consideration when laying out routes are as follows:

a. Existing policies and regulations related to such items as the point of collection and frequency of collection must be identified.
b. Existing system characteristics such as crew size and vehicle types must coordinated.
c. Whenever possible, routes should be laid out so that they begin and end near arterial streets, using topographical and physical barriers as route boundaries.In hilly area, routes should start at the top of the grade and proceed downhill as the vehicle becomes loaded.
d. Routes should be laid out so that the last container to be collected on the route is located nearest to the disposal site.
e. Wastes generated at traffic-congested locations should be collected as early in the day as possible.
f. Sources at which extremely large quantities of wastes are generated should be serviced during the first part of the day.
g. Scattered pickup points (where small quantities of solid waste are generated) that receive the same collection frequency should, if possible, be serviced during one trip or on the same day.

LAYOUT OF COLLECTION ROUTES

STEPS INVOLVED IN THE PROCESS

The following general steps involved in establishing collection routes, include:

1. Preparation of location maps [It showing pertinent (Relevant) data and information concerning the waste generation sources – Total Number of containers and collection points in that pick up Location, collection frequency (Number of trials adopted), Dispatch station to End site (MRF or Transfer station)].
2. Data analysis (As required, preparation of information summary tables)
3. Preliminary layout of routes
4. Evaluation of the preliminary routes and development of balanced routes by successive trials.

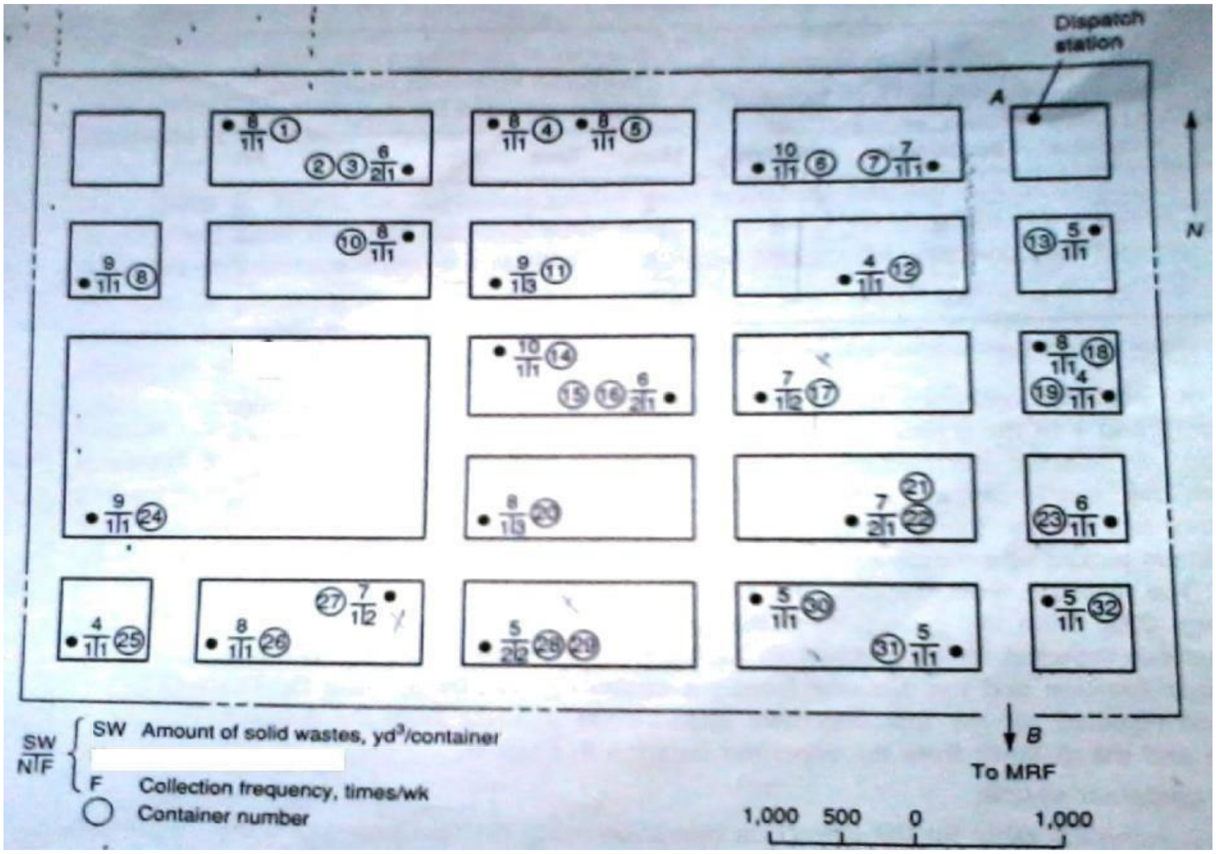

Dispatch station
A
N
B
To MRF
SW/NTF
SW Amount of solid wastes, yd³/container
F Collection frequency, times/wk
Container number
1,000 500 0 1,000

Fig.3.7

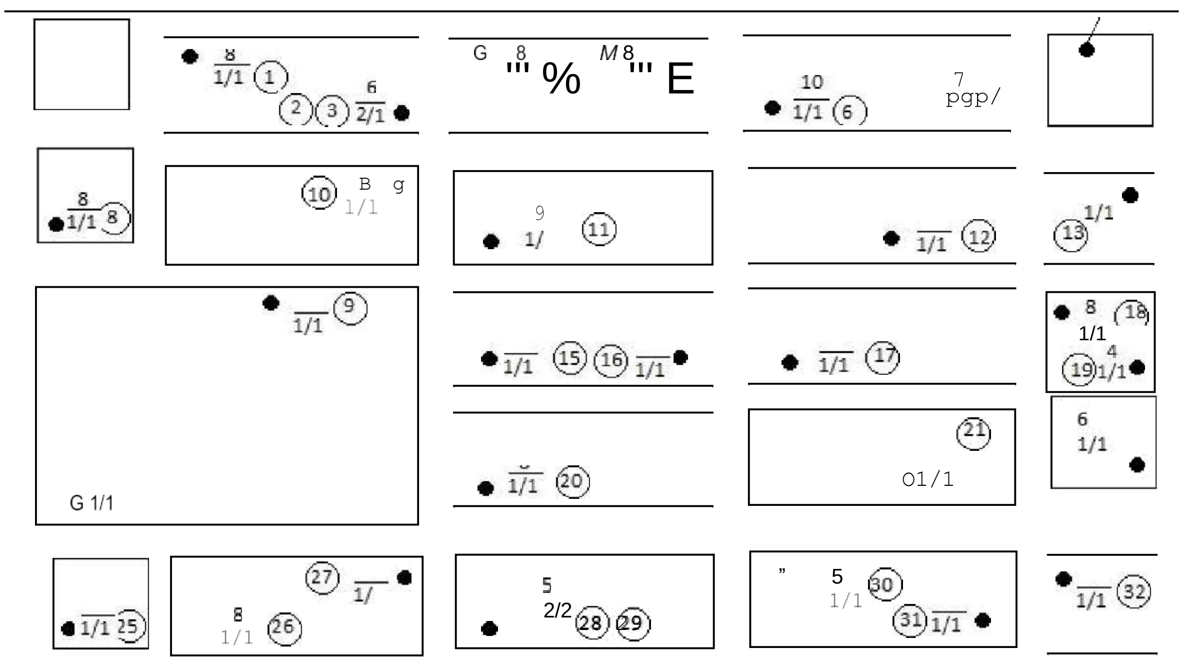


Fig.3.8

TRANSFER OPERATION AND TRANSFER STATION

TRANSFER OF MUNICIPAL WASTE:

DEFENITION (Transfer and transfer Operation):

Transfer and transport refers to the means, facilities, and appurtenances (accessories) used to effect the transfer of waste from one location to another location.

Typically the contents to relatively small collection vehicles are transferred to larger vehicles that are used to transport the waste over extended distances either to MRFs to Disposal sites.

CONDITIONS:

- More common as the distance of landfill sites becomes greater.

Or

- Transfer and transport operations become a necessity when haul (Movable) distances to available processing centers or disposal sites increase so that direct hauling is no longer economically feasible.
- Sometimes the site are situated in remote locations.
- Most common in larger metropolitan areas.
- Variance in types, size, and degree of sophistication (Complexity)
- E.g. open-air stations or enclosed in a building (newer stations).

Transfer stations:

GENERAL:

In the field of solid waste management, the functional element of transfer and transport refers facilities and appurtenances used to effect the transfer of wastes from one location to another, usually more distant location.

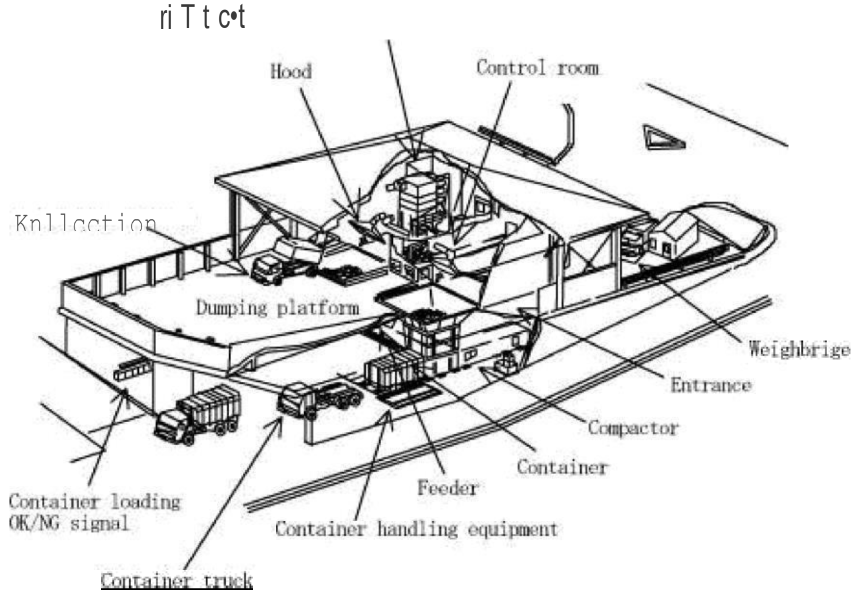


Fig.3.9

DEFENITION:

- A transfer station is a building or processing site for the temporary deposition of waste.

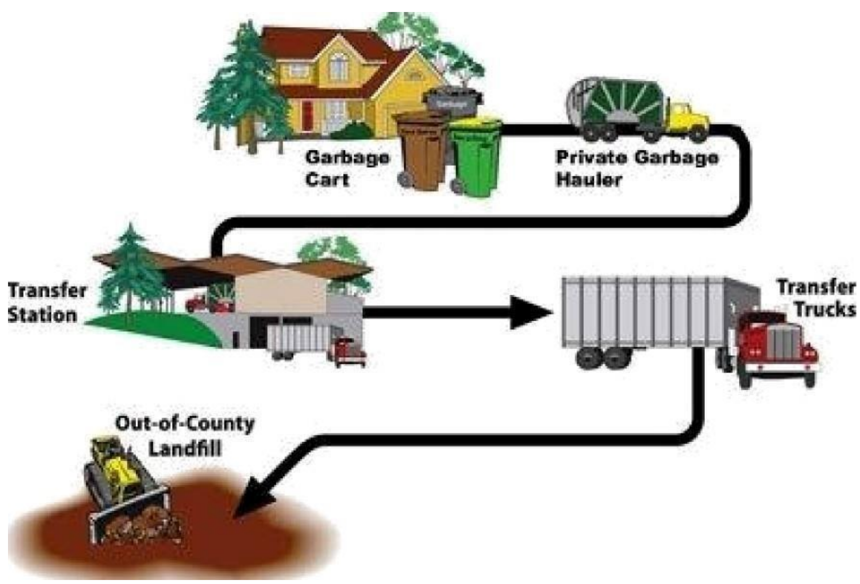


Fig.3.10

- Transfer stations are often used as places where local waste collection vehicles will deposit their waste cargo prior (previous) to loading into larger vehicles.

- These larger vehicles will transport the waste to the end point of disposal in an incinerator, landfill, or hazardous waste facility, or for recycling

- In the future, transfer stations could be equipped with material recovery facilities and with localized mechanical biological treatment systems to remove recyclable items from the waste stream.

Factors to considered Transfer stations operation:

Additional factors that tend to make the use of transfer operations attractive include:

1. The occurrence of illegal dumping due to excessive haul distances.
2. The location of disposal sites relatively far from collection routes. (typically more then 10 miles or 16 km (1 mile = 1.609 km)).
3. The use of small capacity collection vehicles (generally under 20 cubic yard or 5832 meters or 5.832 km (1 yard = 0.9144 m)).
4. The existence of low-density residential service areas.
5. The use of a hauled container system with relatively small container for the collection of wastes from commercial sources.
6. The use of hydraulic or pneumatic (operated by air or by the pressure or exhaustion of air: a pneumatic drill) collection system.

Advantages of Transfer stations:

- better haul roads for collection vehicles

(usually paved - reducing damages to trucks and delay).

- greater traffic control

(avoid traffic jams/congestion or litter (disorder or confusions) + safety to children).

- fewer truck on the sanitary landfill haul routes (reduction ratio of from 3 (trucks) :1 (transfer haul) or 5:1).

- improved landfill operating efficiency (fewer trucks mean better traffic control).

- Lower overall haul cost

(reduction in no. of drivers/crew).

Criteria (STANDARDS or PRINCIPLES) for Transfer Location:

Near the collection area served (to minimize collection crew time for haul to the transfer station).

- **Accessible to major haul routes** (public acceptance and economics - lower transfer haul cost)).

- **Adequate land area** to provide isolation (to handle traffic flow).

- Suitable Zoning (commercial or industrial)

- **Served by utilities** (water, sanitary sewer, storm drainage, electricity) (Size vs. station capacity).

TYPES TRANSFER STATION:

- Depending on the method used to load the transport vehicles, transfer station may be classified into three general types:

    1. Direct-load
    2. Storage-load
    3. combined direct-load and discharge-load

- Transfer station may be classified with respect to throughput capacity (the amount of material that can be transferred and hauled) as follows:

    1. Small, less then 100 ton/day
    2. Medium, between 100 and 500 ton/day
    3. Large, more then 500 ton/day.

STATION CONCEPTS

1. Pit

    a) Direct Dump

    b) Compaction

2. Pit:

    1. Collection vehicles unloaded wastes into a large pit.
    2. Wastes are then pushed to an open-top transfer trailer by a tractor.
    3. The pit - as storage during peak periods.
    4. Compaction of bulk items made by the tractor in the pit.

Direct Dump

- collection vehicles dump directly into open-top transfer trailer
- Large hoppers direct the waste into the transfer trailers.
- Very large transfer trailers are used (due to minimal compaction).
- Efficient - no intermediate handling required (direct from vehicle to transfer trailer).
- Compaction:

    i) Hopper type compaction station : waste drop by gravity into a compactor - packs the waste into the trailers.

    ii) Push pit compactor station: a large hydraulically operated blade moves the waste to the stationary packer - then packs the waste into the trailers.

Advantages & Disadvantages of Design Alternatives:

Option	**Advantages**	**Disadvantages**
1. Tipping floor,open-top trailer · • Large tipping floor where collection vehicles unload • Dozers organize and push waste into open-top trailers	Little site work inv. Low bldg. Cost Can separate recyclables	Not as eff. as other syst. For large vol. of waste
2. Pit, Open-top Trailer • Coll.Veh. unload directly into a large pit · • Tractor w/ dozer or l/fill-type blade organizes the wst.& pushes loads into open-top transfer trailers	Reduced transfer time (coll.veh. unload while loading & transfer operations still going on) · Pit serves as a storage · Efficient system for high volumes of wst. Can sep .recyclables	Requires 3-level facility (considerable amount of site work & capital investment
3. Direct dump, open-top trailer • Coll.veh. dump loads directly into open-top trailers via largehoppers Stationary or mobile clamshell	1. Can be used to distribute the wst. in trailer · 2. No intermediate handling of the wst. inv. 3. Increasing efficiency 4. Fac. shutdown rare	1. May req. separate trailer- packing machines (in case of large uncompacted wst) 2. Req.additional tipping flr/storage space. 3. Coll.veh. not indep. of transfer vehicle loading).

equip	5. No complicated equip. inv.	
4. Hopper-type Compaction Wst. is gravity-fed via hopper into stationary compactors that compacts the wst before or while entering the trailer	1. Efficient for small capacity demand If compactor fails, no alternative method of loading	Trucks may line up waiting to unload because of limited hopper size.
5. Push-pit Compaction • Coll.veh. dump loads into large steel or concrete pits. • Large hydraulic blade moves the wst. to compactor charging box. • Compactor packs the wst. Into trailer.	1. Large compactor can usually handle all types of wst. + large bulky wst. 2. Pit acts storage areaduring peak arrival.	1. Large capital investment. 2. Facil. operations dep. on operation of the compactor .
6. Stationary Compactor, roll-off container • Low-vol. operations (e.g. rural drop-off centers). Refuse unloaded directly into container	Container may be equipped with compactor to handle lighter materials.	1. Bulky and large materials - create problem w. small compactor. 2. Operation dep. on functioning compactor
7.Track and top-load. Tracked compactor followed by loading in open-top trailers	Efficient for larger facilities (> 300 t/d)	

PROCESS OPTIONS AT TRANSFER STATIONS

To prepare waste for transfer haul and subsequent disposal

1. Baling:

- practiced in the US since 1960's
- reduces haul cost
- a more controlled operation at the landfill
- require lower cover material
- density 2000-1500 lb/yd3
- may have wire ties or may not be tied.
- Requires little or no separation of wastes.

Shredding:

- Shredders are used.
- Handles bulky wastes (furniture, tree limbs, etc.)
- Transport - use enclosed transfer trailers.
- Wastes have good compaction characteristics

  - requires small trailers.

NEED FOR TRANSFER OPERATIONS

Transfer and transport operations become a necessity when haul (drag or pull) distances to available processing centres or disposal sites increase so that direct hauling (moving) is no longer economically feasible.

They also become a necessity when processing centres or disposal sites are sited in remote locations and cannot be reached directly by highways.

Transfer operations are an integral part of all types of MRFs (Material Recovery Facilities). Transfer operations can be used successfully with all types of collection vehicles and conveyor systems.

Additional factors that tend to make the use of transfer operations attractive include,

1. The occurrence of illegal dumping due to excessive haul distances.
2. The location of disposal sites relatively far from collection routes (typically more than 10m)
3. The use of small-capacity collection vehicles (generally under 20 yd^3) (yd^3-Cubic yards).
4. The existence of low-density residential service area.
5. The use of hauled container system with relatively small Container for the collection of wastes from commercial sources.
6. The use of hydraulic or pneumatic collection systems.

Location of Transfer Station:

Transfer stations should be located,

1. As near as possible to the weighted center of the individual solid waste production areas to be served.
2. Within easy access of major arterial highway routes as well as near secondary or supplemental means of transportation.
3. Where there will be a minimum of public and environmental objection to the transfer operations, and
4. Where construction and operation will be most economical.
5. Additionally, if the transfer station site is to be used for processing operations involving materials recovery and/or energy production, the requirements for those operations must also be assessed.

Principles to Improve Solid Waste Collection and Transport :

Effective For solid waste collection and transport to be effective, the LA must get the job done. Since a LA is vested with the responsibility of maintaining a disease-free environment for its citizens, it should ensure proper solid waste collection and transport. All the waste collected from households and other establishments should be emptied and disposed of through a socially and environmentally acceptable practice. Failures in waste collection leads to public health hazards.

Efficient

Handle waste as few times as possible. It is a known fact that most LAs have inadequate and limited resources available to engage in the collection and transport of solid waste. The efficient use of resources by the LA in the collection and transport of solid waste shows how effectively the LA engages in this activity.

Cost Effectiveness

Capital Investment Vs Labour Costs. SWM collection and transport makes up at least 60% of the total SWM costs. In most LAs, a large proportion of the annual budget is spent on SWM, mainly attributed to SWM staff costs. Therefore, it is essential to assess the efficiency of the service and develop ways to reduce costs and/or increase services within its current budget.

Environmentally Appropriate

Efficient collection and transport of solid waste will provide citizens with a clean environment in which communicable diseases will be greatly reduced. All the waste collected from households and other establishments should be emptied and disposed of through a socially and environmentally acceptable practice.

Citizen Involvement

successful collection and transport of waste material, not only depends on the efficient operation of the LA, but also on the active involvement of citizens. The public must cooperate with the LA's requirements and the LA must provide an efficient service, particularly for collecting waste on time and according to schedule. The LA should also listen to the public for their ideas, respond to their requests and follow-up to resolve any complaints.

Human Factors

LAs should ensure that trash is collected and litter cleared regularly. When trash and litter accumulates in the environment, it encourages people to add even more to the pile. If the environment is clean, people are discouraged from dumping trash and scattering litter.

Teamwork

Most LAs are not organised in the same way as the private sector. LAs tend to have divisions like finance, operations and maintenance located in different places. In order to coordinate solid waste collection and transport there has to be an understanding of the work required, the impact on citizens as a result of delays and the ability to work as a team

General Issues in Collection and Transport:

- Poor garbage storage/discharge. For example, garbage temporarily discharged at the roadside or in public bins must be re-loaded again by LA labourers into collection vehicles. Often, it takes around 20-25 minutes to transfer the contents of a full concrete bin into a tractor-trailer.
- Inappropriate waste transfer from handcarts to tractor-trailers. Typically, handcarts discharge their loads onto the ground, meaning it must be re-loaded into the trailer. This transfer process takes at least 5 minutes.
- Inappropriate waste transfer from hand tractors to four-wheel tractors. Garbage in two-wheel tractors must be emptied manually onto the ground, which takes around 20 minutes. This garbage must then be re-loaded into a trailer. It takes four labourers around one hour to fully load a 6m3 trailer.
- Collection costs are high and service levels are low. As mentioned earlier, a major proportion of a LA's budget is spent on collection, whereas service typically covers only 30%-70% of the urban population and is often infrequent (less than once a week in the rural areas).
- Poor labour management and supervision.
- Inadequate cooperation from citizens with the LA's collection schedules and methods. • Inappropriate type and size of collection vehicles.
- Non-rational routes for collection service.
- Failure to optimize vehicle productivity by selecting the appropriate crew size and shift duration.
- Inadequate container capacity at the communal collection points.
- Long vehicle down-times from poor equipment maintenance/repair.
- Long haulage times to disposal sites coupled with lack of transfer stations.
- Harsh driving conditions at disposal sites causing vehicle and tyre damage.

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – IV – OFF-SITE PROCESSING – SCIA3004

PROCESS OF SOURCE SEPARATION

Product reuse: Using reusable products, instead of their disposal equivalents, reduce the amount of materials that are to be managed as wastes. An example of product reuse is the reusable shopping bag.

Material volume reduction: Reducing the volume of material used changes the amount of waste entering the waste stream. This helps in controlling the waste generated and its disposal. For example, buying in bulk or using large food containers reduces the amount of packaging waste generated.

Toxicity reduction: Source reduction reduces the amount of toxic constituents in products entering the waste stream and reduces the adverse environmental impacts of recycling or other waste management activities. For example, substitution of lead and cadmium in inks (solvent-based to water-based) and paints is a source reduction activity.

Increased product lifetime: Source reduction facilitates the use of products with longer lifetime over short-lived alternatives that are designed to be discarded at the end of their useful lives. Put differently, it encourages a product design that allows for repair and continued use rather than disposal. Manufacturing long-life tyres is a good example of increasing product lifetime.

Decreased consumption: This refers to the reduced consumption of materials that are not reusable (e.g., using a reusable shopping bag instead of picking up plastic bags from the store). Consumer education about the materials that are difficult to dispose of or are harmful to the environment is essential. Buying practices can thus be altered (e.g., buying in bulk) to reflect environmental consciousness.

Full stream processing technique

This is a high technology separation technique, which processes all components of municipal waste. The materials recovered by this process tend to be of lower quality than those recovered or source separated in MRF because the former is a mix of various types of wastes. To achieve a better quality, the materials obtained through the full stream processing must be cleaned, which is a costly process. However, this technique remains attractive because it does not require source separation, and it is used in the following applications:

Refuse derived fuel (RDF) preparation: In this application, it is used to xtract the combustible portion of munic ipal waste.

Municipal waste comp osting: In this application, it I used to concentrate the compostable portion of m unicipal solid waste. Note that this is sometimes performed as part of RDF preparation.

Material recovery: In this application, it is used to recover and resell certain materials, and thereby makin g material recovery a recycling technology as well. In full stream processing, dependin g on the facility design, the materials are separated either mechanically or by hand, and size and weight are the main characteristics used to separate the materials.

- ✓ when the material is dumped, oversized materials such as furniture, etc., are removed;
- ✓ rotating screens are used to separate materials of different siz es (small and large);
- ✓ ferrous material is extracted using a magnet system;
- ✓ air classifier is us ed to separate the lighter material;
- ✓ light materials including plastic and paper are further processed into RDF; heavy fraction is mechani cally or manually sorted to recover sale able materials such as cardboard, etc.

Recovery of wastes

Recycling is perhaps the most widely recognised form of source reduction involving the pr ocess of separating, collecting, processing , marketing and ultimately using a material that would have otherwise been discarded. This orm of source reduction, i.e., recyclin g, is similar to other forms, in that it:

- ✓ lessens reliance on landfills and incinerators;
- ✓ protects human health and the environment by removing harmful s ubstances from the waste stream;
- ✓ conserves natural resources by reducing the demand for raw materials .

Recycling is one of the fundamental parts of the waste management plan. Although it alone cannot solve a community's municipal SWM problem, it can divert a significant portion of waste stream from disposal in landfill and combustion facilities. Recycling has a lot of direct and indirect significance for the society, and this can be grouped under the following three broad areas.

Economic significance: Economic assessment of waste recycling is a difficult task as many of the beneficial environmental and social impacts of recycling are long- term and are intangible, and, therefore, are difficult to quantify. Some of the short- and long-term economic benefits are:

Cost reduction: Resource recovery through recycling of solid waste could be of interest to waste management authorities as a means of reducing the waste disposal cost. Any saving in waste management cost could be a significant incentive to the authorities to increase the coverage of service areas and improve the service level. They can save cost from fuel for transportation, operation and maintenance, and generate revenue by sale of recyclables , etc.

Employment: Recycling of waste is a labour intensive activity, and its potential to ease the unemployment problem is high. Enhanced recycling activities, for example, can create an additional job market for skilled and unskilled workforce, and they can adapt to any of the occupations such as a labourer

Energy saving: Use of recyclables in some industrial processes is known to consume less energy than the use of any other raw material.The reduction in energy consumption in one industry could mean its availability for some other industry in need.

Reduced health care costs: Improved health and sanitary conditions in urban areas resulting from indirect benefits of waste recycling can reduce the investment in public health programme.

Saving costs for other public utilities: Enhanced solid waste recycling practices can reduce the frequency of sewer clogging, blocking of natural watercourses and pollution of water bodies.

Environmental and health significance: The volume of waste is increasing rapidly because of populatio n growth and economic development. The composition of waste is also changing, leading to waste production with more recyclables. At the same time, polluted waste fraction s are increasing because of increasing complex processes being used in industries, and these contribute increasingly to e nvironmental degradation. This notwithstan ding, recycling helps, among others, in the followingways, to facilitate effective waste management:

Improved en vironment: The environmental pollution may be due to inadequate SWM as well as due to its effect on other urban infrastructure. Recycling reduces the volu me of waste that has to be finally dumped, and thereby causing reduction in pollutio n at the waste disposal sites. When there is reduction in volume of waste because of i ts increased reuse, different types of pollution (e .g., water, air and land) will get abated.

Natural resource conservation: Industries with natural pro ducts as their raw material for production are depleting natural resources. Use of more and more recyclable solid wastes in industrial production will relievethe tremendous pressure on these precious resources. For example, recycling of waste paper means a lower demand for wood, which means less cutting of trees and an enhanced possibility for sustainable use of the forest. Using recyclable items in the production process would reduce the demand for energy as well.

Social significance: People engaged in waste collection activities are normally of low social and e conomic standing. This is especially true with scavengers, which is evident from persisting poor quality of their living and working conditions. Different groups of people engaged in waste recycling have a hierarchical social and economic status, in which, processors are at the top of the hierarchy followed by waste dealers and wholesalers, waste buyers and waste collectors in that very order, while scavengers are at the bottom. Although there is this social and economic hierarchy within the waste recycling business, the overall social esteem of waste recycling A formal recycling arrangement will help promote the social esteem of waste workers and facilitate their upward social mobility due to increased earning. In addition, the improved recycling activity will increase the economic value of the waste and will reduce waste scavenging activity providing opportunity for scavengers to switch to a more socially acceptable occupation. In short, institutionalised recycling programmes will help remove the stigma associated with waste scavenging and transform it to an economic enterprise.

Recycling Program

Numerous recycling options are available, and recycling programmedevelopment requires strategic planning. Planning for recyclinginvolves understanding markets, assessing local expertise, setting goals and fosteringpublic participation. An efficient recycling programme requires a systematic approach to all programme components, which are interrelated, and therefore, decisions about one must be made taking into consideration other components. As a successful recycling requires public participation, programmes must be designed keeping in view public convenience and support.

Build local expertise: Small projects help build local expertise in recycling and minimise the problems associated with poor planning. With small- scale projects, it is easy to compare and evaluate the programmes and techniques that are considered most successful within the community. When the time comes to develop a large-scale programme, there will be practical experience and an established decision-making framework, which will enhance the programme’s success.

Understand and develop a re cycling market: While planning for a recycling programme, it is important to find an outlet for the recyclable material. Market analysis is both a planning and ongoing activity, as even the most suc recycling programme can be severely affected by market fluctuations. Re programmes must, therefore, be designed with the flexibility to handle fluctuating and uncertain outlets for material.

Foster public education and involvement: Public participation is one of the most important factors deciding a programme’s success. The public has a right and a responsibility to understand the full costs and liabilities of managing the waste they produce. A well-planned public education and involvement programme will foster public interest in recycling.

Assess local **waste stream:** Planning any recycling programme requires the knowledge of the local waste stream. Choosing the right material to recycle and designing the logistics of the programme are the important parts of the planning process.

Augment existing programme: Recycling should augment the success that has been attained by other groups operating recycling programmes. This is very important for planning and success. Other programmes may be run by local volunteer organisations to raise funds or as a community service.

Set goals and objectives: Part of the planning process involves setting goals and objectives. The preliminary assessment of waste stream helps in deciding long-term goals for a community. Planning objectives may include determining the type of waste stream component that should be programmed, investigating the feasibility of the curbside (kerbside) programme, public outreach avenues, etc. The community will benefit from carefully developed achievable goals and objectives, and from an integrated approach to waste management (see Unit 10 for a detailed discussion of the integrated approach to waste management).

Coordinate the programme: Recycling programme is considered a public service. Therefore, local governments are required to ensure that all services are provided properly. Like any other public service, recycling programmes should be consistent, predictable, equitable and efficient.

Evaluate the programme: New programmes and technologies are evolving continuously, which make the planning for recycling an ongoing process. This requires experiment and evaluation. Even the best recycling **programmexperimes ent with new techniques to improve on their current effo**rts.

Processing equipment for recycling

Recycling involves a number of processing techniques and these pro cesses require different equipments. However, some of the special equipments used in recy cling are:

Balers: Balers can be used to densify many types of materials inc luding paper, cardboard, plastics and cans. Balers can improve space utilisation and reduce material transportation costs.

Can densifiers: Can crushers are used to densify aluminium and steel cans prior to transport.

Glass crushers: These are used to process glass fraction separated by colo break it in to **small** pieces. This crushed material is then called cullet, and can be repro into new glass products.

Magn etic **separators:** These are used to remove ferrous material from a mixt materials.

Woo d grinders: These are chippers and are used to shred large pieces of woo chips that can be used as much or as fuel.

Scales: These are used to measure the quantity of materials recovered or sold.

Mater ial recovery facilities (MRF)

MRF (pronounced 'murf') is a centralized that receives, separates, processes and **markets recyclable material. It** can be operated with both drop off and curbside programmes. **The primary advantage of MRF** is that it allows materials directly from the municipalities and **processes them uniformly.** It is generally designed to handle all type of recyclables.

Implementation of MRF in a municipality depends upon a number of factors as follows:

Market demand**:** When additional processing is required, MRF is more useful as buyers may have certain material specifications.

Separate **collection:** In systems that require residents to separate their recyclables, intermediate separation and proc essing is required.

Number of different recyclables: In general, a MRF will be more benefi cial when a large number of different recyclables are collected.

Quantities of materials: Because MRF involves substantial capital and operating costs (e.g., buildings, equipment and l abour), it is expected to handle a significant am ount of materials to justify its operation.

Motion time measurement (MTM) technique

Motion time measurement (MTM) studies are now an integral part of the standard procedure in the development of solid waste collection systems. MTM is a tech and estimate the movement of the collection crew with the help of stopwatches.

Sophisticated MTM studies involve hidden or open video cameras at different collection stops to record, replay and study the operation sequence of the collection crew. If the crew is conscious of being observed, they tend to work faster and reduce time wastage in unauthorised salvaging and other non- scheduled activities. Once the crew is familiar with the person(s) observing them, it begins to perform more credibly. In studies involving video cameras, therefore, the first two or three hours of observation are often neglected.

Composting

(i) Composting is an effective method of solid waste disposal. In composting, biodegradable materials break down through natural processes and produce humus. The metabolism of micro-organisms breaks down the waste aerobically or anaerobically.

(ii) Materials that are non- biodegradable must be separated from the degradable materials and disposed of in some other manner.

(iii) Some common non biodegradable materials are glass, plastics, rubber products, and metals. Once nonbiodegradable materials have been removed and only Bio degradable waste has been established, it is brought to a grinder. Grinding increases the surface area of the waste and enhances biological degradation. Most modern compost systems are aerobic rather than anaerobic for several reasons:

e) Aerobic processes are not accompanied by the foul stench present at an unsealed anaerobic composting operation

f) In crop production industries, composting is safer because temperatures do not reach that of pasteurization temperatures which exceed the thermal death point of most plants, animals and parasites.

g) Aerobic composting is more rapid than anaerobic composting.

An aerobic compost operation ideally is an optimal environment for the growth of aerobic organisms. The material to be composted is food. Therefore the "f have a carbon: nitrogen ratio favorable for decomposition. The microbes require a C: N of 25:1 to 30:1. If the C: N is too low (120:1), the ammonium compounds will volatilize into the air, causing an unpleasant odor. Various groups of organisms have different optimum temperatures (some prefer 25 0c, some 37 0c, and others 55 0c), though the optimal temperature for a process as a whole integrates the optimums of the various microbes.

The pH of aerobic composting varies depending on the organisms' need for Aeration is important and is provided by turning the compost mechanically to expose itto oxygen to speed
decomposition. Microbes must have moisture, and such is the case in composting. The amount of moisture needed varies with the composition of the material being composted.

The moisture content should be approximately 45% to 50%. If the moisture is too low, microbial activity slows, and biological activity ceases at a moisture content of about 12%. If the moisture content is too high, it reduces the amount of free oxygen present and slows the process so that it may become anaerobic. Many times, sludge is added to waste for composting to provide microbial food and trace element.

2. Explain the types of composting and operation steps in composting? [CO4]

A. Types of Composting

The three main types of composting are: windrow, static pile, and in-vessel.

1. Windrow: A sludge/refuse mixture configured in long rows (windrows) that are aerated by convection air movement and diffusion, or by turning periodically through mechanical means to expose the organic matter to ambient oxygen.

2. Static pile: A stationary mixture is aerated by a forced aeration system installed under the pile.

3. In-vessel composting: Composting takes place in enclosed containers in which environmental conditions can be controlled. The waste decomposes into a harmless organic material that can be used as a soil conditioner and enhancer for agricultural applications.

B. Operation Steps in Composting

1. Removal of non-compostable wastes, (i.e. cans, glasses).

2. Grinding and shredding Helps to speed up bacterial action.

Raw refuse is shredded before placed in piles, bins and digested before decomposition.

3. Blenching or proportioning of materials

This is also to speed up the bacterial action.

The optimum carbon nitrogen has to be 30 - 35:1

Generally blending is considered to be unnecessary if the ratio is 25 - 30:1

The optimum moisture content for aerobic composting is 40 - 60% depending on the character of
the material.

4. Placement for composting - It can be placed on ground as open piles or windrows in a

shallow pit. Height of windrows or piles should not be greater than 1.5 meter to 1.8 meter and not less than 1.07 meter to 1.2 meter. Width at the bottom of the windrow is 2.44 meter to 3.6 meters.

5. Turning - An aerobic condition is maintained by frequent turning. If the moisture content is high, it requires turning every 2 -3 days.

6. Temperature - It is an important factor and should range 50-70 0 C; usually 600C is satisfactory.

Temperature will be the highest in the middle of pile or windrow. Excessive temperature (710C) is injurious to bacterial action. Excessive temperature is controlled by lowering the height of piles or windrows. If the area
is cool, raise the height in order to maintain optimum temperature. If temperatures drop, the condition will be anaerobic.

3. Explain the Factors in Composting Operation.

A. Factors in Composting Operation

The most important factors in composting operations are:

1. Segregation of refuse and salvage
2. Grinding or shredding of the material
3. carbon-nitrogen ratio
4. Blending or proportioning of wastes
5. Moisture content
6. Placement of materials in the composting pit
7. Maintain temperature level to obtain rapid, nuisance-free decomposition
8. Aeration to reduce high moisture content in composting materials
9. Organisms involved
10. Use of inoculate
11. Physical or chemical reaction
12. Climatic conditions (temperature, wind, rainfall)
13. Destruction of pathogenic organisms
14. Time required for composting
15. Fly control
16. Reclamation of nitrogen and other nutrients
17. Testing and judging the condition of compost
18. Quality of composts, which depends on nature of the material being composted
19. economic aspects of composting ,The final product of composting is compost - a mixture

composed mainly of decayed organic matter, used as a fertilizer.

4. Explain the Uses and Constraints of composting. [CO4]

Uses and Constraints

Compost improves soil moisture retention. It is a good soil conditioner. Compost, depending on the waste source and its composition, may be used as a soil amendment for agricultural soil and landscaping in municipal parks.

The two most important purposes for composting organic wastes are:

a. reclamation or conservation of the nutrient and fertilizer values of the waste b. sanitary treatment and disposal to prevent the spread of disease.

Compost is a brown material, the main constituents of which are humus. It has the following physical properties when applied to the soil:

The lightening of heavy soil

Improvement of the texture of light sandy

Increased water retention

Enlarging root systems of plants

Compost may also be used as a landfill cover, land reclamation, animal litter, and possibly animal feed. It may also be used as an additive to fertilizer as fuel, or in building materials. The presence of toxic levels of pesticides, heavy metals, and pathogens should be determined and evaluated to ensure that the levels are compatible to the intended use of the compost. The total composting time is determined by the material, process used, and exposure to the elements. Two weeks to as much as 18 months may be required for complete stabilization. For pathogen reduction purposes, the temperature of the mixture must be not less than 55 0C for at least 3 consecutive days.

The various Processing techniques and equipment’s

The processing of wastes helps in achieving the best possible benefit from every functional element of the solid waste management (SWM) system and, therefore, requires proper selection of techniques and equipment for every element.

Essentially, the purposes of processing are:

Improving efficiency of SWM system (e.g.) Shredding

Recovering material for reuse

Recovering conversion products & energy

Various Techniques & Equipments

Mechanical Volume & Size reduction

Component Separation

Air Separation

Magnetic Separation

Screening

Drying & Dewatering

Mechanical Volume & Size Reduction

Mechanical volume and size reduction is an important factor in the development and operation of any SWM system.

The main purpose is to reduce the volume and size of waste, as compared to the original form, and produce waste of uniform size.

Volume Reduction (or) Compaction

Volume reduction (or) compaction refers to densifying wastes in order to reduce their volume. The benefits of compaction are:

Reduction in the quantity of materials to be handled at the disposal siteImproved efficiency of collection and disposal of wastes

Increased life of landfills

Economically viable waste management system

Equipments for Volume reduction (or) Compaction:

Stationary Equipments:This represents the equipment in which wastes are brought to, and loaded

into, either manually (or) mechanically

Movable Equipment:

This represents the wheeled and tracked equipment used to place and compact solid wastes.

Low Pressure (< 7 kg / cm2)

Compactors:

These compactors are used at apartments, commercial establishments.

Example:

Baling equipment – For waste papers & card boards Stationary compactors – For transfer station

In low pressure compaction, wastes are compacted in large containers.

High Pressure (> 7Kg / cm 2)Compactors:

Compact systems with a capacity up to 351.5 Kg / cm2

came under this category.

Here, specialized compaction equipment are used to compress solid wastes in to blocks (or) bales of various sizes.Typically, the reduction ranges from about 3 to 1 through 8 to 1

Compaction Ratio = $V1 / V2$

$V1$ = Volume of waste before compaction, $V2$ = Volume of waste after compaction

Size Reduction (or) Shredding

This is required to convert the large sized wastes into smaller pieces.Size reduction helps in obtaining the final product in a reasonably size in comparison to the original form.

Equipments for Size Reduction (or) Shredding:

Hammer Mill:

These are used most often in large commercial operations for reducing the size of wastes.

Hammer mill is an impact device consisting of a number of hammers, fastened flexibly to an inner disk, which rotates at a very high speed. Solid wastes as they enter the mill, are hit by sufficient force, which crush (or) tear them with a velocity so that they do not adhere to the hammers. Wastes are further reduced in size by being struck between breaker plates & cutting bars fixed around the periphery of the inner chamber.

Hydro-pulper:

An alternate method of size reduction involves the use of a hydropulper

Solid wastes and recycled water are added to the hydro-pulper.

The high speed cutting blades, mounted on a rotor in the bottom of the unit, convert palpable and friable materials in to slurry with a solid content varying from 25 to 35%

The rejected material passes down a chute that is connected to a bucket elevator, while the solid slurry passes out through the bottom of the pulper tank and is pumped to the next processing operation.

Component Separation

Component separation is a necessary operation in which the waste components are identified and either manually (or) mechanically to aid further processing.

Air Separation

This technique has been in use for a number of years in industrial operations for segregating various components from dry mixtures. Air separation is primarily used to separate lighter materials from theheavier ones. The lighter materials may include plastics, paper products and otherorganic materials. Equipments used for Air Separation

Conventional Chute Type:

Its one of the simplest type of air classifier. In this type, when the processed solid wastes are dropped into the vertical chute, the lighter materials are carried by the air flow to the top while the heavier materials fall to the bottom of the chute. A rotary air lock feed mechanism is required to introduce the shredded wastes into the classifier.

Zig-Zag Classifier:

It consists of a continuous vertical column with internal zig-zag deflectors through which air is drawn at high rate. Shredded wastes are introduced at the top of the column at a controlled rate, and air is introduced at the bottom of the column. As the wastes drop into the air stream, the lighter friction is fluidized and moves upward and out of column, while the heavy fraction falls to the bottom.

Magnetic Separation

The most common method of recovering ferrous scrap from shredded solid wastes involves the use of magnetic recovery system. Ferrous materials are usually recovered either after shredding (or) before air separation Equipments Used For Magnetic Separation

Suspended Magnet:

In this type of separator, a permanent magnet is used to attract the ferrous metal from the waste stream. When the attracted metal reaches the area where there is no magnetism, it falls away freely. This ferrous metal is then collected in a separate container.

Magnetic Pulley:

This consists of a drum type device containing magnets (or) electromagnets over which a conveyor (or) a similar transfer mechanism carries the waste stream. The conveyor belt conforms to the rounded shape of the magnetic drum and the magnetic force pulls the ferrous material away from the falling stream of solid waste.

Screening

Screening is the most common form of separating solid wastes, depending on their size by the use of one (or) more screening surfaces. Screening has a number of applications in solid waste resource & energy recovery systems.

Screens can be used before (or) after shredding and after air separation of wastes in various applications dealing with both light & heavy fraction materials.

Drying & Dewatering

Drying and dewatering operations are used primarily for incineration systems with (or) without energy recovery systems. These are also used for drying of sludges in wastewater treatment plants, prior to their incineration (or) transport to land disposal

Drying

The following methods are used to apply the heat required for drying the wastes.

Convection Drying: In this method, hot air is in direct contact with the wet solid waste stream. Conduction Drying: In this method, the wet solid waste stream is in contact with a heated surface. Radiation Drying: In this method, heat is transmitted directly to the wet solid waste stream by radiation from the heated body

Dewatering

When drying beds, lagoons (or) spreading on land are not feasible mechanical means of dewatering are used. The objective is to reduce the liquid volume in the solid waste stream. Once dewatered, the sludge can be mixed with other solid waste, and the resulting mixture can be:

Incinerated to reduce volume

Used for the production of recoverable by-products Used for production of compost

Buried in a landfill

Explain the incineration process.

Incineration

Incineration is a process of burning the combustible components of garbage and refuse. Disposal of solid waste by incineration can be effectively carried out on a small scale in food service establishments as well as in institutions such as hospitals, schools etc.

The disadvantage of this method is that only combustible materials are incinerated, hence there is a need for separation of the waste into combustible and non- combustible. The noncombustible waste needs separate disposal.

Generally there are two types of incinerators, the open and the closed systems In the open system the refuse is incinerated in a chamber open to the air; while the closed system contains a special chamber designed with various parts to facilitate incineration. It requires a chimney of appropriate height to provide a good flow of air through the combustion chamber. There are varieties of designs for small scale incinerators. A typical example of design is shown in Figure 4. The size can be varied depending on the volume of the refuse to be incinerated.

The combustion chamber is laid with iron grids, at the bottom of which are air inlets in front and at the back.

The front and back walls are with provision for installing a chimney.

The feeding door has a baffle wall to facilitate refuse feeding.

he base below the combustion chamber is for collecting.

On-site Incineration

This term applies to incineration of refuse at home, office, apartment house, commercial building, hospital or industrial site. Refuse collection and disposal could be reduced satisfactorily by using on-site incineration. Generally, air pollution can be expected.

Advantages of an incinerator

1. Less land is required for landfills
2. A central location is possible, allowing short hauling for the collection service.
3. Ash and other residue produced are free of organic matter, nuisance- free, and acceptable as fill material.
4. Many kinds of refuse can be burned. Even noncombustible materials will be reduced in bulk.
5. Climate or unusual weather does not affect it.
6. Flexibility is possible - no restriction for its operation.
7. Getting income through the sale of waste heat for steam or power is possible.

Disadvantages of an incinerator

1 Initial cost is high during construction.

2 Operating cost is relatively high.

3 Skilled employees are required for operation and maintenance.

An example of this type is commonly seen in some institutions in Ethiopia. A typical design consists
of the following dimensions: width = 110 cm; length =110cm; height in front = 135cm; height at back
=150cm. Concrete base (chamber)= 60cm by 75cm by 10cm; top fueling door = 60cm by 60cm square,
with thickness 5cm. With proper management and little fuel the incinerator can effectively burn dry
as well as wet materials.

Pyrolysis process.

Pyrolysis is a process in which oxygen is excluded from the reactor, which is heated externally to
produce the elevated temperature environment that causes the organic solids (waste input) to breakdown via

Physical and chemical processes into three products;

1. solid char,
2. Pyrolysis oil and
3. Pyrolysis gas,

With the proportions of each being governed by the operating temperature within the Paralysis reactor.

There is a certain amount of misunderstanding concerning the differences between Pyrolysis and gasification with some people believing that they are the same. True Pyrolysis is a low temperature thermal conversion technology that operates with an air free environment and produces a primary liquid product as well as gas and solid phase products.

If Pyrolysis is operated at high temperature (>800oC) then the primary product becomes syngas but the process will also produce liquid and solid phase products in lesser amounts. By increasing the operating temperature the thermodynamics governing the reactions taking places cause a greater production of Pyrolysis gas (syngas) at the expense of Pyrolysis oil. The quantity of char produced at low and high temperatures does not vary greatly.

For biomass processing the lower temperature pyrolysis processes have been used with the objective of maximising the production of pyrolysis oil, referred to as bio-oil, which was seen as a pre-cursor to the production of many other chemicals in a bio- refinery context. In a waste processing context the higher temperature pyrolysis processes have been developed in order to maximize the production of syngas, which is more easily converted to electricity. It is these processes that we will consider in this report and we will refer to them henceforth as gasification as the sole objective is to produce syngas like gasification.

SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – V – DISPOSAL METHODS – SCIA3004

PROPER DISPOSAL SYSTEM

Municipal capacities: With the increasing volume of waste generation, collection of wastes gets more attention than disposal. Furthermore, in India, only a few municipalities seem to have the required experience or capacity for controlled disposal. Some municipalities may have identified disposal sites but still only few may actively manage them. In some places, contracting out waste disposal is seen as a solution. But, municipalities arenot equipped to deal with the problems associated with it, such as issues of privatisation and monitoring of the contract.

Political commitment: SWM is more than a technical issue, as anysuccessful programme needs effective political and governmental support. This is rarely a priority of government authorities, unless there is a strong and active public interest as well as international interventions.

Finance and cost recovery: Development of a sanitary landfill site represents a major investment and it generally receives less priority over other resource demands. And, even when establishment costs are secured for a disposal site, recurrent costs to maintain it always pose problems.

Technical guidelines: Standards established for waste disposal in one country need not necessarily be appropriate for another, due to reasons such as climatic conditions, resources availability, institutional infrastructure, socio- cultural values, etc. In the absence of adequate data and/or the means of collecting/acquiring it, officials often struggle to plan a safe and economically viable disposal option.

Institutional role and responsibility: A disposal site may be located outside the boundary of a town and may serve more than one town. This necessitates the co-ordination of all authorities concerned, and the roles and responsibilities of different departments need to be clearly defined and accepted by all concerned.

Location: The accessibility of a disposal site, especially its distance from town, is an important factor in site selection, especially when staff and public do not have a strong incentive to use it, when compared to indiscriminate dumping. Site selection is perhaps the most difficultstage in the development of suitable disposal option.

DISPOSAL OPTIONS AND SELECTION CRITERIA

The most common disposal option practised currently in many countries is either uncontrolled dumping or dumping with moderate control. The environmental costs of uncontrolled dumping include breeding of disease causing vectors (e.g., flies, mosquitoes and rodents), pollution, odour and smoke.

Disposal options

Uncontrolled dumping or non-engineered disposal: As mentioned, this is the most common method being practised in many parts of the world, and India is no exception. In this method, wastes are dumped at a designated site without any environmental control. They tend to remain there for a long period of time, pose health risks and cause environmental degradation. Due to the adverse health and environmental impact associated with it, the non-engineered disposal is not considered a viable and safe option.

Sanitary landfill: Unlike the non-engineered disposal, sanitary landfill is a fully engineered disposal option in that the selected location or wasteland is carefully engineered in advance before it is pressed into service. Operators of sanitary landfills can minimise the effects of leachate (i.e., polluted water which flows from a landfill) and gas production through proper site selection, preparation and management. This particular option of waste disposal is suitable when the land is available at an affordable price, and adequate workforce and technical resources are available to operate and manage the site.

Composting: This is a biological process of decomposition in which organisms, under controlled conditions of ventilation, temperature and moisture, convert the organic portion of solid waste into humus -like material. If this process is carried out effectively, what we get as the final product is a stable, odour-free soil conditioner. Generally, the option of composting is considered, when a considerable amount of biodegradable waste

Incineration: This refers to the controlled burning of wastes, at a high temperature (roughly 1200 – 1500 C), which sterilises and stabilisesthe waste in addition to reducing its volume. In the process, most of the combustible m aterials (i.e., self-sustaining combustible matter, which saves the energy needed to maintain the combustion) such as paper or plastics get converted into carbon dioxide and ash. Incineration may be used as a disposal option, when land filling is not possible and the waste composition is highly combustible. An appropriate technology, infrastructure and skilled workforce are required to operate and maintain the plant.

Gasification:

Gasification is a process that converts biomass- or fossil fuel-based carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the material at high temperatures (>700 °C), without combustion, with a controlled amount of oxygen and/or steam. The resulting gas mixture is called syngas (from synthesis gas) or producer gas and is itself a fuel. The power derived from gasification and combustion of the resultant gas is considered to be a source of renewable energy if the gasified compounds were obtained from biomass

The advantage of gasification is that using the syngas (synthesis gas H_2/CO) is potentially more efficient than direct combustion of the original fuel because it can be combusted at higher temperatures or even in fuel cells, so that the thermodynamic upper limit to the efficiency defined by Carnot's rule is higher (or in case of fuel cells not applicable). Syngas may be burned directly in gas engines, used to produce methanol and hydrogen, or converted via the Fischer–Tropsch process into synthetic fuel. For some materials gasification can be an alternative to landfillingand incineration. Some gasification processes aims at refining out corrosive ash elements such as chloride and potassium, allowing clean gas production from otherwise problematic fuels. Gasification of fossil fuels is currently widely used on industrial scales to generate electricity. Gasification can generate lower amounts of some pollutants as SOx and NOx than combustion

Refuse-derived fuel (RDF): This is the combustible part of raw waste, separated for burning as fuel. Various physical processes such as screening, size reduction, magnetic separation, etc., are used to separate the combustibles.

Pyrolysis: This is the thermal degradation of carbonaceous material to gaseous, liquid and solid fraction in the absence of oxygen. This occurs at a temperature between 200 and 900 C.

Selection criteria

With the help of proper frameworks and sub-frameworks, we can assess the effectiveness of each of the waste disposal options. While a framework represents an aid to decision-making and helps to ensure the key issues are considered, a sub-framework explains how and why the necessary information should be obtained (Ali, et al 1999). A framework contains a list of issues and questions pertaining to the technical, institutional, financial, social and environmental features of a waste disposal system to assess the capacity of a disposal option to meet the requirements. For example, an appraisal of waste disposal option must include the following:

(i) **Technical:** This feature, involving ef fi c i en t and effective operation of the technology being used, evaluates the following components of a SWM system:

- Composition of wastes, e.g., type, characteristics and quantity. Existing practices, e.g., collection, transport, and recycling process.
- Siting, e.g., location of disposal site, engineering material, etc.
- Technology, e.g., operation, maintenance, technical support, etc.
- Impact, e.g., anticipated by-product, requirement for their reatment and disposal, etc.

•

(ii) **Institutional:** This involves the ability and willingness of responsible agencies to operate and manage the system by evaluating the following:

structures, roles and responsibilities, e.g., current institutional frameworks. operational capacity, e.g., municipal capacities, local experience and staff training. incentives, e.g., management improvement and waste disposal practices.

innovation and partnership.

(iii) **Financial:** This assesses the ability to finance the implementation, operation and maintenance of the system by evaluating the following:

financing and cost recovery, e.g., willingness to raise finance for waste management. current revenue and expenditure on waste management. potential need for external finance for capital cost.

Social: This helps in avoiding adverse social impact by evaluating the Following: health and income implication. public opinions on the existing and proposed system.

SANITARY LANDFILL

The term landfill generally refers to an engineered deposit of wastes either in pits/trenches or on the surface. And, a sanitary landfill is essentially a landfill, where proper mechanisms are available to control the environmental risks associated with the disposal of wastes and to make available the land, subsequent to disposal, for other purposes. However, you must note that a landfill need not necessarily be an engineered site, when the waste is largely inert at final disposal, as in rural areas, where wastes contain a large proportion of soil and dirt. This practice is generally designated as non-engineered disposal method. When compared to uncontrolled dumping, engineered landfills are more likely to have pre-planned installations, environmental monitoring, and organised and trained workforce. Sanitary landfill implementation, therefore, requires careful site selection, preparation and management.

The four minimum requirements you need to consider for a sanitary landfill are:

(i) full or partial hydrological isolation;

(ii) formal engineering preparation;

(iii) permanent control;

(iii) planned waste emplacement and covering.

Principle

The purpose of land filling is to bury or alter the chemical compos ition of the wastes so that they do not pose any threat to the environment or public health. Landfillsare not homogeneous and are usually made up of cells in which a discrete volume of waste is kept isolated from adjacent waste cells by a suitable barrier. The barriers between cells generally consist of a layer of natural soil (i.e., clay), which restricts downward or lateral escape of the waste constituents or leachate.Land filling relies on containment rather than treatment (for control) of wastes. If

properly executed, it is a safer and cheaper method than incineration. An environmentally sound sanitary landfill comprises appropriate liners for protection of the groundwater (from contaminated leachate), run-off controls, leachate collection andtreatment, monitoring wells and appropriate final cover design (Phelps, 1995). Figure below gives a schematic layout of sanitary landfill along with its various components:

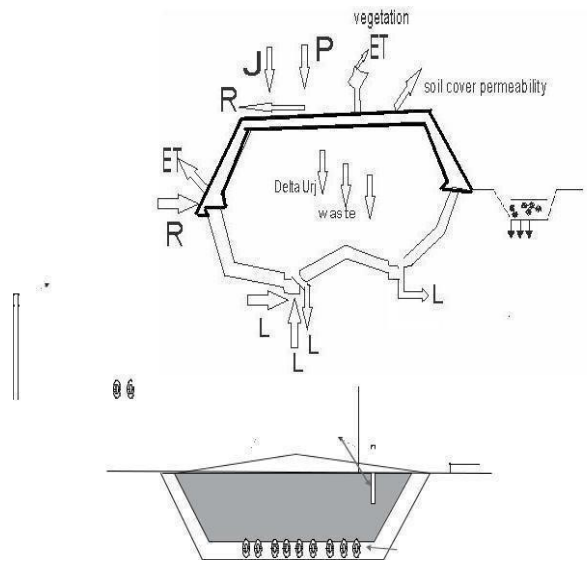

Fig 5.1

Landfill processes

(i) **Site selection process and considerations:** This requires the development of a working plan – a plan, or a series of plans, outlining the development and descriptions of site location, operation, engineering and site restoration. Considerations for site include public opinion, traffic patterns and congestion, climate, zoning requirements, availability of cover material and liner as well, high trees or buffer in the site perimeter, historic buildings, and endangered species, wetlands, and site land environmental factors, speed limits, underpass limitations, load limits on roadways, bridge capacities, and proximity of major roadways, haul distance, hydrology and detours.

(ii) **Settling** process**:** The waste body of a landfill undergoes different stages of settling or deformation.

Settling Processes in Landfill

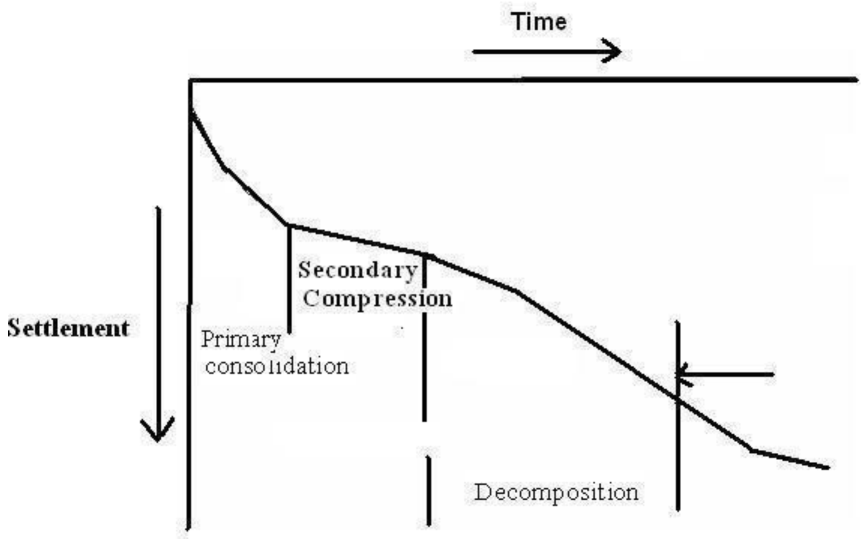

Fig. 5.2

The three stages shown in the figure above are described below:

Primar y consolidation: During this stage, a substantial amount of settling occurs. This settlement is caused by the weight of the waste layers. The movement of trucks, bulldozers or mechanical compactors will also enhance this process. After this primary consolidation, or short-term deformation stage, *aerobic degradation* processes occur.

Secondary compression: During this stage, the rate of settling is much lower than that in the primary consolidation stage, as the settling occurs through compression,which cannot be enhanced.

Decomposition:

During the degradation processes, organic material is converted into gas and leachate. The settling rate during this stage increases compared to the secondary compression stage, and continues until all decomposable organic matter is degraded. The settling rate, however, gradually decreases with the passage of time. To appropriately design protective liners,and gas and leachate collection systems, it is, therefore, necessary to have a proper knowledge of the settling process of wastes.

Microbial degradation process: The microbialdegradation process is the most important biological process occurring in a landfill. These processes induce changes in the chemical and physical environment within the waste body, which determine the quality of leachate and both the quality and quantity of landfill gas (see Subsection 4.3.2). Assuming that landfills mostly receive organic wastes, microbial processes will dominate the stabilisation of the waste and therefore govern landfill gas generation and leachate composition. Soon after disposal, the predominant part of the wastes becomes *anaerobic*, and the bacteria will start degrading the solid organic carbon, eventually to produce carbon dioxide and methane. The *anaerobic degradation* process undergoes the following stages:

- Solid and complex dissolved organic compounds are hydrolysed and fermented by the fermenters primarily to volatile fatty acids, alcohols, hydrogen and carbon dioxide. An acidogenic group of bacteria converts the products of the first stage to acetic acid, hydrogen and carbon dioxide. Methanogenic bacteria convert acetic acid to methane and carbon dioxide and hydrogenophilic bacteria convert hydrogen and carbon dioxide to methane. The biotic factors that affect methane formation in the landfill are pH, alkalinity, nutrients, temperature, oxygen and moisture content.

LANDFILL GAS AND LEACHATE

Leachate and landfill gas comprise the major hazards associated with a landfill. While leachate may contaminate the surrounding land and water, landfill gas can be toxic and lead to global warming and explosion leading to human catastrophe (Phelps, 1995). (Note that global warming, also known as greenhouse effect, refers to the warming of the earth's atmosphere by the accumulation of gases (e.g., methane, carbon dioxide and chlorofluorocarbons) that absorbs reflected solar radiation. Nature of waste: The deposition of waste containing biodegradable matter invariably leads to the production of gas and leachate, and the amount depends on the content of biodegradable material in the waste.

- **Moisture content:** Most micro-organisms require a minimum of approximately 12% (by weight) moisture for growth, and thus the moisture content of landfill waste is an important factor in determining the amount and extent of leachate and gas production.
- **pH:** The methanogenic bacteria within a landfill produce methane gas, which will grow only at low pH range around neutrality.
- **Particle size and density:** The size of waste particle affects the density that can be achieved upon compaction and affects the surface area and hence volume. Both affect moisture absorption and therefore are potential for biological degradation.
- **Temperature:** An increase in temperature tends to increase gas production. The temperature affects the microbial activity to the extent that it is possible to segregate bacteria, according to their optimum temperature operating conditions.

LANDFILL GAS EMISSION

Landfill gas contains a high percentage of methane due to the anaerobic decomposition of organic matter, which can be utilised as a source of energy. In Subsections 4.4.1 to 4.4.4, we will explain the composition and properties, risks, migration and control of landfill gas.

Composition and properties

Climatic and environmental conditions also influence gas composition. Due to the heterogeneous nature of the landfill, some acid-phase anaerobic decomposition occurs along with the methanogenic decomposition. Since aerobic and acid-phase degradation give rise

to carbon dioxide and not methane, there may be a higher carbon dioxide content in the gas generated than what would otherwise be expected. Furthermore, depending on the moisture distribution, some carbon dioxide goes into solution.This may appear to increase (artificially) the methane content of the gas measured in the landfill. A typical landfill gas contains a number of components such as the following, which tend to occur within a characteristic range:

Methane: This is a colourless, odourless and flammable gas with a density lighter than air, typically making up 50 – 60% of the landfill gas.

Carbon dioxide: This is a colourless, odourless and non-inflammable gas that is denser than air, typically accounting for 30 – 40%.

Oxygen: The flammability of methane depends on the percentage of oxygen. It is, therefore, important to control oxygen levels, where gas abstraction is undertaken.

Nitrogen: This is essentially inert and will have little effect, except to modify t**o** explosive range of methane.

Hazards

Landfill gas consists of a mixture of flammable, asphyxiating and noxious gases and may be hazardous to health and safety, and hence the need for precautions. Some of the major hazards are listed below

Explosion and fire: Methane is flammable in air within the range of 5 – 15% by volume, while hydrogen is flammable within the range of 4.1 – 7.5% (in the presence of oxygen) and potentiallyexplosive. Fire, occurring within the waste, can be difficult to extinguish and can lead to unpredictable and uncontrolled subsidence as well as production of smoke and toxic fumes.

Trace components: These comprise mostly alkanes and alkenes, and their oxidation products such as aldehydes, alcohols and esters . Many of them are recognised as toxicants, when present in air atconcentrations above occupational exposure standards.

Global warming: Known also as greenhouse effect, it is the warming of the earth's atmosphere by the accumulation of gases (methane, carbon dioxide and chlorofluorocarbons) that absorbs reflected solar radiation.

Migration

During landfill development, most of the gas produced is vented to the tmosphere, provided the permeable intermediate cover has been used. While biological and hemical processes affect gas composition through methane oxidation, which converts methane to carbon dioxide, physical factors affect gas migration. The physical factors that affect gas migration include:

Environmental **conditions:** These affect the rate of degradation and gas pressure build up.

Geophysical conditions: These affect migration pathways. In the presence of fractured geological strata or a mineshaft, the gas may travel large distances, unless restricted by the water table.

Climatic conditions: Falling atmospheric pressure, rainfall and water infiltration rate affect landfill gas migration.

The proportion of void space in the ground, rather than permeability, determines the variability of gas emission. If the escape of landfill gas is controlled and proper extraction system is designed, this gas can be utilised as a source of energy. If landfill gas is not utilised, it should be burnt by means of flaring. However, landfill gas utilisation can save on the use of fossil fuels since its heating value is approximately 63 kWh/m and can be utilized in internal combustion engines for production of electricity and heat.

It is important that landfill gas is extracted during the operation phase. It is extracted out of the landfill by means of gas wells, which are normally drilled by auger and are driven into the landfill at a spacing of 40 – 70 m. In addition, horizontal systems can be installed during operation of the landfill. The gas wells consist mainly of perforated plastic pipes surrounded by coarse gravel and are connected with the gas transportation pipe with flexible tubing.

The vacuum necessary for gas extraction and transportation is created by means of a blower. The most important factors influencing planning and construction of landfill gas extraction systems are settling of waste, water tables in landfills and gas quality.

LEACHATE FORMATION

Leachate can pollute both groundwater and surface water supplies. The degree of pollution will depend on local geology and hydrogeology, nature of waste and the proximity of susceptible receptors. Once groundwater is contaminated, it is very costly to clean it up. Landfills, therefore, undergo siting, design and construction procedures that control leachate migration.

Composition and properties

Leachate comprises soluble components of waste and its degradation products enter water, as it percolates through the landfill. The amount of leachate generated depends on:

water
availability;
landfill
surface
condition;
refuse state;
condition of surrounding strata.

The major factor, i.e., water a v a i l a b i l i t y , is affected by precipitation, surface

The best way to control leachate is through prevention, which should be integral to the site design. In most cases, it is necessary to control liquid access, collection and treatment, all of which can be done using the following landfill liners:

Natural liners: These refer to compacted clay or shale, bitumen or soil sealants, etc., and are generally less permeable, resistant to chemical attack and have good sorption properties. They generally do not act as true containment barriers, because sometimes leachate migrates through them.

Synthetic (geo-membrane) liners: These are typically made up of high or medium density polyethylene and are generally less permeable, easy to install, relatively strong and have good deformation characteristics. They sometimes expand or shrink according to temperature and age.

Treatment

Concentrations of various s u b s t a n c e s occurring in leachate are too high to be discharged to surface water or into a sewer system. These concentrations, therefore, have to be reduced by removal, treatment or both. The various treatments of leachate include:

Leachate recirculation: It is one of the simplest forms of treatment. Recirculation of leachate reduces the hazardous nature of leachate and helps wet the waste, increasing its potential for biological degradation. by biological means, due to high content of volatile fatty acids (VFAs). The common methods are aerated lagoons (i.e., special devices which enhance the aerobic process es of degradation of organicsubstances over the entire depth of the tank) and activated sludge process, which differs from aerated lagoons in that discharged sludge is recirculated and is often used for BOD and ammonia removal. While under conditions of low COD, rotating biological contactors (i.e., biomass is brought into contact with circular blades fixed to a common axle which is rotated) are very effective in removing ammonia. In an anaerobic treatment system, complex organic molecules are fermented in filter. The common types

Biological treatment: This removes BOD, ammonia and suspended solids. Leachate from land filled waste can be readily degraded e anaerobic filters, anaerobic lagoon and digesters.

Physicochemical treatment: After biological degradation, effluents still contain significant concentrations of different substances. Physicochemical treatment processes could be installed to improve the leachate effluent quality. Some of these processes are flocculation-precipitation. (Note that addition of chemicals to the water attracts the metal by floc formation). Separation of the floc from water takes place by sedimentation, adsorption and reverse osmosis.

ENVIRONMENTAL EFFECTS OF LANDFILL

The environmental effects of a landfill include wind-blown litter and dust, noise, obnoxious odour, vermin and insects attracted by the waste, surface runoff and inaesthetic conditions.

Wind-blown litter and dust are continuous problems of the ongoing landfill operation and a nuisance to the neighbourhood. Covering the waste cells with soil and spraying water on dirt roads and waste in dry periods, in combination with fencing and movable screens, may minimise the problem of wind-blown litter and dust. However, note that the problem will remain at the tipping front of the landfill.

Movement of waste collection vehicles, emptying of wastes from them, compactors, earthmoving equipment, etc., produce noise. Improving the technical capability of the equipment, surrounding the fill area with soil embankments and plantations, limiting the working hours and appropriately training the workforce will help minimise noise pollution.

Birds (e.g., scavengers), vermin, insects and animals are attracted to the landfill for feeding and breeding. Since many of these may act as disease vectors, their presence is a potential health problem.

Surface run-off, which has been in contact with the land filled waste, may be a problem in areas of intense rainfall. If not controlled, heavily polluted run-off may enter directly into creeks and streams.

An operating landfill, where equipment and waste are exposed, appearsinaesthetic

Earthworks: Various features of landfill operations may require substantial earthworks, and therefore, the working plan must include earthworks to be carried out before wastes can be deposited. Details about earthworks gain significance, if artificial liners are to be installed, which involves grading the base and sides of the site (including construction of 25 slopes to drain leachate to the collection areas) and the formation of embankments. Material may also have to be placed in stockpiles for later use at the site. The cell method of operation requires the construction of cell walls. At some sites, it may be necessary to construct earth banks around the site perimeter to screen the landfill operations from the public. Trees or shrubs may then be planted on the banks to enhance the screening effect. The construction of roads leading to disposal sites also involves earthworks.

Lining landfill sites: Where the use of a liner is envisaged, the suitability of a site for lining should be evaluated at the site investigation stage. However, they should not be installed, unt il the site has been properly prepared. The area to be lined should be free of objects likely to cause physical damage to the liner, such as vegetation and hard rocks. If synthetic liner materials are used, a binding layer of suitable fine-grained material should be laid to support the liner. However, if the supporting layer consists of low permeable material (e.g., clay), the synthetic liner must be placed on top of this layer.

Leachate and landfill gas management: The basic elements of the leachate collection system (i.e., drain pipes, drainage layers, collection pipes, sumps, etc.) must be installed immediately above the liner, before any waste is deposited. Particular care must also be taken to prevent the drain and collection pipes from settling. During landfill operations, waste cells are covered with soil to avoid additional contact between waste and the environment. The soil layers have to be sufficiently permeable to allow downward leachate transport. Landfill gas is not extracted before completion, which includes construction of final cover, of the waste body. Extraction wells (diameter 0.3 to 1.0 m) may be constructed during or after operation.

Landfill capping**:** Capping is required to control and minimise leachate generation (by minimising water ingress into the landfill) and facilitate landfill gas control or collection (by installing a low permeability cap over the whole site). A cap may consist of natural (e.g.,

clay) or synthetic (e.g., poly-ethylene) material with thickness of at least 1 m. An uneven settlement of the waste may be a major cause of cap failure. Designs for capping should, therefore, include consideration of leachate and landfill gas collection wells or vents. For the cap to remain effective, it must be protected from agricultural machinery, drying and cracking, plant root penetration, burrowing animals and erosion.