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POLLACHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE and Affiliated to Anna University)

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Department of Civil Engineering

Regulation 2021
III Year – VI Semester
CE3033 Solid and Hazardous Waste Management

UNIT-1:

MUNICIPALSOLIDWASTE:

All types of solid wastes generated by households and commercial establishments,except medicaland hazardouswasteandcollected usuallybylocal government bodies are termed as **Municipal Solid Waste** (MSW).

Solid waste refers to non-soluble material such as agricultural refuse, industrial waste, mining residues, demolition waste, municipal garbage or even sewage sludge. Most of these wastes cannot be recycled or rehabilitatedfor further use.

(or)

Thewastesgeneratedfrom human andanimal activitiesthatarenormally solid and are discarded as useless or unwanted are called as solid waste.

SOLIDWASTEMANAGEMENT

Solid waste management (SWM) is associated with the control of waste generation, itsstorage, collection, transfer and transport, processing and disposal inamannerthatisinaccordancewiththebestprinciplesofpublic health, economics, engineering, conservation, aesthetics, public attitude and other environmental considerations.

CLASSIFICATIONOFSOLIDWASTES

Solid wastes are the organic and inorganic waste materials such as product packaging, grass clippings, furniture, clothing, bottles, kitchen refuse, paper, appliances, paint cans, batteries, etc., produced in a society, which donot generally carry any value to the first user. Solid wastes, thus, encompass both a heterogeneous mass of wastes from the urban community as well as a more homogeneous accumulation of agricultural, industrial and mineral wastes.

1. Source-basedclassification

Classificationbasedonplace/locationofwastesbeinggenerated.

(i) **Residential**: This refers to wastes from dwellings, apartments, etc., and consists of leftover food, vegetable peels, plastic, clothes, ashes, etc.

(ii) **Commercial**:Thisreferstowastesconsistingofleftoverfood, glasses, metals, ashes, etc., generated from stores, restaurants, markets, hotels, motels, auto-repair shops, medical facilities, etc.

(iii) **Institutional**: This mainly consists of paper, plastic, glasses, etc., generated from educational, administrative and public buildings such as schools, colleges, offices, prisons, etc.

(iv) **Municipal**: This includes dust, leafy matter, building debris, treatment plant residualsludge, etc., generated from various municipalactivities like construction and demolition, street cleaning, landscaping, etc.

(v) **Industrial**: This mainly consists of process wastes, ashes, demolition and construction wastes, hazardous wastes, etc., due to industrial activities.

(vi) **Agricultural**: This mainly consists of spoiled food grains and vegetables, agriculturalremains, litter, etc., generated from fields, orchards, vineyards, farms, etc.

(vii) **Open areas**: this includes wastes from areas such as Streets, alleys, parks, vacant lots, playgrounds, beaches, highways, recreational areas, etc.

2. Type-basedclassification

Classificationofwastesbasedoncomposition/natureofwastes

(i)**Garbage**:

- ✓ Itreferstoanimalandvegetablewastesresultingfromthehandling, sale, storage, preparation, cooking and serving of food.
- ✓ Suchwastescontainputrescible(rotting)organic matter,whichproducesan obnoxious odour and attracts rats and other vermin.
- ✓ It,therefore,requiresspecialattentioninstorage,handlinganddisposal.

(ii) **Ashesandresidues**:

- ✓ It refers to waste remaining fromthe burning ofwood, coal, charcoal, coke and other combustible materials.
- ✓ Ashesconsistoffinepowderyresidue,cindersand clinkeroftenmixedwith small pieces of metal and glass.

- ✓ Since ashes and residues are almost entirely inorganic, theyare valuable in landfills.

(iii) **Combustibleandnon-combustiblewastes**:

- ✓ Includes wastes generated from households, institutions, commercial activities, etc.,excluding food wastes and other highlyputrescible material.
- ✓ combustiblematerial consistsofpaper,cardboard,textile,rubber,garden trimmings, etc.,
- ✓ Non-combustible material consists ofsuch items as glass, crockery, tin and aluminium cans, ferrous and non-ferrous material and dirt.

(iv) **Bulkywastes**:

- ✓ It includeslargehousehold appliancessuch as refrigerators,washing machines,furniture,crates,vehicleparts,tyres,wood,treesandbranches.
- ✓ Itcannotbeaccommodatedinnormalstoragecontainers,theyrequirea special collection mechanism.

(v) **Streetwastes**:

- ✓ It refer to wastes that are collected fromstreets, walkways, alleys, parks and vacant plots, and include paper, cardboard, plastics, dirt, leaves and other vegetable matter.

(vi) **Biodegradableandnon-biodegradablewastes**:

- ✓ Biodegradable wastes mainly refer to substances consisting of organic matter such as leftover food, vegetable and fruit peels, paper, textile, wood, etc., due to the action of micro-organisms, these wastes are degraded from complex to simpler compounds.
- ✓ Non-biodegradable wastes consist of inorganic and recyclable materials such as plastic, glass, cans, metals, etc.

(vii) **Deadanimals**:

- ✓ Dead animals are those that die naturally or are accidentally killed on the road.
- ✓ Dead animals are divided into two groups - large and small. Among the largeanimalsare horses,cows,goats,sheep,pigs,etc.,andamongthesmall ones are dogs, cats, rabbits, rats, etc.
- ✓ The reason for this differentiation is that large animals require special equipment for lifting and handling when they are removed.
- ✓ If not collected promptly, dead animals pose a threat to public health since they attract flies and other vermin as they decay.

(viii) **Abandonedvehicles**:

- ✓ It includes automobiles, trucks and trailers that are abandoned on streets and other public places.
- ✓ It has significant scrap value for their metal, and their value to collectorsis highly variable.

(ix) **Constructionanddemolitionwastes**:

- ✓ It refers to waste generated as a result of construction,refurbishment, repairanddemolitionofhouses,commercialbuildings andotherstructures.
- ✓ They consist mainly of earth, stones, concrete, bricks, lumber, roofing and plumbing materials, heating systems and electrical wires and parts of the general municipal waste stream.

(x) **FarmWastes**:

- ✓ Wastes result from diverse agricultural activities such as planting, harvesting, production of milk, rearing of animals for slaughter and the operation of feedlots.

(xi) **Hazardouswastes**:

- ✓ Hazardous wastes are those defined as wastes from industrial, institutional or consumer origin that are potentially dangerous either immediately or over a period of time to human beings and the environment.

- ✓ This is due to their physical, chemical and biological or radioactive characteristics like ignitability, corrosivity, reactivity and toxicity.
- ✓ Typical examples of hazardous wastes are empty containers of solvents, paints and pesticides, which are frequently mixed with municipal wastes and become part of the urban waste stream.

(xii) **Sewagewastes**:

- ✓ Thesolidby-productsofsewagetreatmentareclassifiedassewagewastes.
- ✓ They are mostly organic and derived from the treatment of organic sludge separated from both raw and treated sewages.
- ✓ Inorganicsewagesaregritandeggshell.

EFFECTSOFIMPROPERDISPOSAL OFSOLID WASTE

1.4 EFFECTS OF IMPROPER DISPOSAL OF SOLID WASTES – PUBLIC HEALTH EFFECTS

- ✓ Improper handling of solid wastes leads to potential risk to environment and public health. Direct health risks concern mainly the workers, due to contact with wastes.
- ✓ The main risk to public health is indirect and arises from the breeding of vectors, primarily flies & rats. It also affects aesthetic & beauty of the city.
- ✓ Uncontrolled hazardous wastes from industries mixing up with municipal wastes cause heavy metal mixing and create potential health risks to human being.

1.4.2 Public Health Effects

i) **Disease vectors & pathways:**

- ✓ waste dump provides food to vermin & agents of various diseases.
- ✓ Pathogens transmit via insects, flies, mosquitoes, roaches and animals like pigs, rodents, etc.

ii) **Flies:**

- ✓ Mostly housefly, transmits Typhoid, GI and dysentery. They have flight range of 10km, and spread to wide area.
- ✓ 4 stages in their life cycle are

Stage I : egg- deposited on worm & moist condition.

Stage II : larva- feed on organic matters.

Stage III : pupa- inactive for 4-10 days.

Stage IV : adult.

- ✓ To avoid flies, frequency of waste collection is adequate.
- ✓ Also the containers used for storage is to restrict access to flies.
- ✓ Covering solid wastes with a layer of earth at landfill sites at the end of every day, arrests the problem of fly breeding at the final stage.

iii) Mosquitoes:

- ✓ Transmit malaria, filarial & dengue fevers.
- ✓ Since they breed in stagnant water, control measures should taken on elimination of breeding places such as tins, tires , cans, etc.

iv) Roaches:

- ✓ cause infection by physical contact and transmit Typhoid, Cholera and Amoebiasis.

v) Rodents (rats):

- ✓ Spread plague, leptospirosis, rat bite fever.

vi) Occupational hazards:

- ✓ Workers handling wastes face risk of accidents, due to lack of safety like injuries.
- ✓ So they must wear gloves, masks & be vaccinated.

The diseases include:

- ✓ Skin & blood infections due to glass , metals
- ✓ Eye and respiratory infections resulting from exposure to infected dust.
- ✓ Disease that results from bites of animals feeding on the wastes.

- ✓ Intestinal infection by microbes on wastes.
- ✓ Chronic respiratory disease, including cancer resulting from exposure to dust & hazardous compounds.
- ✓ Bone & muscle disorder resulting from the handling of heavy containers & loading of vehicles
- ✓ Reduced visibility , due to dust and thus leads to accidents
- ✓ Poisoning and chemical burns due to contact with small amounts of chemical wastes like pesticides, cleansing solution /solvents.
- ✓ Burns due to methane gas from landfills
- ✓ Serious health hazards, particularly for children, due to careless dumping of lead acid batteries, cadmium- nickel & mercuric oxide batteries.

vii) **Animals:**

Dogs, cats, cows, goats, also act as carriers of disease.

1.4.3 Enviromental Effects

i) Air Pollution:

- ✓ Burning of solid wastes in open dumps (or) in improperly designed incinerators emit pollutants to atmosphere.
- ✓ Emission includes particulate matters, SO_2, NO_2, HCl, CO & CO_2, Hg, etc.
- ✓ Discharge of Arsenic, Cadmium and Selenium is to be controlled, since they are toxic at relatively low levels.
  - Polychlorinated dibenzofurans (PCDFs) commonly called Dioxins & Furans, are concern because of their toxicity, carcinogenicity & possible mutagenicity.

ii) Water and Land Pollution:

- ✓ results from dumping in open areas and storms water drains, improper design & construction of landfills.
- ✓ Control of infiltration rate from rainfall and surface runoff is essential to minimize lechate.
- ✓ Due to flow of ground water via SW at Landfill , percolation of rainwater cause ground water contaminations
- ✓ CO_2 produced keeps P^H low and dissolve minerals in aquifers & affects ground water quality. Also depending on permeability & porosity of aquifers, it may spread to distant places.

iii) Visual Pollution:

- ✓ Aesthetic view is affected by piles of wastes on road side.

iv) Noise Pollution:

- ✓ Nosie Pollution due to operations at sorting, incineration, transferring, landfills due to operation of large machines, vehicles movements, etc.

v) Odour Pollution:

- ✓ Obnoxious odor due to the presence of decaying organic matter of open dumps

vi) Explosion Hazards:

- ✓ Landfill gas released by anaerobic decomposition contains Methane (CH_4) (35-70%) prevented by venting, flaring by use of barriers.

SAMPLINGANDCHARACTERIZATIONOFWASTES

Itisalaboratorytestingofwastestostudy thecharacteristics,sincesolid waste is heterogeneous in nature.

Collectionofsamplesofsolidwaste:

- ✓ Majorcollectionsitesareidentified.
- ✓ Samplingpointsaredistributedoverthestudyarea.
- ✓ 10kgofwasteiscollectedandmixedthoroughly.
- ✓ Wasteisreducedbythe methodofquartering.
- ✓ Sampleissubjectedtophysicalandchemicalanalysis.

Characterization/CompositionofMSW:

- ✓ ThecompositionandcharacteristicsofMSWvarythroughouttheworld; even in the same country it changes from place to place.
- ✓ MSW is heterogenous in nature and consists ofa number ofdifferent materials derived from various types of activities.
- ✓ Wastecompositionvarieswithsocio-economicstatuswithinaparticular community.
- ✓ Theproportionofpaperwasteincreaseswithincreasingnationalincome.
- ✓ The proportionofputrescible organic matter (food) is greater incountries of low income than those of high income.
- ✓ variation in waste composition ismore dependent on national income than geographic location.
- ✓ Wastedensityandmoisturecontentishighinlowincomecountries.

Physicalcharacteristics

- ✓ Density
- ✓ Moisturecontent
- ✓ Size
- ✓ CalorificValue

Chemicalcharacteristics

- ✓ Chemicals
- ✓ Biochemical
- ✓ Toxic

Physicalcharacteristics

Density:

- Density of waste is its **mass per unit volume (kg/m^3),** is a critical factor in the design of a solid waste management system, e.g., the design of sanitary landfills, storage, types of collection and transport vehicles, etc.
- Maximumlimitofdensityis600kg/m3.

Moisturecontent:

- Moisture content is defined as the ratio of the weight of water (wet weight - dry weight) to the total wet weight ofthe waste. Moisture increases the weight ofsolid wastes, and thereby, the cost ofcollection and transport.
- Atypicalrangeofmoisturecontentis20to 40%.

SizeofWasteconstituents:

- significance in the design of mechanical separators and shredder and waste treatment process.

CalorificValue:

- Calorific value is the amount of heat generated from combustion of a unit weight of a substance, expressed as kcal/kg.

Chemicalcharacteristics

Chemical:

Chemical characteristicsincludepH,Nitrogen,PhosphorusandPotassium (N-P-K), total Carbon, C/N ratio, calorific value.

Bio-Chemical:

Bio-Chemical characteristicsinclude carbohydrates, proteins,natural fibre, and biodegradable factor.

Toxic:

Toxicity characteristics include heavy metals, pesticides, insecticides, Toxicity test for Leachates (TCLP), etc.

Lipids

- Thisclassofcompoundsincludesfats,oilsandgrease.
- Majorsourceoflipidsaregarbage,cookingoilsandfats.
- Lipidshavehighcalorificvalues,about38000kcal/kg.
- Therateofbiodegradationisrelativelyslow.

Carbohydrates

- Carbohydrates are found primarily in food and yard waste. They includesugarsandpolymersofsugarssuchasstarchandcellulose.
- Decomposingcarbohydratesareparticularlyattractiveforfliesand rats.
- Partialdecompositionofthesecompoundscanresult intheproduction of amines that have unpleasant odours.

Proteins

- Proteins are compounds containing carbon, hydrogen, oxygen and nitrogenand consist ofanorganic acid witha substituted amine group (NH_2).
- They arefoundmainlyinfoodandgardenwastesandcomprise5- 10% of the dry solids in solid waste.

Naturalfibres

- This class includes the natural compounds, cellulose and lignin, both of which are resistant to biodegradation.
- Theyarefoundinpaperandpaperproductsandinfoodandyard waste.
- Calorificvalueranges12000-18000KJ/kg

Syntheticorganicmaterial(Plastics)

- They are highly resistant to biodegradation and, therefore, are objectionableandofspecialconcerninsolidwastemanagement.

- Theincreasingattentionbeingpaidtotherecyclingofplasticsto reduce the proportion of this waste component at disposal sites.

Non-combustibles

- This class includes glass, ceramics, metals, dust and ashes, and accounts for 12 – 25% of dry solids.

ELEMENTSOFSOLIDWASTEMANAGEMENT

1. Wastegeneration:

Wastes are generatedat the start of any process, and thereafter, at every stage as raw materials are converted into goods for consumption. For example, wastes are generated from households, commercial areas, industries, institutions, street cleaning and other municipal services.

2. Wastestorage:

Storage is a key functional element because collection of wastes never takes place at the source or at the time of their generation. Onsite storage is of primary importance due to aesthetic consideration, public health and economics involved.

3. Wastecollection:

This includes gathering of wastes and haulingthem to the location, where the collection vehicle is emptied, which may be a transfer station, a processing plant or a disposal site.

4. Transferandtransport:

The transfer of wastes from smaller collection vehicles, where necessary to overcome the problem of narrow access lanes, to larger ones attransfer stations.The subsequent transport of the wastes, usually over long distances, to disposal sites.

5. Processing:

Processing is required to alter the physical and chemical characteristics of wastes for energy and resource recovery and recycling. The important processing techniques include compaction, thermal volume reduction, manual separation of waste components, incineration and composting.

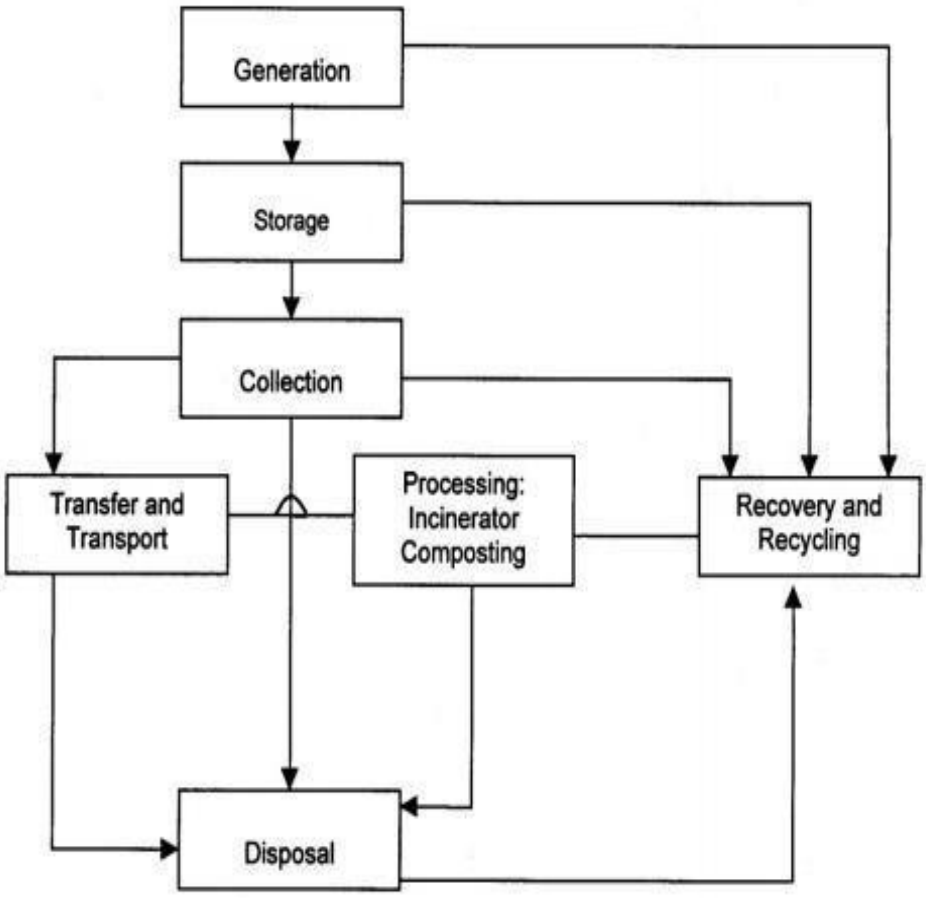
6. Recoveryandrecycling:

Recovery involves the separation ofvaluable resources from the mixed solid wastes, delivered at transfer stations or processing plants. It also involves size reduction and density separation by air classifier, magnetic device for iron and screens for glass.

7. Wastedisposal:

Disposal is the ultimate fate of all solid wastes, be they residential wastes, semi-solid wastes from municipal and industrial treatment plants, incinerator residues, composts or other substances that have no further use to the society.

Typical SWM System: Functional Elements



FACTORSAFFECTINGGENERATIONOFSOLIDWASTE:

Geographiclocation

The influence of geographic location is related primarily todifferent climates that can influence both the amount of certain types of solid waste generated and the collection operation

Seasons

Seasons of the year have implications for the quantities and composition of certain types of solid wastes. For eg. The growing season of fruits and vegetables may vary.

Collectionfrequency

In localities where there are ultimate collection services, more wastes are collected. It does not mean that more wastes are generated. But due to the frequency of collection waste generation rate gets vary in other areas.

Populationdiversity

The characteristics of the population influence the quantity and composition of waste generated.

Publicattitude

Significant reduction in the quantity ofsolid waste is possible ifonly people are willing to change their habits and lifestyles to conserve the natural resources.

Legislation

The existence of local and state regulations concerning the use and disposal of specific materials is an important factor that influence the composition and generation of wastes.

Extentofsalvagingandrecycling

The existence of salvaging and recycling affects the quantities of wastes collected.

PRINCIPLEOFMUNICIPALSOLIDWASTEMANAGEMENT

- ✓ MunicipalSolidWasteManagementinvolvestheprincipleofIntegrated Solid Waste Management (ISWM) to solid waste.
- ✓ ISWMistheapplicationofsuitabletechniquestoachievethetwin objectives,

    - Wastereduction
    - Effectivemanagementof waste still producedafterwaste reduction

Wastereduction:

Sustainable development can only be achieved if society and industry produces "more with less" i.e more goods and services with less use of world's resources (raw materials and energy) and less pollution and waste.

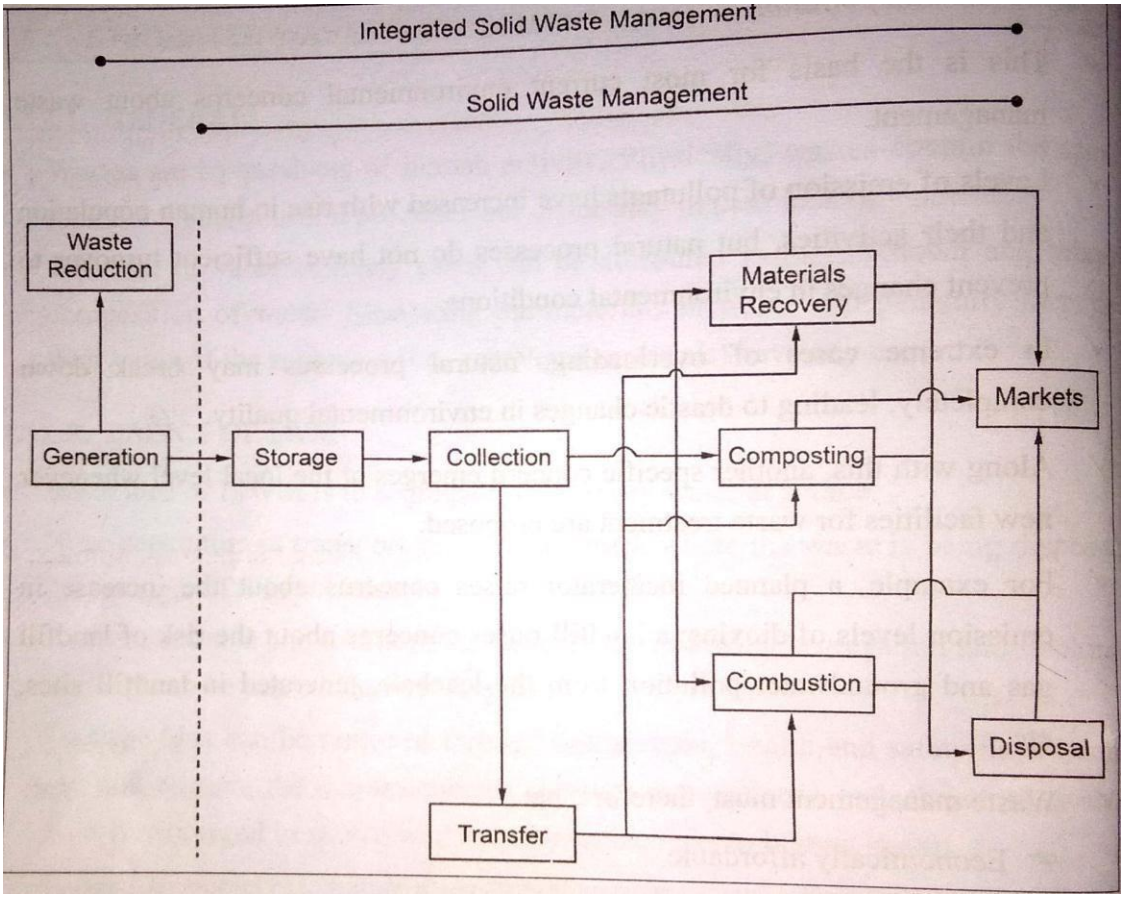
EffectivemanagementofSolidwaste:

Effective management of Solid waste is needed to ensure betterhuman health and safety. It should be,

- ✓ Economicallyaffordable
- ✓ Sociallyacceptable
- ✓ Environmentallyeffectiveandsafe

Effectivewastemanagementsystemincludesoneormoreofthefollowingoptions,

- ✓ Wastecollectionandtransportation.
- ✓ Resource recovery through sorting and recycling i.e recovery of materials through separation.
- ✓ Resource recovery through waste processing i.e recovery of energy through biological, thermal or other processes.
- ✓ Waste transformation i.e reduction of volume, toxicity or other physical/chemical properties of waste to make it suitable for final disposal.



CharacteristicsofISWM:

- ✓ AnIntegratedsystem
- ✓ Flexibility
- ✓ Marketoriented
- ✓ Sociallyacceptable

Requirements and salient features of Solid waste management rules(2016)

- ✓ Application
- ✓ Dutiesofwastegenerators
- ✓ DutiesofMinistryofUrbanDevelopment
- ✓ DutiesofDepartmentofFertilisers,MinistryofChemicalsand Fertilizers
- ✓ DutiesofMinistryofAgriculture,GovernmentofIndia.
- ✓ DutiesoftheMinistryofPower
- ✓ DutiesofMinistryofNewandRenewableEnergySources
- ✓ Duties of the Secretary-in-charge, Urban Development in the States and Union Territories and Duties of the Secretary-in-charge of Village Panchayats or Rural Development Department in the State and Union Territory.
- ✓ DutiesofCentralPollutionControlBoard
- ✓ Duties and Responsibilities of local authorities and village Panchayats of census towns and urban agglomerations.
- ✓ Duties of District Magistrate or District Collector or Deputy Commissioner
- ✓ Duties of State Pollution Control Board or Pollution Control Committee
- ✓ Duty ofmanufacturersor Brandownersof disposable products and sanitary napkins and diapers
- ✓ Duties ofthe industrialunitslocatedwithin onehundred kmfrom the RDF and Waste to Energy plants based on solid waste
- ✓ Criteria for setting up solid waste processing and treatment facility
- ✓ Criteriaandactionstobetakenforsolidwastemanagementin hilly areas

1. Application

The Rules shall apply to every urban local body and to every domestic, institutional, commercial and any other non residential solid wastegenerator **except industrial waste, hazardous waste, hazardous chemicals, bio-medical wastes, e-waste, lead acid batteries and radio-active waste.**

2. Dutiesofwastegenerators

- ✓ All waste generators shall segregate andstore the waste generated by them in three separate streams namely bio-degradable, non bio-degradable and domestic hazardous wastes in suitable bins.
- ✓ handoversegregatedwastestoauthorizedrag-pickersorwastecollectors
- ✓ Shall store separately construction and demolition waste, as and when generated and dispose off as per the Construction and Demolition Waste Management Rules,2016
- ✓ Shall store horticulture waste and garden waste generated from his premises separately and dispose of as per the directions of the local authority.
- ✓ Shall not throw**,** burn or burry the solid waste generated by him, on streets, open public spaces outside his premises or in the drain or water bodies.
- ✓ Shallpaysuchuserfeeforsolidwastemanagement,asspecifiedin thebye-lawsofthelocalbodies.
- ✓ Shall wrap securely the used sanitary waste like diapers, sanitary padsetc., in thepouches provided by the manufacturers or brand owners of these products

3. DutiesofMinistryofUrbanDevelopment

- ✓ formulate National Policy and Strategy on Solid Waste Management including policy on Waste to Energy.
- ✓ promoteresearchanddevelopment.
- ✓ undertaketrainingandcapacitybuildingoflocalbodies.
- ✓ providetechnicalguidelinesandprojectfinance.
- ✓ reviewperiodicallythemeasurestakenbytheStates.

4. DutiesofMinistryofAgriculture,GovernmentofIndia

- ✓ ToprovideflexibilityinFertiliserControlOrderformanufacturingand sale of compost.
- ✓ propagateutilisationofcompostonfarmland.
- ✓ set up laboratories to test quality of compost produced by local authorities or their authorized agencies.

5. DutiesofDepartmentofFertilisers,MinistryofChemicalsandFertilizers

- ✓ Toprovidemarketdevelopmentassistanceoncitycompost.
- ✓ Toensurepromotionofco-marketingofcompostwithchemical fertilizers in the ratio of3 to 4bags compost: 6 to 7 bags chemical fertilizer.

6. DutiesoftheMinistryofPower

- ✓ To decide and declare tariff or charges for the power generated from the Waste to Energy plants based on solid waste.
- ✓ TO ensure compulsory purchase power generated from such Wasteto Energy plants based on solid waste by power distribution companies.

7. DutiesofMinistryofNewandRenewableEnergySources

- ✓ TofacilitateinfrastructurecreationforWastetoEnergyplants.
- ✓ To provide appropriate subsidy or incentives for such Waste toEnergy plants

8. Duties of the Secretary-in -charge, Urban Development in the States and Union Territories and Duties of the Secretary -in- charge of Village Panchayats or Rural Development Department in the State and Union Territory.

- ✓ Shall prepare a state policy on solid waste management within ayear through the Director ofMunicipal Administrationand it is reckoned from1st July 2017.
- ✓ ensure identificationand allocation ofsuitable land for setting up processing and disposal facilities for solid wastes within one year.
- ✓ Thepolicytoemphasizeonwasteminimization,recycle,reuse,recoveryand utilization of solid waste.
- ✓ ensure that the developers of Special Economic Zone, Industrial Estate, Industrialparkearmarkatleast5%ofthetotalareaoftheplotor minimum5 plots/ sheds for recovery and recycling facility.
- ✓ notify buffer zone for the solid waste processing and disposal facilities of more than 5 tons per day in consultation with the State Pollution Control Board.

9. DutiesofCentralPollutionControlBoard

- ✓ The Central Pollution Control Board shall co-ordinate with the State Pollution Control Boards and the Pollution Control Committees for implementation of these rules and adherence to the prescribed standards by local authorities.
- ✓ review the proposals of state pollution control boards or pollution control committees on use of any new technologies for processing, recycling and treatment of solid waste and prescribe performance standards, emission norms for the same within 6 months.

- ✓ formulate /review the standards for ground water, ambient air, noise pollution, leachate inrespect of all solid waste processing and disposal facilities;
- ✓ toreviewandupdatethenormsfromtimetotime.
- ✓ Toreviewtheimplementationofsuchnormsatleastonceinayear.

10. DutiesandResponsibilitiesoflocalauthoritiesandvillagePanchayatsof census towns and urban agglomerations.

- ✓ local authorities and Panchayats shallprepare a solid waste management plan as per State Policy within six months
- ✓ arrange for door to door collection of segregated solid waste; integrate rag pickers /informal waste collectors in solid waste management
- ✓ frame bye-laws incorporating the provisions of these rules within one year, prescribe user fee;
- ✓ direct waste generators not to litter and to segregate the waste at source and handover the segregated waste to authorized waste pickers the waste collector authorized by the local authority;
- ✓ setup material recovery facilities or secondary storage facilities and provide easy access to waste pickers and recyclers for collection of segregated recyclable waste;
- ✓ establish waste deposition centres for domestic hazardous waste and ensure safe storage and transportation of the domestic hazardous waste to the hazardous waste disposal facilityor as may be directed bythe state pollution control board/committee;
- ✓ direct street sweepers not to burn tree leaves collected fromstreet sweeping and store them separately and handover to the waste collectors or agency authorised by local authority;

- ✓ provide training on solid waste management to waste-pickers and waste collectors;
- ✓ promote setting up of decentralized compost plant or bio-methanation plant at suitable locations in the markets or in the vicinity of markets ensuring hygienic conditions;
- ✓ collect separately waste from sweeping of streets, lanes and by-lanes daily, or on alternate days or twice a week depending on the density ofpopulation, commercial activity and local situation.;
- ✓ prepare and submit annual report before the 30th April of thesucceeding year to the Commissioner or Director, Municipal Administration or designated Officer and be send to the Secretary, -in-Charge of State Urban Development Department or village panchayat or rural development department and to the respective State Pollution Control Board or Pollution Control Committee by the 31st May of every year;
- ✓ educateworkers includingcontractworkers andsupervisors fordoortodoor collection of segregated waste and transporting the unmixed waste during primary and secondary transportation to processing or disposal facility;
- ✓ ensure that the operator of a facility provides personal protection equipment including uniform, fluorescent jacket, hand gloves, raincoats, appropriate foot wear and masks to all workers handling solid waste and the same are used by the workforce
- ✓ createpublicawarenessonSWM
- ✓ stop land filling or dumping of mixed waste soon after the timeline as specified in Rule 23 for setting up and operationalization of sanitary landfill is over;
- ✓ allow only the non-usable, non-recyclable, non-biodegradable, non-combustible and non-reactive inert waste and pre-processing rejects & residues from waste processing facilities to go to sanitary landfill;

11. Duties of District Magistrate or District Collector or Deputy Commissioner

- ✓ The District Magistrate shall facilitate identification and allocation ofsuitablelandforsettingupsolidwasteprocessinganddisposalfacilities.
- ✓ reviewtheperformanceoflocalbodies,atleastonceinaquarter.

12. DutiesofStatePollutionControlBoard

- ✓ TheStatePollutionControlBoardshallenforcetheserulesintheirState.
- ✓ monitorenvironmentalstandards.
- ✓ examinetheproposalforgrantofauthorization.

- ✓ regulateInter-Statemovementofwaste.

13. Duty of manufacturers or Brand owners of disposable products and sanitary napkins and diapers

- ✓ All marketingcompaniesshalleducatethe masses forwrappinganddisposal of their products.
- ✓ All brand owners who sale or market their products in such packaging material which are non-biodegradable shall put in place a system to collect back the packaging waste generated due to their production.

14. Duties of the industrial units located within one hundred km from the RDF and Waste to Energy plants based on solid waste

- ✓ All industrialunits using fueland located within 100 kmfromansolid waste based RDF plant shall make arrangements withinsix months from the date of notification of these rules to replace at least 5 % of their fuel requirement by RDF so produced.

15. Criteriaforsettingupsolidwasteprocessingandtreatmentfacility.

- ✓ The department dealing the allocation of land will be responsible for providing suitable land.
- ✓ The operator of the facility shall obtain necessary approvals from the State Pollution Control Board and responsible for safe and environmentally sound operations of the solid waste processing and treatment facilities.
- ✓ The operator of the solid waste processing and treatment facility shall submit annual report by 30th April to the State Pollution Control Board/ Pollution Committee and Local authority.

16. Criteriaandactionstobetakenforsolidwastemanagementinhillyareas

- ✓ Constructionoflandfillonthehillshallbe avoided.
- ✓ A suitable land shall be identified in the plain areas down the hill within 25 kilometers for setting up sanitary landfill.

ELEMENTSOFMUNICIPALSOLIDWASTEMANAGEMENTPLAN

- ✓ PlanningProcess
- ✓ DesignPeriod
- ✓ PopulationForecast
- ✓ BasicPlanningModel
- ✓ Coordination
- ✓ PlanOutline

PlanningProcess

- recognizingtheproblemsthatexist;
- collectingandanalysingdataaboutheseproblems;
- suggestingactionstochangethesituationorcorrecttheproblem;
- evolvesuitablestrategyforimplementationwithrespecttotimeframe;
- evaluation of the actions taken of success or failure in achieving objectives and modification of the plan to meet changing conditions.

DesignPeriod

- While preparing a municipal solid waste management plan, the following design period involving all such activities would have to be decided depending upon the necessity of solid waste management plan
- (i)Short-termplan(2-5years)
- (ii)Medium-termplan(5-15years)
- (iii)Long-termplan (15-25years)

PopulationForecast

- The designpopulationwill have to be estimated with due regard to all the factors governing the future growth and development of the project area inthe industrial, commercial, educational, socialand administrative spheres.

BasicPlanningModel

(1) In the planning process is awareness that a problem exists and needs to be solved.

(2) Tocollectandanalyzedatarelatingtotheproblem

(3) Significance ofenvironmentaland health impact assessment is aimed for proper management of municipal solid waste.

(4) Problemdefinitionforboththepresentandfuturesituation.

(5) Helpstosuggestobjectivesthatifachievedwouldsolvetheproblems.

6)Twoor more alternatives mightbeavailable forsolvingtheproblemand achieving objectives.

(7) Alternativesareselectedby considering technical,political,social andother factors.

(8) Oncethisdecision hasbeen made a plan for solution of theproblemscan be adopted.

Theagencyconductingtheplanningshouldhaveinitiatedaninformationand education program early in the plan formulation stages,

- Print and electronic media can play vital role in creating awareness and educating the public
- News releases, films, articles, and speakers, for example, can help develop public awareness and aid in approval of solid waste management plans and programs.

Coordination

- Essence of planning is coordination. Planning requires resolution of conflicting interests, allocation of available funds and other resources, inter-governmental and interdepartmental cooperation, and establishment of priorities.

PlanOutline

- The basic planning model can be translated into an outline for reporting the established plan. the following sample format for the preparation of the Municipal Solid Waste Management Plan.
    - Introduction
    - ExecutiveSummary
    - BackgroundofthePlanningArea
        - Jurisdictions(national, state, city, location, transportation land)
        - PhysicalConditions(climate,enevironment, soil, financial and legislation status)
    - ExistingSWMConditions
    - FutureConditionsandProblemDefinition
    - Objectives
    - RecommendationsforSolution
    - Implementation
    - MonitoringandPerformanceEvaluationoftheProgramme

ROLEOFPUBLICANDNGO'S

- Carryout SWM program in areas where municipal corporation are not providing Service.
- Doortodoorcollectionofwaste.
- Setting up and operation and maintenance of work disposal facility and treatment plants.
- Supplyingvehiclesonrent,lease,repairsandmaintenanceatprivategarage.
- Transportationofwasteoncontractualbasis

- Activelysupportthenewstrategiesadoptedbythelocalbodyandbringpublic awareness.

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Unit II

SourceReduction,WasteStorageandRecycling

WasteManagementHierarchy-Reduction, ReuseandRecycling -sourcereduction of waste – On-site storage methods – Effect of storage, materials usedforcontainers – segregation of solid wastes – Public health and economic aspects of open storage – case studies under Indian conditions – Recycling of Plastics and Construction/Demolition wastes.

WASTEMANAGEMENTHIERARCHY

- ✓ Theaimofthewastehierarchyistoextract the maximumpracticalbenefits from products and to generate the minimum amount of waste.
- ✓ Itcanhelppreventemissionsofgreenhousegases,reducespollutants,save energy, conserves resources.

WASTEPREVENTION

Accordingtothisprinciple,themanufacturingindustries,

- ✓ Should make use of less hazardous materials in the design and manufacturing of the products.

- ✓ They should develop strategies to have a cleaner and environment friendly production.

REDUCTION

- ✓ secondpreferredoptionofthewaste managementhierarchy.
- ✓ to make changes in the type of materials that are being used for the production of the specific products, so as to ensure that the by-products are of the least toxicity.

REUSE

- ✓ Reuse happens when something that already fulfilled its original function is used for another purpose.
- ✓ It helps in minimizing the amount of wastes produced as end product, saves the natural resources and reduces the costs associated with the production and manufacturing.

RECYCLE

- ✓ Thewastematerialsareimplementedintheproductionofanewproduct.
- ✓ The waste materials of various forms are collected and then processed to give rise to new products.
- ✓ Thisprocesspreventspollutionandsavesenergy.

RECOVERY

- ✓ Theenergyrecoveryprocessisalsocalledaswastetoenergyconversion.
- ✓ Thewastesthatcannotberecycledarebeingconvertedintouseableformsofenergy such as heat, light and electricity etc.
- ✓ Thishelpsinthesavingofvariousnaturalresources.
- ✓ Various processes such as combustion, anaerobic digestion, landfill gas recovery, pyrolization and gasification are being implemented to carry out the conversion process.

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DISPOSAL

- ✓ The disposal process holds the last position in the waste management hierarchy.
- ✓ Remaining waste or residues from various waste management processes must be stored in final disposal site.

SOURCEREDUCTIONOFWASTE

- ✓ Source reduction, also known as wasteprevention or pollution prevention,is the elimination of waste before it is created.
- ✓ It involves the design, manufacture, purchase or use of materials and products to reduce the amount or toxicity of what is thrown away.
- ✓ Source reduction is the top solid waste priority of environmental protection agencies of many of the developed countries.

Exampleofsourcereductionofwaste,

- ✓ Replacingplasticgrocerybagswithareusableclothbagwouldbe an example.
- ✓ Source reduction, including reuse, can help reduce wastedisposal and handling costs, because it avoids the costs of recycling, municipal composting, landfilling, and combustion.

ADVANTAGES OF SOURCE REDUCTION AND ON-SITE PROCESSING:

- ✓ Hazardousmaterialfromgeneralwasteareremoved.
- ✓ Cleanrecycleablematerialsaregenerated.
- ✓ Health risks to the general population particularly the waste handlers are minimized.
- ✓ Workingconditionwithinrecyclingplantsisimproved.
- ✓ Efficiencyofenergyrecoveryprocessisimproved.

- ✓ Qualityofendproductsgetsimproved.
- ✓ Overallwastemanagementcostisminimized.

SOURCEREDUCTIONANDRECYCLING.

- ✓ Recyclingiscollectingalreadyusedmaterialsandmakingthemintoanother product.
- ✓ Recycling begins at the end of a product's life, while source reduction firsttakesplacewhentheproductanditspackagingarebeingdesigned.

The best way to think about source reduction and recycling is as complementary activities - combined, source reduction and recycling have a significant impact on preventing solid waste and saving resources

Importanceofsourcereductionofwaste:

(a) Source reduction conserves raw material and energy resources. Smaller packages and concentrated products typically use fewer materials and less energy to manufacture and transport.

(b) Source reduction reduces releases to air, land and water. For example, it takes less fuel to transport lighter weight materials.

(c) Source reduction cuts back on what has to be thrown away. That helps keep solid waste disposal costs down, which is good for municipal budgets and consumers.

(d) Source-reduced products take up less space, and are more efficient and easier to use.

STORAGEOFWASTE:

- ✓ Atsource
- ✓ Atcommunitylevel
- ✓ Attransferstations

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ONSITEHANDLING

- ✓ Onsite handling refers to the activities associated with handling of solid waste until they are placed in the containers used for their storage before collection.

IMPORTANCEOFON-SITEHANDLING:

- ✓ Reducevolumeofwastegenerated
- ✓ Alterphysicalform
- ✓ Recoverusablematerials

ONSITE HANDLING METHODS:

- ✓ Sorting
- ✓ Shredding
- ✓ Grinding
- ✓ composting

SORTING:

- ✓ The sorting or separation of waste materials into newspapers, aluminum cans, and glass and others by hand at the household is one of the most positive ways to achieve the recovery and reuse materials

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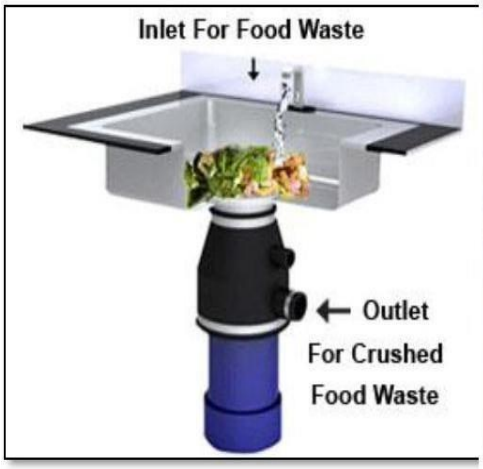
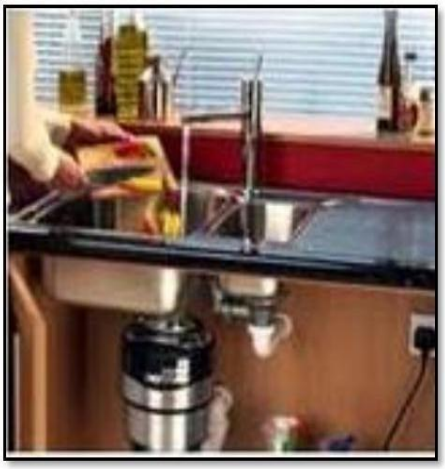
SHREDDING:

Mechanical operations used to reduce the size and volume of wastesthat must be handled. It is used alone without the addition of water, where the volume of wastes has often been observed to increase.eg. Paper wastes.

GRINDING:

Itisalsousedforreducingthesizeofsolidwaste.





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COMPOSTING:

It is an effective way of reducing the volume and altering the physical composition of solid waste while at the same time producing a useful by-product.

FACTORSINON-SITESTORAGEOFSOLIDWASTE

1. Effectsofstorageonthewastecomponents
2. Typeofcontainertobeused
3. Containerlocation
4. Publichealthandaesthetics

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1. Effectsofstorageonthewastecomponents

Biological decomposition

- ✓ Food and other wastes placed in onsite storage containers will almost immediately start to undergo microbiological decomposition often called putrefaction which results in the growth of bacteria and fungi.
- ✓ Ifwastes are allowed to remain instorage containers for extended periods of time, flies can start to breed and odorous compounds can develop.

Absorptionoffluids

- ✓ The components that comprise solid wastes have differing initial moisture contentsre-equilibrationtakes place as wastes are stored onsite incontainers. Where mixed wastes are stored together, paper will absorb moisture from food wastes and fresh garden trimmings.

Contaminationofwastecomponents

- ✓ The mostseriouseffectofonsitestorageofwastesisthecontaminationthat occurs.
- ✓ Themajorwastecomponentsmaybecontaminatedbysmallamountsofwastes such as motor oils, household cleaners, and paints.
- ✓ Theeffectofthiscontaminationistoreducethevalueoftheindividual components for recycling.

STORAGECONTAINER

3. **Storage Containers-** Efficient collection system requires careful consideration of type, size and location of containers.
- ✓Family – Small containers (manual handling)
- ✓Residential units – large – Mechanical handling

Desirablecharacteristics:

- ✓ Lowcost
- ✓ Size
- ✓ Weight
- ✓ Shape
- ✓ Resistanttocorossion
- ✓ Watertightness
- ✓ Strengthanddurability

2. Typeofcontainertobeused

- ✓ **Stationarycontainer:**

usedforcontentstobetransferredtocollectionvehiclesatthesiteof storage.

- ✓ **Hauledcontainer:**

Used for contents to be directly transferred to a processing plant, transfer station or disposal site for emptying before being returned to the storage site.

Materialsusedforcontainers:

- Plastics
- PVC/Polymermaterialse.g.Nylon
- Wood/bamboo
- Steel/ironbins
- Discardedcans/tins
- Packingboxes

Typesofcontainerspresentlyusedforstorageinhousesare,

- Buckets
- Plasticbins
- Plasticbags
- Metalbinswithorwithoutlids

- Steelandferrouscontainersareheavyandsubjecttocorossion;therustpeelsoff exposing sharp edges.
- Materialslikecardboard,wood,bambooreadilyabsorbandretainmoisture and their surfaces are generally rough, irregular and difficult to clean.
- Galvanizedmetalispreferableforgarbagestoragebecauseitisresistantto corossion.
- Plasticcansarelightinweightbuteasilydamaged byratsandalso ultraviolet rays also destroy it.

- RCC binsof concrete pipe section with 1m dia and 1mheight are readilyavailable inthe market,itbecomeswetsincenocoverontop.
- Largebrickmasonrybinsof1mx1mx1m.

Litterbins

- Theseareprovidedtoenablethecitizenstodepositthewastealong streetsand public places.
- Consistsof2partswithanouterpartofstandardsizeandseparateinnerpart which can be easily lifted and emptied during collection.
- Capacityof30to50litres.
- Itusuallyhaveacovertopreventrainwaterfromenteringinside.

Communal container– Compactor collection container. Fixed/moving. Movable containers are with accessories provided for lifting mechanism of collection vehicles.

Vehicle can lift and empty mechanically. Capacity is generally 1-4 m^3.

At vegetable markets & large commercial centers, capacity is 15- 20 m^3 and consist of wheels.

Collection vehicle keep empty container before it hauls the filled container.

Ideally these should be located 100 -200 m apart for economic reasons. Fuel consumption increases if vehicle has to stop at every 50m.

3. ContainerLocation

Itisadvisabletoplacethecontainers100-200mapartforeconomicreasons.

The communal containers are usually staggered such that the effective distance of 100m is maintained as shown in fig.

This means that the farthest distance the householderwill have to walk is 50 metres. However in narrow streets with low traffic where the house owner can readily cross the street, a longer distance is advisable.

If the collection vehicle has to stop frequently at every 50m fuel consumption increases and this must be avoided.

Location of communal containers in Narrow Roads

DISADVANTAGESOFCOMMUNALCONTAINERS

- Potentiallackofmaintenance
- Scatteredandresidualwasteemitsfoulsmell
- Consumelongtimeforcleaningbycrew

TEMPORARYANDDISPOSABLECONTAINERS

- paper bags, cardboard boxes, plastic containers and bags, and wooden boxes are routinely used as temporary and disposable containers of accumulated wastes .
- Undernormalcircumstances,temporarycontainersareremovedalong with the wastes.

Presentscenario

InIndiawastestoragedepotsisinefficient,unhygienicandunscientificcausinga serious threat to public health and environment.

- Opensites
- Cementconcretecylindricalbins/Masonrybins
- Metalrings
- Dhalavs(Largeconcretebins)

Colorcoding

- The color coding makes the process understandable even for low-skilled workers with language and reading problems an easy way by a fixed color.
- Warning colors for hazardous waste (Red, yellow, orange) . Positive colors for recycling (Blue, green, etc.) • Neutral colors for normal waste (Black, etc.) •

4. PublicHealthandAesthetics

- ✓ Public health concerns are related primarily to the infestation of areas used for the storage of solid wastes with vermin and insects that often serve as potential reservoirs of disease.

- ✓ The most effective control measure for both rats and flies is proper sanitation.
- ✓ Itinvolvestheuseofcontainerswithtightlids.
- ✓ The periodic washing of the containers as well as of the storage areas, and the periodic removal of biodegradable materials (usually within less than 8days, in areas with warm climates).
- ✓ Aesthetic considerations are related to the *production of odors* and the unsightly conditions that can develop when" adequate attention is not given to" the maintenance of sanitary conditions.
- ✓ Most odors can be controlled through the use of containers with tight lids and with the maintenance of a reasonable collection frequency.
- ✓ If odors persist, the contents of the container can be sprayed as a temporary expedient.
- ✓ To maintain aesthetic conditions, the container should be scrubbed and washed periodically.

OnsiteSegregationOfSolidWastes

- ✓ It means separation or sorting of individual constituents of waste materials at the point of generation.

ObjectivesofOnsiteSeparationorSortingorSegregation:

- ✓ Toseparaterecyclablematerialsforreuse.
- ✓ To ensure the waste, which can be processed for recovery of material and energy.
- ✓ To separately store hazardous materials for disposal in hazardous waste landfills or appropriate processing.
- ✓ To minimize the waste and ensure reduction in landfill space for final disposal.

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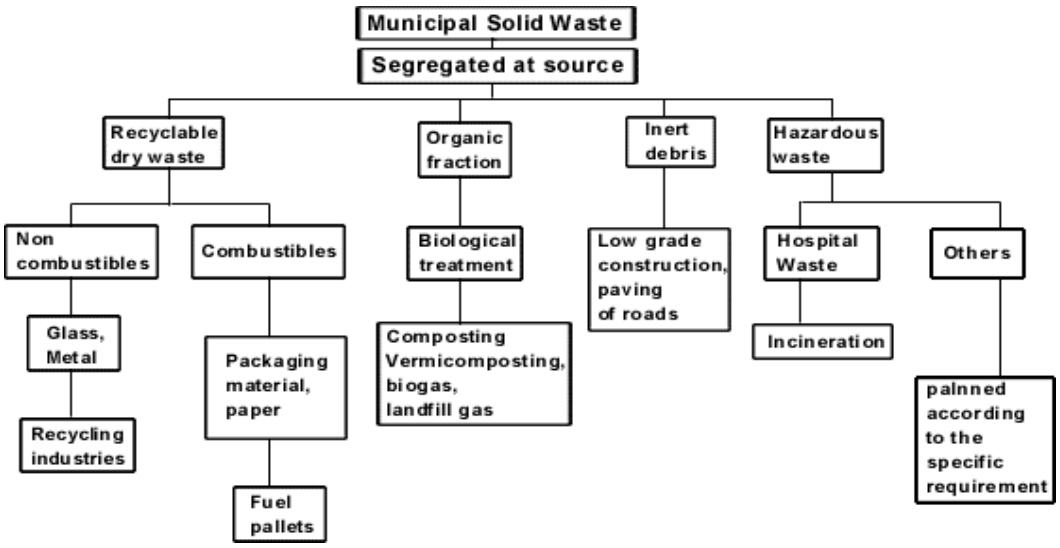
StagesofSorting:

- ✓ Atthesources/householdlevel
- ✓ Atthecommunitybin
- ✓ Atthetransferstation
- ✓ Atwasteprocessingsite
- ✓ Atlandfillsite.

Sortedwastestreams

- ✓ Dryrecyclables
- ✓ Constructionanddemolitionwastes
- ✓ Bio-degradablewaste
- ✓ Bulkywaste
- ✓ Hazardouswaste



Sourceseparationmaybe voluntaryormandatedandisdoneinconjunction with several recycling programs.

Sourceseparationelements:

- ✓ Dropoff
- ✓ Buy-back
- ✓ Curbsideprogram

Drop–off

- ✓ Requiresresidentstoseparatetherecyclablematerialsandbringthem back to a specific drop off center.

Buyback

- ✓ Buybackreferstoadropoffprogrammethatprovidesincentives toparticipate.

Curbsideprogram

- ✓ Sourceseparatedrecyclablesarecollectedatcurbside.

Processingequipmentsforsegregationofsolidwaste

- ✓ Balers:todensifymaterials
- ✓ Condensifiers:crushesaluminium/steelcans
- ✓ Glasscrushers:breakglassesintopieces
- ✓ Magneticseparators:removeferrousmaterials
- ✓ Woodgrinders:breakswoodintosmallpieces
- ✓ Scales:weighthequantityofmaterial

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PublichealthandeconomicaspectsofopenstorageHealth

aspects in open storage:

- ✓ Waste gets scattered at bins while storage and segregating. During sorting it causes injuries as well as disease through infected wastes.
- ✓ Food wastes if stored more than five days leads to foul smell and generates flies and cause disease to the occupants.
- ✓ Some type of wastes do not get recycled since it may cost less or not currently recycled and recycling takes place in very poor health and environmentally unsafe conditions.
- ✓ Whilehandlingtoxicand hazardouswastehealthissuesoccur,sopropercare should be made.

Economicaspectsinopenstorage

- ✓ Reducing the generation of waste before it occurs is a logical way it save cost i.e source reduction.
- ✓ Recycling thus reduces volume of waste generated which in turn cuts pollution and increase the economic value of the waste.
- ✓ Recycling programs will convert the waste scattered and scavenging into an economic enterprise.

RECYCLINGCONSTRUCTIONANDDEMOLITIONWASTE

- ✓ Recyclingconstructionanddemolitionwasteisprofitableandenvironmentalway to produce aggregates and reuse valuable materials that wouldotherwise be disposed.
- ✓ Processing the waste near the worksites also reduces the need for truck transportation resulting in lower logistics costs.

Component of Construction Waste

- C&D materials often contain bulky, heavy materials such as:
  - Concrete
  - Wood (from buildings)
  - Asphalt (from roads and roofing shingles)
  - Gypsum (the main component of drywall)
  - Metals
  - Bricks
  - Glass
  - Plastics
  - Salvaged building components (doors, windows, and plumbing fixtures)
  - Trees, stumps, earth, and rock from clearing sites

Present Fate of C&D Waste

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WASTETOVALUE

- ✓ Rapid urbanization and population growth have increased the demand for new housing, urban environments and infrastructure.
- ✓ While roads, buildings and bridges are renovated and renewed, massive amountsofconstructionanddemolitionwasteisgeneratedaroundtheworld.
- ✓ To cope with both rising stockpiles of waste and yet growing need for raw materials, governments have started to impose new environmental regulations encouraging to use recycled materials instead of natural resources.

- ✓ Crushedaggregate made ofdemolition waste,for **basesofroadsandsportsfields,soundbarriersandparkinglots**.
- ✓ Better load-bearing capabilities have been measured with thinner layer thickness when crushed concrete was used.
- ✓ Oneothergoodexampleistheuseofcrushedconcreteas**erosioncontrol**.

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BENEFITSOFUSINGRECYCLEDCONCRETE

- ✓ Recycledconcretesavesboththeenvironmentandmoney.
- ✓ Recyclingwecanconsumelessrawmaterialsandpreservegravelresources.
- ✓ Costsavingscomefromthesameaspects:lesstransportationmeanslessfuel costs and eliminating the waste material means that there are no costs associated with dumping.

ReducingtheamountofC&Dmaterialsdisposedofinlandfillsorincineratorscan:

- ✓ Createemploymentand economicactivities inrecyclingindustriesand provide increased business opportunities within the local community, especially when deconstruction and selective demolition methods are used.
- ✓ Reduce overall building project expenses through avoided purchase/disposal costs, and the donation ofrecovered materials to qualified 501(c)(3) charities, which provides a tax benefit.
- ✓ Onsitereusealsoreducestransportationcosts.
- ✓ Lead to fewer disposal facilities, potentially reducing the associated environmental issues.
- ✓ Offset the environmental impact associated with the extraction and consumption of virgin resources and production of new materials.
- ✓ Conservelandfillspace.

DeconstructionforReuse

- ✓ Deconstruction is the process of carefully dismantling buildings to salvage components for reuse and recycling. Deconstruction can be applied onanumberoflevelstosalvageusablematerialsandsignificantlycutwaste.

Deconstructionhasmanybenefits,includingthefollowing:

- Maximizestherecoveryofmaterials.
- Conservesfinite,old-growthforestresources.
- Providesmanyemploymentandjobtrainingopportunities.
- When coupled with traditional demolition methods, allows communities to create local economic activities around manufacturing or reprocessing salvaged materials.
- Divertsdemolitiondebrisboundfordisposal
- Preservesresourcesthroughreuse.

WhatMaterialsCanBeReused?

- Easy-to-remove items like doors, hardware, appliances, and fixtures. These can be salvaged for donation or use during the rebuild or on other jobs.
- Wood cutoffs can be used for cripples, lintels, and blocking to eliminate the need to cut full length lumber. Scrap wood can be chipped on site and used as mulch or groundcover.
- Brick, concrete and masonrycanbe recycled onsite as fill, subbase material or driveway bedding.
- Excess insulation from exterior walls can be used in interior walls as noise deadening material.
- Paint can be remixed and used in garage or storage areas, or as primer coat on other jobs.
- Packagingmaterialscanbereturnedtosuppliersforreuse.

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RebuyingC&DMaterials

BuyingusedC&Dmaterialsandrecycledcontentproductsforuseinnewconstructioncan:

- Boostthelocaleconomyasrecoveredmaterialsaretypicallylocallysourced.
- Lower constructionand renovationcosts while maintaining buildingfunction and performance.
- Ensure materials collected from reuse and recycling programs will be used again in the manufacture of new products and/or new construction, thereby fully realizing the benefits of reuse and recycling efforts;
- Preserve local architectural character and historic significance (in cases of preserved or restored buildings).

Recyclingofplastics

What is plastics?

- A wide range of synthetic or semi synthetic organic solid materials suitable for the manufacture of industrial products. Plastics are polymers of high molecular weight. They may contain other substances to improve performance or reduce costs.

TYPESOFPLASTICS

- **Thermoplastics**
  - Plastics that do not undergo chemical change in their composition when heated. Can be molded again and again. Examples: Polyethylene Tetraphthalate Polypropylene (PP) Poly Vinyl Acetate (PVA) Poly Vinyl Chloride (PVC) Polystyrene (PS)
- **Thermosetplastics**
  - Plastics that are permanently "set" once, they're initially formed and can't be melted. Examples: Bakelite Melamine Polyester Polyurethane Urea – Formaldehyde.

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Advantagesofplastic

- ✓ resistant
- ✓ inexpensive
- ✓ easytoproduce
- ✓ durable
- ✓ elastic

DisadvantagesofPlastic

- ✓ Decomposition
- ✓ Non-Renewable
- ✓ HardtoReuse
- ✓ DifficulttoRecycle
- ✓ ToxicThreattoAnimals

Plasticrecycling

- ✓ Plastic recycling is the process of recovering scrap orwaste plasticand reprocessing the material into useful products.
- ✓ Since the majority of plastic is non-biodegradable, recycling is a part of global efforts to reduce plastic in the waste stream, especially the approximately 8 million metric tonnes of waste plasticthat enters the Earth's ocean every year.
- ✓ plastic polymers recycling is often more challenging because of low density and low value.
- ✓ There are also numerous technical hurdles to overcome when recycling plastic.
- ✓ Materials recovery facilities are responsible for sorting and processing plastics.
- ✓ When different types of plasticsare melted together, they tend to phase-separate, like oil and water, and set in these layers.

- ✓ The two most widely manufactured plastics, polypropyleneand polyethylene.
- ✓ Each time plastic is recycled, additional virgin materials must be added to help improve the integrity of the material.
- ✓ So, even recycled plastic has new plastic material added in. The same piece ofplastic canonlybe recycled about 2–3 times before its qualitydecreasesto the point where it can no longer be used.

Recyclingprocess

Therearetwomajorwaystorecycleplastic:

(1) **mechanicalrecycling**

(2) **Chemicalrecycling**

Mechanicalrecycling

- ✓ Formechanicalrecyclingtheplasticrecyclablesarethenshredded.
- ✓ These shredded fragments then undergo processes to eliminate impurities like paper labels.
- ✓ This material is melted and often extrudedinto the form of pellets which are then used to manufacture other products.
- ✓ Thehighestqualitypurificationmaybereferredtoas"regeneration".

Chemicalrecycling

- ✓ For some polymers, it is possible to convert them back into monomers, for example, PET can be treated with an alcohol and a catalyst to forma dialkyl terephthalate.
- ✓ Theterephthalatediestercanbeusedwithethyleneglycoltoforma newpolyesterpolymer,thusmakingitpossibletousethepurepolymeragain.

- **METHODS INVOLVED:**

✓ **THERMAL DEPOLYMERIZATION:**

Depolymerization process using hydrous pyrolysis for the reduction of complex organic materials into light crude oil.

Under pressure and heat, long chain polymers of hydrogen, oxygen, and carbon decompose into short-chain petroleum hydrocarbons.

Polyethylene teraphthalate (PET) and certain polyamides (nylon 6 (PA 6) and nylon 66) can be efficiently depolymerised.

✓ **HEAT COMPRESSION:**

It takes all unsorted, cleaned plastic in all forms, from soft plastic bags to hard industrial waste, and mixes the load in tumblers.

Benefit :all plastic is recyclable, not just matching forms.

Use of Waste Plastic in Flexible Pavements-Green Roads

- No wonder scientists have even derived a way of recycling the waste plastics in constructing the pavements for increasing their **strength** and d**urability**.
- It is very effective step towards eco-friendliness compared to conventional and traditional techniques of flexible pavements construction.
- The waste plastic gets coated over the surface of aggregate by heating (140˚C - 160˚C) as plastics like PE, PS, PP used in PET Bottles, disposal glasses, handbags, etc soften up to 160˚C.
- The LDPE can only be used in this technique as it gets softened at the desired temperature *i.e.,* 160˚C and coated over the aggregates.
- **This is an effective technique of plastic waste recycling as no fuel consumption takes place**.
- Use of waste plastic in bitumen increase the binding property as compared to the conventional bitumen. It improves the properties of bitumen resulting in increase in Softening Point and decrease in Penetration value thus improving the durability.**(Punith,2010)**

MEALWORMS : A SOLUTION TO DEGRADE PLASTIC WASTE NATURALLY

- Researchers at Stanford University reveals a species of **MEALWORMS** capable of consuming and digesting polystyrene foam, often referred to as "styrofoam."
- **These are small, brownish, squirmy ,larvae form of the darkling beetle**.
- Mealworms are the first reported insect capable of degrading and mineralizing a common persistent petroleum-based plastic.
- The scientists placed 100 mealworms on top of blocks of styrofoam, where they subsisted on nothing but the plastic, foam-like material for 30 days.
- 100 mealworms eat 34 to 39 milligrams of polystyrene per day, which is equivalent to the weight of a small pill.
- Mealworms' safe digestion of styrofoam suggests that their stomach contain special enzymes or bacteria that can break down polystyrene.**(Yu Yang et.al ,2010)**

- They examined the mealworms' excrement, and discovered that the polystyrene had mineralized: What hadn't been converted to carbon dioxide or biomass turned into fecal matter.
- The waste is **safe for reuse in soil** on crops.
- Waxworms, the larvae of Indian mealmoths, have microorganisms in their guts that can biodegrade polyethylene that is used to make garbage bags.
- The new research on mealworms is significant, as Styrofoam was thought to have been non-biodegradable and more problematic for the environment.

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Sevengroupsofplasticpolymers

Polyethyleneterephthalate(PET,PETE) Clarity,strength,toughness,barriertogas and moisture.	Soft drink, water and salad dressing bottles; peanut butter and jam jars; ice cream cone lids; small consumer electronics
High-densitypolyethylene(HDPE) Stiffness,strength,toughness,resistanceto moisture, permeability to gas	Waterpipes,Gas&FirePipelines,Electrical & Communications conduit,[63]hulahooprings,fivegallonbuckets, milk, juice and water bottles; grocery bags, some shampoo/toiletry bottles
Polyvinylchloride(PVC Versatility, ease of blending, strength, toughness.	Blisterpackagingfornon-fooditems;cling filmsfornon-fooduse.Maybeusedforfoodpackagingwiththeadditionoftheplasticisersneededtomakenativelyrigid PVC flexible. Non-packaging uses are electrical cable insulation;rigid piping; vinyl records.
Low-densitypolyethylene(LDPE) Ease of processing, strength, toughness, flexibility, ease of sealing, barrier to moisture.	Frozen food bags; squeezable bottles, e.g. honey, mustard; cling films; flexible container lids
polypropylene Strength, toughness, resistance to heat, chemicals, grease and oil, versatile, barrier to moisture	Reusable microwaveable ware; kitchenware;yogurtcontainers;margarine tubs;microwaveabledisposabletake-awaycontainers; disposable cups; soft drink bottle caps; plates.

Polystyrene(PS) **Versatility,clarity,easilyformed**	Egg cartons; packing peanuts; disposable cups, plates, trays and cutlery; disposable take-away containers
Other (often polycarbonateor ABS) dependentonpolymersorcombinationof polymers	Beveragebottles,babymilkbottles.Non-packagingusesforpolycarbonate,compact discs, "unbreakable" glazing, electronic apparatus housing, lenses (including sunglasses), prescription glasses, automotive headlamps, riot shields, instrumentpanels

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Unit III

CollectionandTransferofWastes

Methods of Residential and commercial waste collection – Collection vehicles – Manpower – Collection routes – Analysis of waste collection systems; Transfer stations –location, operation and maintenance; options under Indian conditions – Field problems- solving.

WasteCollection:

- ✓ It is the process of collection of solid waste from point of production(residential, commercial, industrial, institutional, etc.) to the point of treatment or disposal.
- ✓ The quantity of MSW collected varies widely by region and income level; collection within cities will also differ greatly.
- ✓ Collectionrate is found to range froma low of41%in low income countries to a high of 98% in high income countries.

MethodsofResidentialWasteCollection:

- ✓ Doorstep collection
- ✓ Communitybinsystem
- ✓ Bellringingsystem
- ✓ Collectionthroughmotorizedvehicles
- ✓ Collectionfromslums
- ✓ Collectionofhotel/restaurantwaste
- ✓ Collectionofconstructionanddemolitionwaste
- ✓ Collectionofbiomedicalwaste

1. Doorstep collection
    - Curbservice
    - Alleyservice
    - Setout;setbackservice
    - Setoutservice
    - Backyardservice
    - Blockcollection

- **Curbservice:**

- Placing the containers to be emptied at the curb on collection day and returning the empty container to their storage location is done by the house owner.

- **Alleyservice**

- This is collection of waste from the alleyways besides houses, which will take the container to the collection vehicles , could be arranged between the owner of the house and the collection crew.

- **Setout,setbackservice/Backyardservice:**
- Containeraresetoutfromthe homeowner'spropertybythecollectioncrew.
- Setbackafterbeingemptiedbyadditionalcrews.
- Workinconjunctionwiththecollectioncrewresponsibleforloadingthe collection vehicle.

- **Setoutservice**

✓ Sameassetout-setbackservice.

✓ Homeowner is responsible for returning the containers to their storage location.

- **Blockcollection**

✓ In this system, collection vehicles stopped at selected locations on specific days.

✓ The house owner brings his waste and deposits the same in the vehiclewhich then moves ahead and the process is continued till the vehicle is full.

2. Communitybinsystem

✓ Adopted in areas where community bins are located in street corners and at specific frequencies, along the road side.

✓ Theresidentsareexpectedtodepositatthecommunitybins.

✓ Spacing of the containers should be fixed on the basis of per capita quantity and the population contributing the waste and the maximum distance limit between two bins should be 100meters.

3. Bellringingsystem

- ✓ Itisamodifiedformofthehouse-to–housecollectionsystem.
- ✓ The collection vehicle is provided with a bell and on reaching specified target point, it is rung.
- ✓ Residents from adjoining areas come to the vehicle and deposit the waste in the vehicle.
- ✓ As he moves slowly residents can still find him in the vicinity and deposit the waste in the handcart.
- ✓ Hewaitsatspecificpointsanddepositsthewastetransportvehicle.

4. Collectionthroughmotorizedvehicles

- ✓ Local bodies as an alternative to doorstep collection through containerized handcarts, may use motor vehicles having sounding horn.
- ✓ Driver of the vehicle should intermittently blow the horn to announce his arrival;the individualscandepositwastedirectlyinto vehiclewithout lossof time.

7. Collectionofconstructionanddemolitionwaste

- ✓ Local bodies should prescribe the rate per ton for collection, transportation and disposal of construction waste and notify the same to the people.
- ✓ Charges for removal of construction waste to be doubled for those who fail to deposit the amount in advance.

8. Collectionofbiomedicalwaste

- ✓ It is collected as per rules established by the Ministry of Environment and Forest, Government of India.

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CollectionofWaste:

- ✓ CollectionOfWasteSeparatedatthesource
- ✓ CollectionOfunseparatedWaste

CollectionOfWasteSeparatedatthesource

- ✓ Sourceseparatedrecyclablesarecollectedseparately.
- ✓ Residents to separate different materials (newspaper, plastic, glass and metals).
- ✓ Storedinowncontainerandcollectedseparately.
- ❖ Onecontainer–commingledrecyclables
- ❖ Onecontainer–Paper
- ❖ Onecontainer–Heavyrecyclables(glass,aluminumandtincans.)
- ✓ Specializedcollectionvehicleincludingclosedbody recyclingtrucks, recycling, trailers, modified flatbed trucks, open bin recycling trucks.

CollectionOfunseparatedWaste

- ✓ Fromlowrisedetacheddwellings
- ✓ Fromlowandmediumriseapartments
- ✓ Fromhighriseapartment
- ✓ Fromcommercialandindustrialfacilities

➢ Fromlowrisedetacheddwellings

- ✓ Curbservice
- ✓ Alleyservice
- ✓ Setout;setbackservice
- ✓ Setoutservice

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- Fromlowandmediumriseapartments
  - ✓ Curbsidecollectionserviceiscommon.
  - ✓ MaintenanceStaffisresponsiblefortransporting thecontainerstothe street by manual or mechanical means.
  - ✓ If large containersareused, the containersare emptied by mechanical means.
- Fromhighriseapartment
  - ✓ Large containersare used tocollect wastesfrom largeapartment buildings.
  - ✓ Dependingonthesizeandtypeofcontainerused, container maybe emptied mechanically using collection vehicle.
- Fromcommercialandindustrialfacilities
  - ✓ ManualandMechanicalmeansusedtocollectthewaste.
  - ✓ To avoid traffic congestion during the day, solid waste collected in the late evening and early morning hours.
  - ✓ ManualCollection–Wastecollected inplasticbag,cardboardboxother disposable containers.
  - ✓ WasteCollection–Fourpersoncrew-1driver+2or3morecollector
  - ✓ Spaceforstoragecontaineravailable–Containercoupledwithlarge stationary compactor.
  - ✓ Depending on the size and type of containerused–mechanized collection system.
  - ✓ To minimize difficulties due to traffic congestion – mechanical collection during the evening hours.

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COLLECTIONCOMPONENTS

- ✓ Collectionpoints
- ✓ Collectionfrequency
- ✓ Storagecontainers
- ✓ Collectioncrew
- ✓ Collection route
- ✓ Transferstation

Collectionpoints

- ✓ The collection points depend on locality and may be residential, commercial or industrial.
- ✓ Theseaffectsuch collectionsystemcomponentsascrewsizeand storage, which ultimately control the cost of collection.

Collectionfrequency:

- ✓ Climatic conditions and requirements of a locality as well ascontainersand costsdeterminethe collectionfrequency.
- ✓ The quality of solid waste containers onsitealsodeterminesthecollection frequency.
- ✓ Optimal collectionfrequency reducesthecostasitinvolvesfewertrucks, employees and reduction in total route distance, storage space.
- ✓ Lessfrequentcollectionmayrequiremorestoragespaceinthelocality
- ✓ Frequent collection reduces concerns about health, safety and nuisance associated with stored refuse.

Storagecontainers:

- ✓ Proper container selection can save collection energy, increase the speed of collection and reduce crew size.

- ✓ Whileevaluatingresidentialwastecontainersitshouldhave,
- efficiency, i.e., the containers should help maximise the overall collection efficiency.
- convenience, i.e., the containers must be easily manageable bothfor residents and collection crew.
- compatibility, i.e., the containers must be compatible with collection equipment.
- public health and safety, i.e., the containers should be securely covered and stored.
- ownership,i.e., the municipalownershipmust guaranteecompatibilitywith collection equipment.

Collectioncrew

- ✓ The optimum crew size for a community depends on labour and equipment costs, collection methods and route characteristics.
- ✓ The size of the collection crew also depends on the size and type of collection vehicle used, space between the houses, waste generation rate and collection frequency.

Collectionroute:

- ✓ An efficient routing of collection vehicles helps decrease costs by reducing the labour expended for collection.
- ✓ Properplanning ofcollectionroute also helps conserve energyand minimise working hours and vehicle fuel consumption.
- ✓ Thesizeofeachroute,however,dependsontheamountofwaste collected per stop, distance between stops, loading time and traffic conditions.
- ✓ Barriers, such as railroad, embankments, rivers androadswithheavytraffic, canbeconsideredtodivideroute territories.

Transferstation:

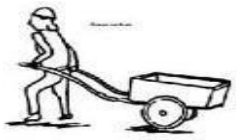
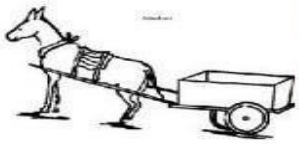
- ✓ If the disposal site is far from the collection area, it is justifiable to have a transfer station, where smaller collection vehicles transfer their loads to larger vehicles, which then haul the waste long distances.
- ✓ In some instances, the transfer station serves as a pre- processing point, where wastes are dewatered, scooped or compressed.

Collectionvehicles

- ✓ The collection vehicle selected must be appropriate to the terrain, type and density of waste generation points, the way it travels and type and kind of material.
- ✓ The most commonly used collection vehicle is the dump truck fitted with a hydraulic lifting mechanism.
  - ➢ **Small-scalecollectionandmuscle-powered vehicles**
  - ➢ **Non-compactortrucks**
  - ➢ **Compactortruck**

Small-scale collectionand muscle-powered vehicles

- ✓ These are common vehicles used for waste collection in many countries and are generallyused in rural hilly areas.


- ✓ They are suitable for densely populated areas with narrow lanes,andsquatter settlements, where there is relatively low volumeof waste generated.
- ✓ Somedrawbacks of thesecollectionvehiclesincludelimited travel range of the vehicles and weather exposure that affect humans and animals.
- ✓ These can be small rickshaws, carts or wagons pulled by people or animals, and are less expensive, easier to build and maintain compared to other vehicles

Non-compactortrucks

- ✓ Non-compactortrucksareefficientandcosteffectivein small cities and in areas wherewastestendtobe verydense andhave littlepotential for compaction.
    - ✓ When these trucks are used forwaste collection, they need a dumping system to easily discharge the waste.
    - ✓ It is generally required to cover the trucks in order to prevent residue flying off or rain soaking the wastes.

Non-compactor Trucks

- ✓ Truckswith capacitiesof 10 -12m^3 are effective,if the distancebetween the disposal site and the collection area is less than 15 km.
- ✓ If the distance is longer, a potential transfer station closer than 10 km from the collection area is required.
- ✓ Non-compacttrucksaregenerallyused,whenlabourcostishigh.

Compactortruck:

- ✓ Compaction vehicles are more common these days, generally having capacities of 12 - 15 m^3 due to limitations imposed by narrow roads.
- ✓ Although the capacity of a compaction vehicle, is similar to that of a dump truck, the weight of solid wastes collected per trip is 2 to 2.5 times larger since the wastes are hydraulically compacted.

- ✓ Compactortruckallowswastecontainerstobeemptied intothe vehicle from therear,frontorsidesandinhibitsvectors(ofdisease)from reachingthe waste during collection and transport.
- ✓ It works poorly when waste stream is very dense, wet, collected materialsare gritty or abrasive, or when the roads are dusty.

Theadvantagesofthecompactorcollectionvehicleincludethefollowing:

- Containersareuniform,large,coveredandrelativelyvisuallyinoffensive;
- Wasteissetoutincontainerssothatthecrewcanpickthemupquickly;
- Health risktothe collectors andodouronthestreets are minimized, wasteis relatively inaccessible to the waste pickers.

TYPESOFCOLLECTIONSYSTEM

- **1.Modeofoperation**
- Hauledcontainersystem
- Hoisttrucksystem
- Tiltframesystem
- Trashtrailersystem

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- Stationarycontainersystem
  - ✓ Mechanicallyloadedsystems
  - ✓ Manuallyloadedsystems

Mechanically loaded collection vehicles

1. Equipmentuse

containers,machineries,handtoolsetc,.

2. Typeofwastecollected

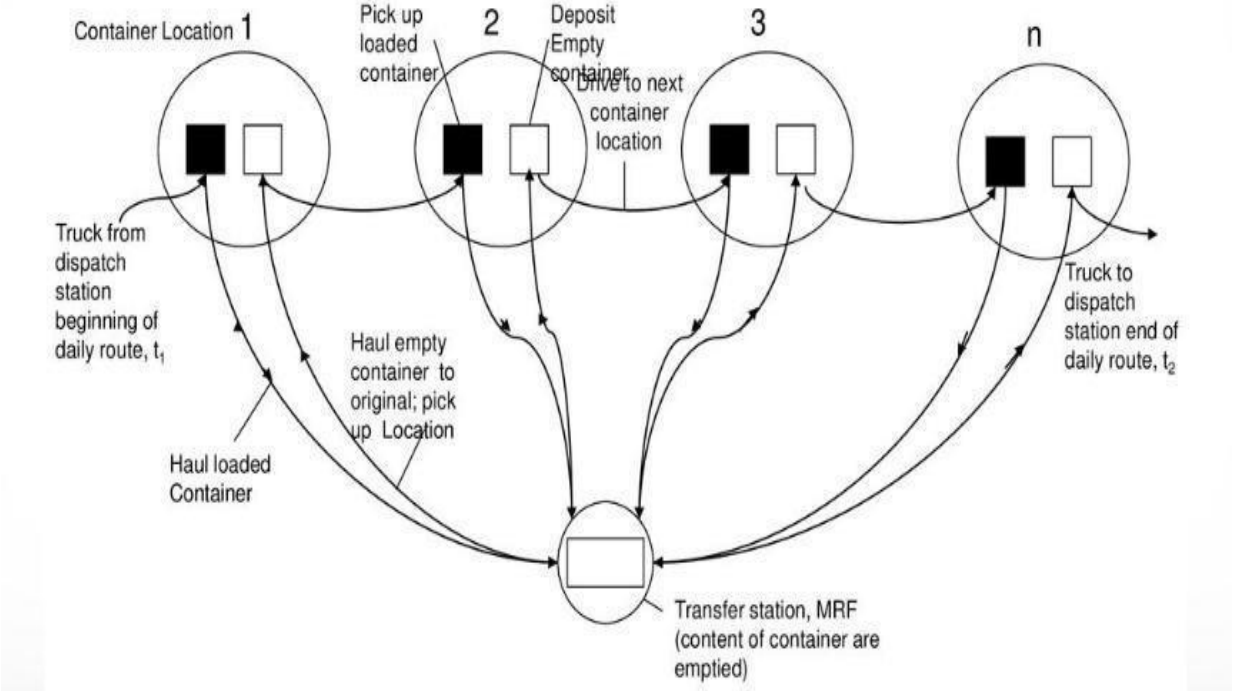
- ✓ Phaseone-generatedwastetodustbin
- ✓ Phasetwo-fromtemporarystoragetocollectiontruck
- ✓ Phasethree-truckmovesfromhousetohouseorcollection center to collection center.
- ✓ Phasefour-collectedwastetodisposalsite ortransferstation
- ✓ Phase five- wastestored for resource recovery or other management.

Analysisofcollectionsystem

To establish labour and vehicle requirement for the various collection systems and methods, the unit time required to perform each task must be determined.

- ✓ Pickup
  - ❑ Hauledcontainersystem(conventionalmode)
  - ❑ Hauledcontainersystem(exchangecontainermode)
  - ❑ Hauledcontainersystem(stationarycontainermode)
- ✓ Haul
- ✓ At-site
- ✓ Off-route/site

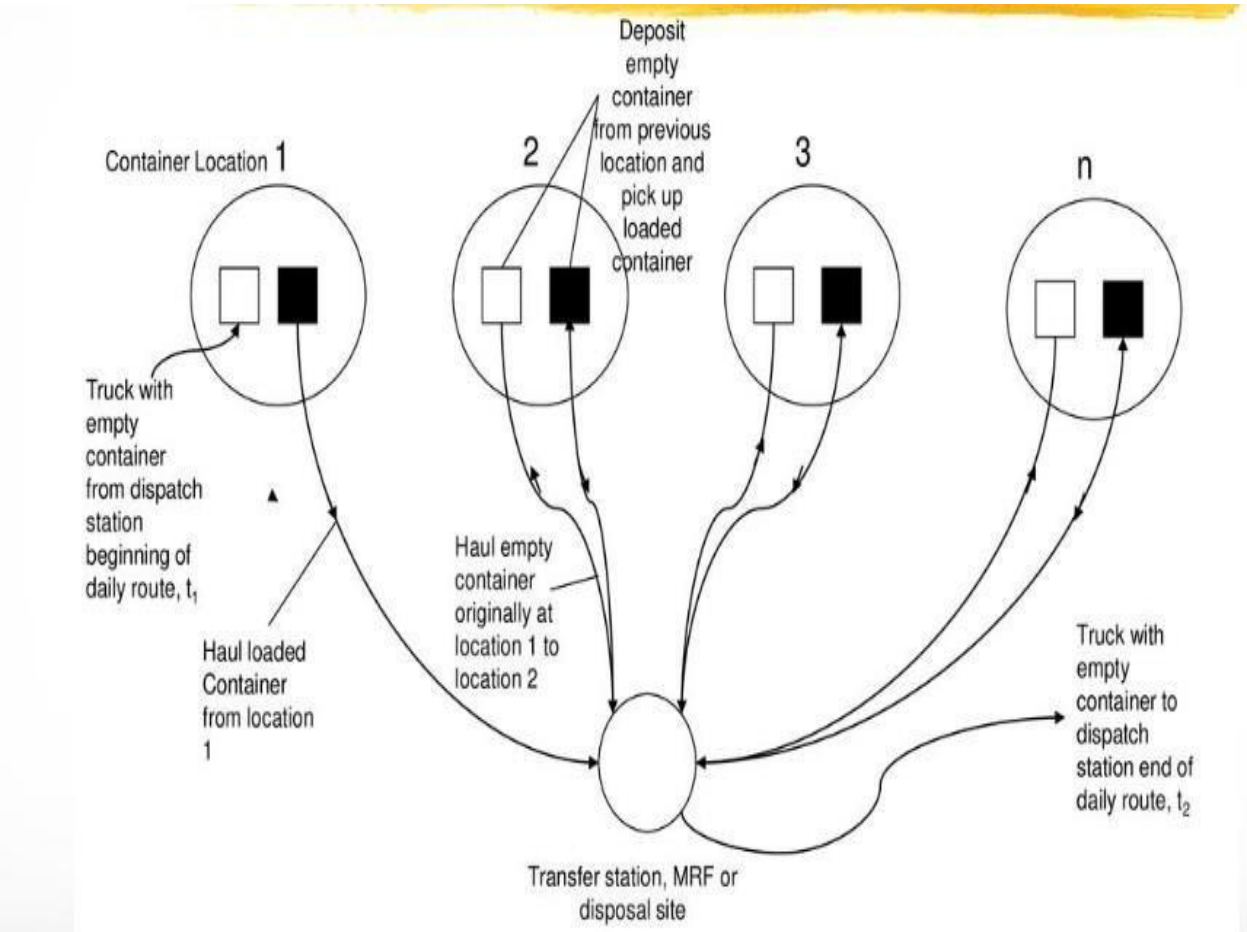
❑ Hauledcontainersystem(conventionalmode)



Pickupasrelatedto hauledcontainersystemoperated intheconventionalmode refers to,

- ✓ Time spent driving to the next container after an empty container has beendeposited.
- ✓ Timespentpickinguptheloadedcontainer.
- ✓ Timerequiredtoredepositthecontainer.
- ✓

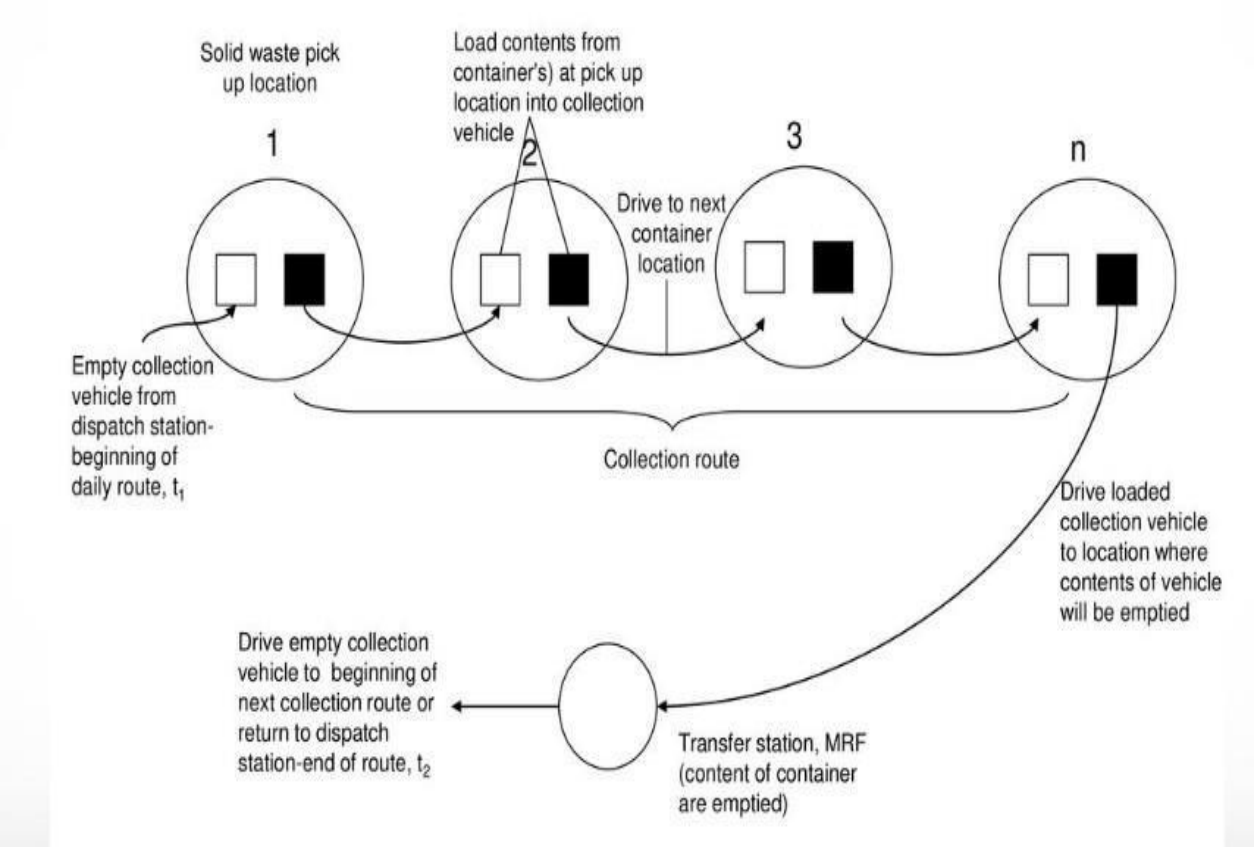
❑ Hauledcontainersystem(exchangecontainermode)



Pick-upasrelatedtotheexchangecontainermoderefers to,

- ✓ Time required to pickup a loaded container and to deposit a container at the next location after its content have been emptied.

❑ Hauledcontainersystem(stationarycontainermode)



Pick-upforstationarycontainersystemrefers to,

The time spent loading the collection vehicle beginning with the stopping of the vehicle prior to loading to the content of the first container and ending whenthe content of the last container to be emptied have been loaded.

✓ Haul

❑ Forhauledcontainersystem

haulingsolidwaste representthe time requiredtoreachthe disposalsite plus time required to deposit the empty container.

❑ Forstationarycontainersystem

the time required to reachthe disposalsite startingafter the last container on the route has been emptied.

- ✓ **Atsite**

  TimeSpentatdisposalandtimespentatLoadingandunloading.

- ✓ **Off-Route**

  Timespentonactivities frompointofoverallcollectionofthesystem.

Mathematical anlysis Haul containersystem

- ✓ Timerequiredpertrip

  Thcs = Phcs +s+ h

  Phcs=pickuptimepertripforhauledcontainersystem. s= at site time/ trip

  h=haultime/ trip

- ✓ Haultime,

  h = a + bx

  a,b=empirical constant

  x=roundtripheaddistance

- ✓ Pickuptimeforhaulcontainersystem

  Phcs =pc + uc +dbc

  pc=timerequiredtopickuploadedcontainer

  uc=timerequiredto unload emptycontainer

  dbc=timerequiredtodrivebetweencontainerlocation.

- ✓ Numberoftripsmadevehicleperday,

Nd =[H(I-w)-(t1+t2)]/Thcs

H=lengthofworkdayh/day

W=off-routefactor,expressedasafraction

t1=time required to drive from dispatch station to the first containerlocation.

t2=timerequiredtodrivefromlastcontainerlocationtodispatch station.

Thcs=timepertripforhauledcontainersystem.

TRANSFERSTATION

Transfer station is a centralized facility where waste is unloadedfrom smaller collection vehicles and reloaded into large vehicles for transport to a disposal or processing site.

Dependingonthesize,transferstationscanbeeitherofthefollowingtwotypes:

- ✓ Smallto mediumtransferstations
- ✓ Largetransferstations

Smalltomediumtransferstations

- ✓ Small to medium transfer stations are direct-discharge stations that provide no intermediate waste storage area.
- ✓ The capacities are generally small (less than 100 tonnes /day) and medium (100 to 500 tonnes / day).
- ✓ Depending on weather, site aesthetics, and environmental concerns, transfer operations of this size maybe located either indoors or outdoors.

Largetransferstations

- ✓ Larger transfer stations are designed for heavy commercial use by private and municipal collection vehicles having capacity more than 500 tonnes/day.
- ✓ When collection vehicles arrive at the site, they are checked in for billing, weighed, and directed to the appropriate dumping area.
- ✓ Collection vehicles travel to the dumping area and empty wastes into a waiting trailer, a pit, or onto a platform.

DesignforLargeTransferOperations:

- ✓ Direct-dischargenoncompactionstation
- ✓ Platform/pitnoncompactionstation
- ✓ Compactionstation

Directdischargenon-compactionstation:

- ✓ Direct-discharge non compaction stations are generally designed with two main operating floors.

- ✓ In the transfer operation, wastes are dumped directly fromcollection vehicles (on the top floor), through a hopper,and into open top trailers on the lower floor. After loading, a cover is placed over the trailer top.

Platform/pitnoncompactionstation

- ✓ In platform or pit stations, collection vehicles dump their wastes onto a floororarea where wastes canbe temporarilystored, and, ifdesired, picked through for recyclables or unacceptable materials.
- ✓ The waste is then pushed into open-top trailers, usually by front-end loaders.
- ✓ Like direct discharge stations, platform stations have two levels. If a pit is used, the station has three levels.

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Compactionstation

- ✓ Compactiontransferstationsusemechanicalequipmenttodensify wastes before they are transferred.
- ✓ Themostcommontypeofcompactionstationusesahydraulically powered compactor to compress wastes.

Benefitsoftransferstations:

- ✓ Offers more flexibility in waste handling and disposal options(choice of landfill or waste to energy).
- ✓ Reducesairpollution,fuelconsumptionandroadwear.
- ✓ Allows for screening of waste between recyclable waste or inappropriate wastes(tires, automobile batteries)that are not allowed inlandfillorwaste to energy facility.
- ✓ Reducestrafficatdisposalsite.
- ✓ Offerscitizens facilities forconvenientdrop-offofwasteandrecyclables.

COLLECTIONROUTES:

- ✓ Detailed route configuration and collection schedules should be developed for the selected collection design.
- ✓ Effective routing can decrease costs by reducing the labor expended for collection.

1. Macroroutingmethod
2. Microroutingmethod
3. Districtingmethod

Macro Routing

- It consists of dividing the total collection area into routes, in such a way as to represent a day's collection for each crew.
- The size of each route depends on the amount of wastes collected per stop, distance between stops, loading time and traffic conditions.
- Natural barriers such as rail road embankments, rivers and roads with heavy competing traffic, can be used to divide route territories.
- As much as possible, the size and shape of route areas should be balanced.

Micro Routing:

- Using the results of the macro-routing analysis, micro-routing can define the specific path that each crew and collection vehicle will take on each collection day.

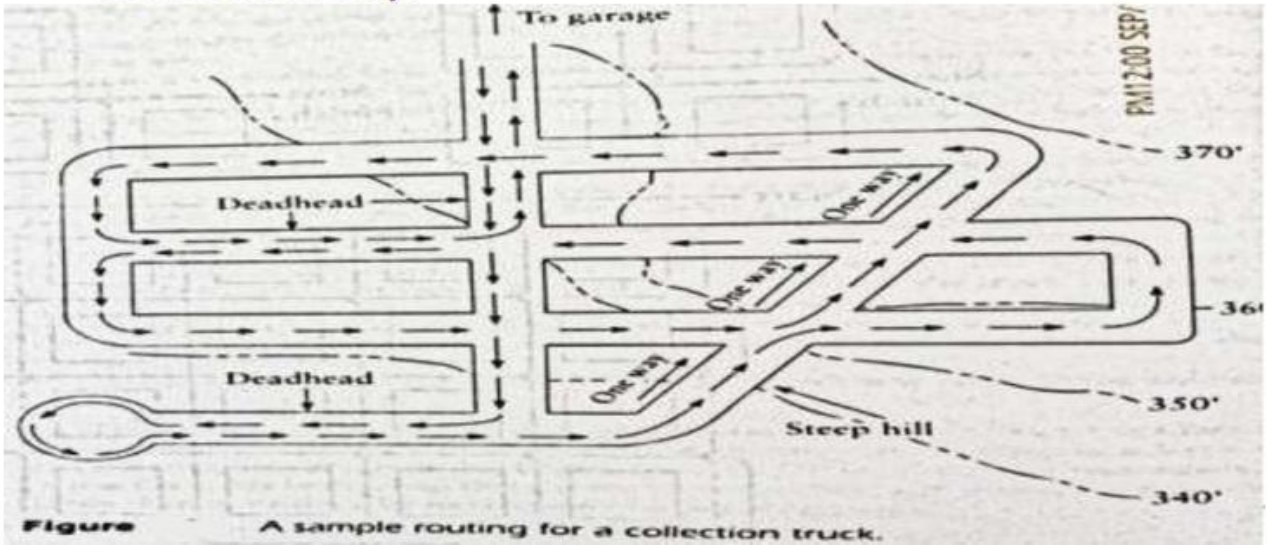
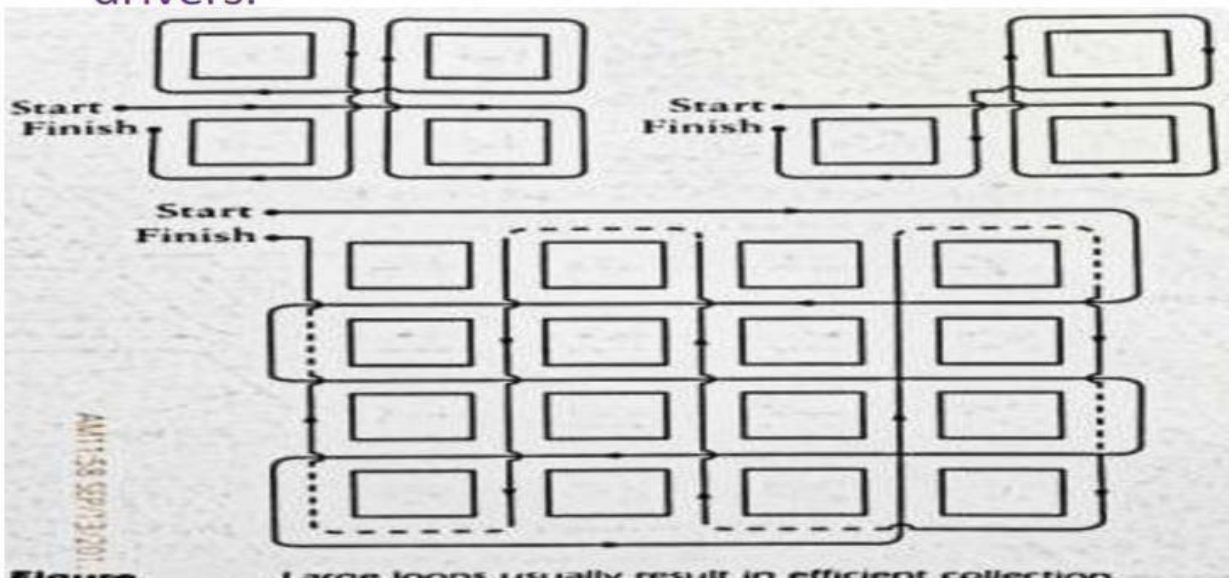


Figure A sample routing for a collection truck.

- Results of micro-routing analysis should also be done by the review of experienced collection drivers.



Deciding Factors for Collection Vehicle Routing:

- The trial & error route development process is a relatively simple manual approach that applies specific routing patterns to block configurations.
- The map should show collection service locations, disposal (or) transfer sites, one-way streets, natural barriers and the area of heavy traffic flows.

- Then, routes should be traced out onto the tracing paper using the following factors:

  (a) Routes should not be fragmented (or) overlapping.

  (b) Total collection (+) Hauling time reasonably constant for each route in the community.

  (c) The collection route should be started as close to the garage (or) motor pool as possible.

  (d) Heavily travelled streets should not be visited during rush hours.

(e) In case of one-way streets, it is best to start the route near the upper end of the street.

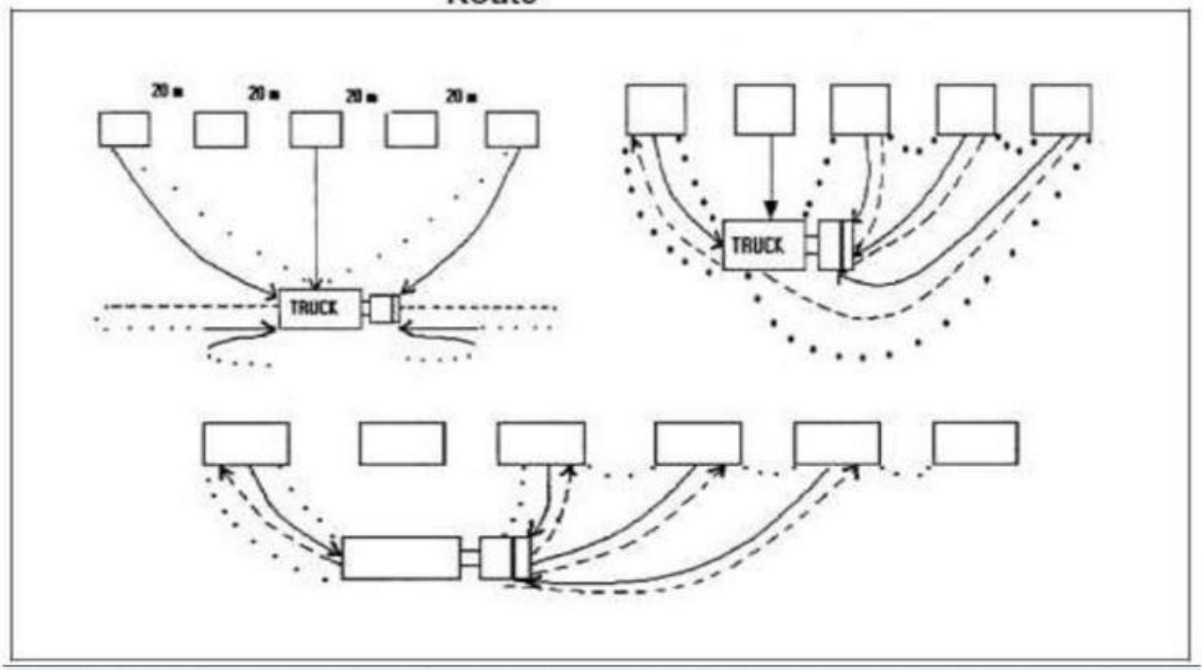
(f) In case of dead-end streets, wastes must be collected by walking down, reversing the vehicle (or) taking a U-turn.

(g) Higher elevations should be at the start of the route.

(h) For collection from one side of the street at a time, it is generally best to route with many anti-clockwise turns around the blocks.

- Based on the above rules, a typical vehicle routing is illustrated below:

Figure Collection Vehicle Route



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Unit IV

Processingof

Wastes

Objectives of waste processing – Physical Processing techniques and Equipment; Resource recovery from solid waste composting and biomethanation; Thermal processing options – case studies under Indian conditions.

ObjectivesofWasteprocessing

Processingtechniquesareusedinsolidwastemanagementsystems,

(1) Toimprovetheefficiencyofsolid-Wastedisposalsystems.

(2) TorecoverResources and

(3) Topreparematerialsfortherecoveryofconversionproductsandenergy.

PhysicalProcessingtechniquesandEquipment

TypesofVolumeReductionforSWM

- ✓ MechanicalVolumereduction
  - ❑ Compaction
  - ❑ Sizereductionandshredding
- ✓ ThermalVolumereduction
- ✓ ChemicalVolumereduction

MechanicalVolume

reductionCompaction

- ✓ The mainpurposeis toreducethe volume (amount)andsizeofwaste,as compared to its original form, and produce waste of uniform size.
- ✓ Compactionisdonebystationaryaswellas movableequipments.

Compactors are based oncompaction pressureapplied to the waste mechanically, for example

- ✓ **Low-pressure (less than 7kg/cm^2) compaction**: In low-pressure compaction, wastes are compacted in large containers.
- ✓ **High-pressure(more than 7kg/cm^2) compaction:**pulverised wastes are extruded after compaction in the form of logs/blocks/bale.

Advantages	Disadvantages
• reduction in the quantity of materials to be handled at the disposal site; • improved efficiency of collection and disposal of wastes; • increased life of landfills; • Economically viable waste management system	• poor quality of recyclable materials sorted out of compaction vehicle; • difficulty in segregation or sorting (since the various recyclable materials are mixed and compressed in lumps); • Bio-degradable materials (e.g., leftover food, fruits and vegetables) destroy the value of paper and plastic material.

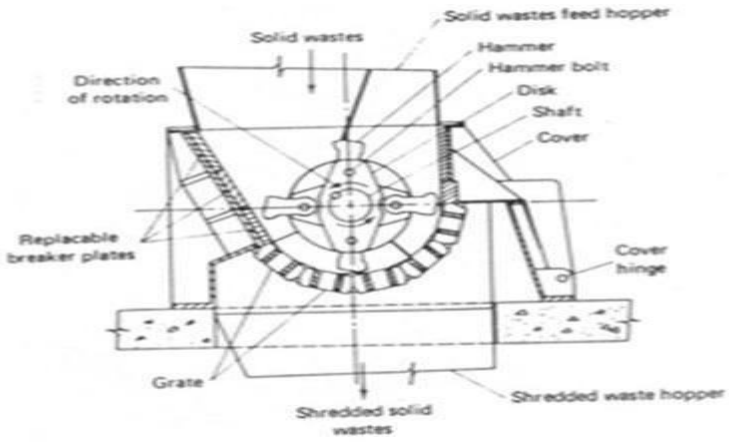
Sizereductionandshredding

Thisisrequiredtoconvertlargesizedwastesintosmallerpieces.

EquipmentsUsed:

- ✓ Hydropulper
- ✓ HammerMill
- ✓ Chipper/Grinder/Shredder/jawcrusher

Hydropulper



HammerMill

Shredder

ThermalVolumereduction

Thermalprocessingofsolidwaste canbe defined as the conversionof wastes into gaseous, liquid and solid production.

Process	Conversion product	Pre-processing
Combustion (Incineration)	Energy in the form of steam or electricity	None in mass-fired incinerator
Gasification	Low-energy gas	Separation of the organic fraction, particle size reduction, preparation of fuel cubes or other RDF
Pyrolysis	Medium-energy gas, liquid fuel, solid fuel	Separation of the organic fraction, particle size reduction, preparation of fuel cubes or other RDF

- ✓ **Combustion** is an exothermic process, which means, it release spontaneously, significant energy to the process become autonomous and, also, to export energy in heat, or, most important, in electric energy
- ✓ **Gasification and pyrolysis** processes are endothermic, which means, it's necessary to supply thermal energy to perform the pyrolysis reactions.

ChemicalVolumeReduction

- ✓ Chemical volume reduction is a method, where in volume reduction occurs through chemical changes brought within the waste either through an addition of chemicals or changes in temperature.
- ✓ chemical methods used to reduce volume of waste chemically include pyrolysis, hydrolysis and chemical conversions.

ComponentSeparation

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

Objectives

- ✓ recoveryofvaluablematerialsforrecycling;
- ✓ preparation of solid wastes by removing certain components prior to incineration, energy recovery, composting and biogas production.

Typesofcomponentseparation

- ✓ AirSeparation
- ✓ Magnetic Separation
- ✓ Screening
- ✓ Floatation

AirSeparation

- ✓ Air separation is primarily used to separate lightermaterials(usually organic) from heavier (usually inorganic) ones.
- ✓ Thelightermaterialmayincludeplastics,paperandpaperproductsand other organic materials.
- ✓ In this technique, the heavy fraction is removed fromthe airclassifier to the recycling stage or to land disposal, as appropriate.
- ✓ Thelightfractionmaybeused,withorwithoutfurthersizereduction,asfuel for incinerators or as compost material.

Commonlyusedairclassifiers,

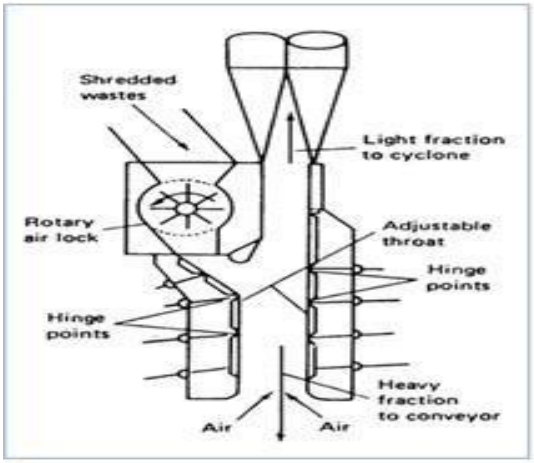
(i) Conventionalchutetype

- ✓ In this type, when the processed solid wastes are dropped into the vertical chute, the lighter material is carried by the airflow to the top while the heavier materials fall to the bottom of the chute.
- ✓ The control of the percentage split between the light and heavy fraction is accomplished by varying the waste loading rate, airflow rate and the cross section of chute.
- ✓ A rotary air lock feed mechanism is required to introduce the shredded wastes into the classifier.

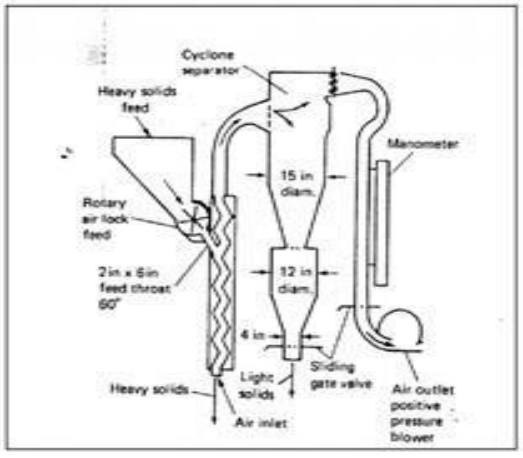
ii)Zigzagairclassifier:

- ✓ Zigzag air classifier consists of a continuous vertical column with internal zigzag deflectors through which air is drawn at a high rate.
- ✓ Shredded wastes are introduced at the top ofthe 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 fraction is fluidised and moves upward and out of column, while the heavy fraction falls to the bottom.
- ✓ Best separation can be achieved through proper design of the separation chamber, airflow rate and influent feed rate.

ConventionalChuteType



Zigzag Air Classifier

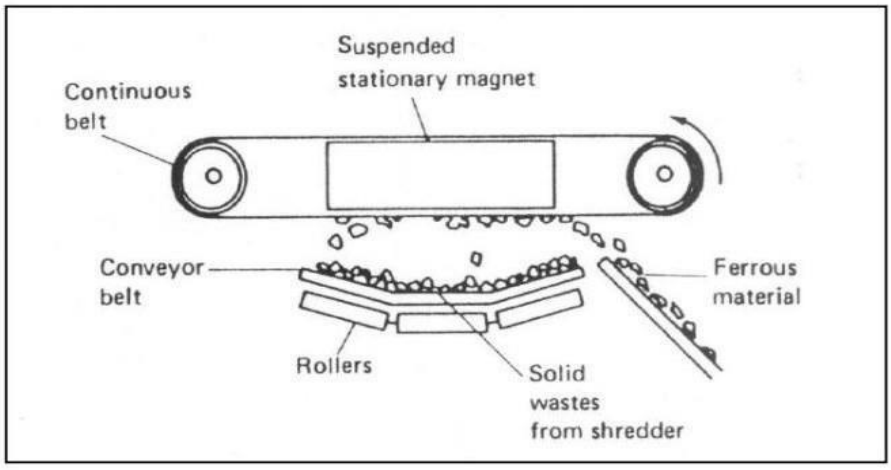


MagneticSeparation

- ✓ The most common method of recovering ferrous scrap from shredded solid wastes involves the use of magnetic recovery systems.
- ✓ Ferrous materials are usually recovered either after shredding or before air classification.
- ✓ Whenwastesare mass-firedinincinerators,the magneticseparatoris usedto remove the ferrous material from the incinerator residue.
- ✓ Magneticrecoverysystems havealsobeenusedatlandfilldisposalsites.
- ✓ Themostcommontypesarethefollowing:

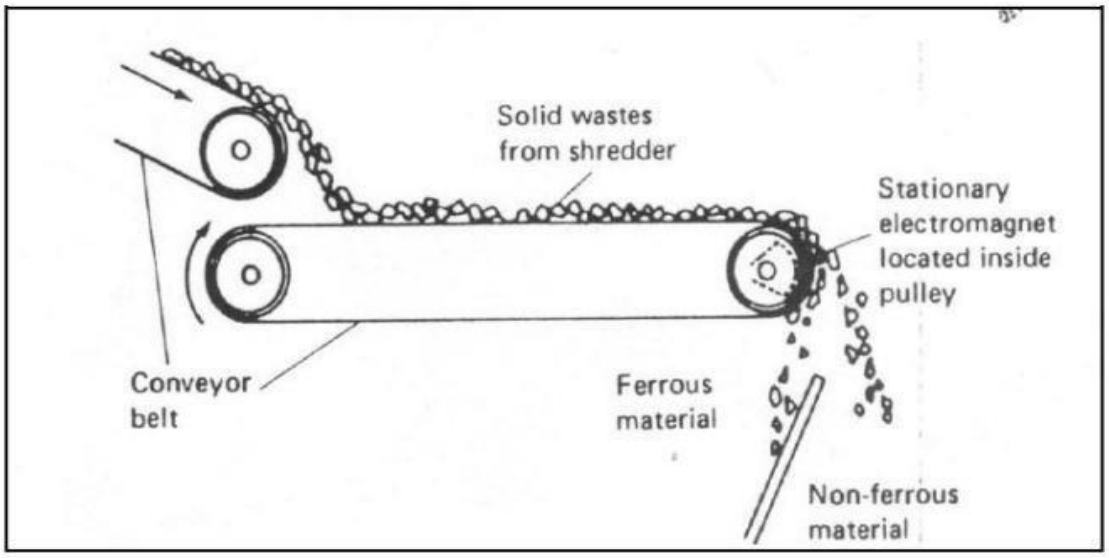
Suspendedmagnet

- ✓ 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 container.
- ✓ This type of separation device is suitable for processing raw refuse, where separators can remove large pieces of ferrous metal easily from the waste stream.



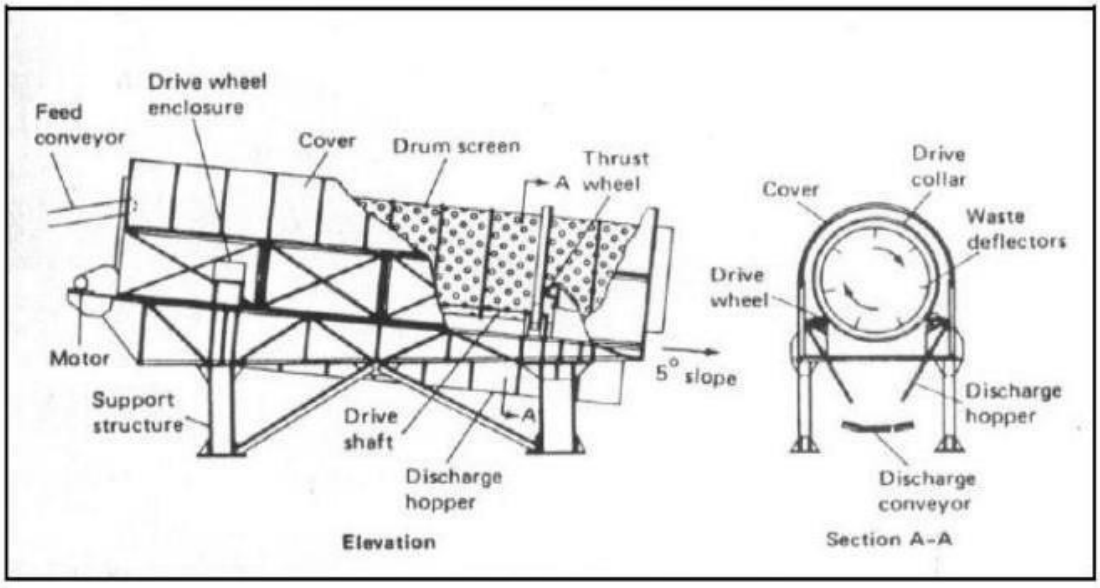
(ii) Magneticpulley:

- ✓ This consists of a drum type device containing permanent 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 materialaway fromthe falling streamof solid waste.



Screeningofwaste

- ✓ Screens can be used before or after shredding and after air separation of wastes in various applications dealing with both light and heavy fraction materials.
- ✓ The size of the sieve is decided based on the waste size required for treatment.
- ✓ The most commonly used screens are rotary drum screens and vibrating screens.



SeparationTechniques

1. Hand-sortingorpreviewing

- ✓ Previewing ofthe waste streamand manual removal of large sized materials is necessary, prior to most types of separation or size reduction techniques.
- ✓ This is done to prevent damage or stoppage of equipment such as shredders or screens, due to items such as rugs, pillows, mattresses, large metallic or plastic objects, wood or other construction materials, paint cans, etc.

2. Inertialseparation

- ✓ Inertialmethods rely on ballistic orgravityseparationprinciplestoseparate *shredded solid wastes* into light (i.e., organic) and heavy (i.e., inorganic) particles.

3. SeparationbyFlotation:

- ✓ Inthe flotationprocess,glass-richfeedstock,whichisproduced byscreening the heavy fraction of the air-classified wastes after ferrous metal separation, is immersed in water in a soluble tank.
- ✓ Heavymaterialsettles andlighterareremovedfromfloatables.

4. Opticalsorting

Optical sorting is used mostly to separate glass from the waste stream, and this can be accomplished by identification of the transparent propertiesofglasstosortitfromopaque materials(e.g.,stones,ceramics, bottle caps, corks, etc.) in the waste stream.

5. Dryingand Dewatering

- ✓ Dryinganddewateringoperationsareusedprimarilyforincineration systems, with or without energy recovery systems.
- ✓ Thesearealsousedfordryingofsludgesinwastewatertreatmentplants, prior to their incineration or transport to land disposal.
- ✓ The purpose ofdrying and dewateringoperation is to remove moisture from wastes and thereby make it a better fuel.

Basictechniquesofenergy recovery

Thermo-chemicalconversion

- ✓ Thermal decomposition of organic matter to produce heat energy or fuel or gas.
- ✓ Techniquesincludeincinerationandpyrolysisandgasification.

Bio- chemical conversion

- ✓ Decomposition oforganic matter by microbialactionto produce compost or methane gas or alcohol.
- ✓ Techniquesincludeanaerobicdigestion,alsoreferredasbiomethanation.

Parametersaffectingenergyrecovery:

Physicalparameters

- ✓ Sizeofconstituents
- ✓ Density
- ✓ Moisturecontent

Chemicalparameters

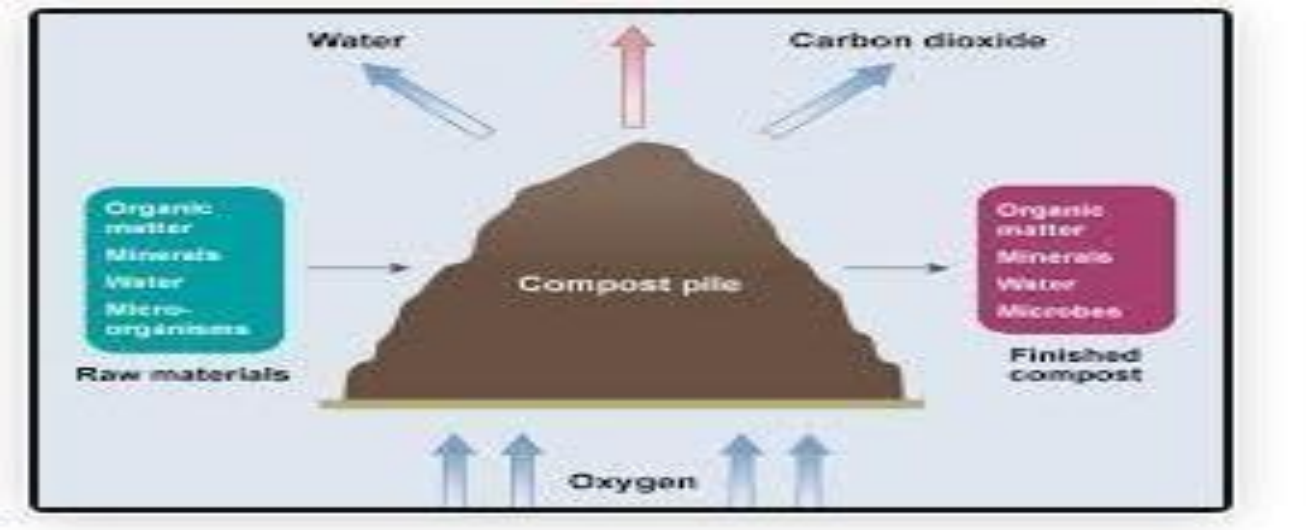
- ✓ Volatilesolids
- ✓ Fixedcarboncontent
- ✓ Inerts
- ✓ calorificvalue
- ✓ C/Nratio
- ✓ toxicity

Waste treatment method	Basic principle	Important waste parameters	Desirable range
Thermochemicalconversion - Incineration - Pyrolysis - Gasification	Decomposition of organic matter by action of heat	Moisture content Volatile matter Fixed carbon Total inerts Calorific value (Net CV)	< 45 % > 40% < 15 % < 35 % > 1200 Kcal/Kg
Biochemical Conversion - Anaerobic digestion - Biomethanation	Decomposition of organic matter by microbial action	Moisture content Volatile matter C/N ratio	> 50% > 40% 25-30

Source :[COWI, 2004]

COMPOSTING

Composting is an aerobic method (meaning that it requires the presence of air) of decomposing organic solid wastes. It can therefore be used to recycle organic material. The process involves decomposition of organic material into a humus-like material, known as compost, which is a good fertilizer for plants.



COMPOSTINGSTAGES

- ✓ Prepartion
- ✓ Digestion
- ✓ Curing
- ✓ ScreeningOrFinishing
- ✓ StorageOrDisposal

✓ **COMPOSTINGTECHNOLOGY**

1. WindrowComposting

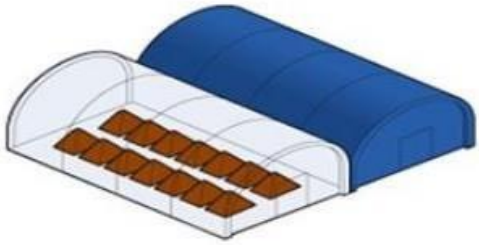
- There is usually some level of feedstock preparation (i.e. size reduction, mixing etc.).
- Large piles or windrows of composting materials can be composted outdoors on a paved or unpaved surface.
- Aeration and mixing is provided specialized windrow turner.
- This is a common method for composting, particularly for leaf and yard wastes

2. Aeratedstaticpilecomposting

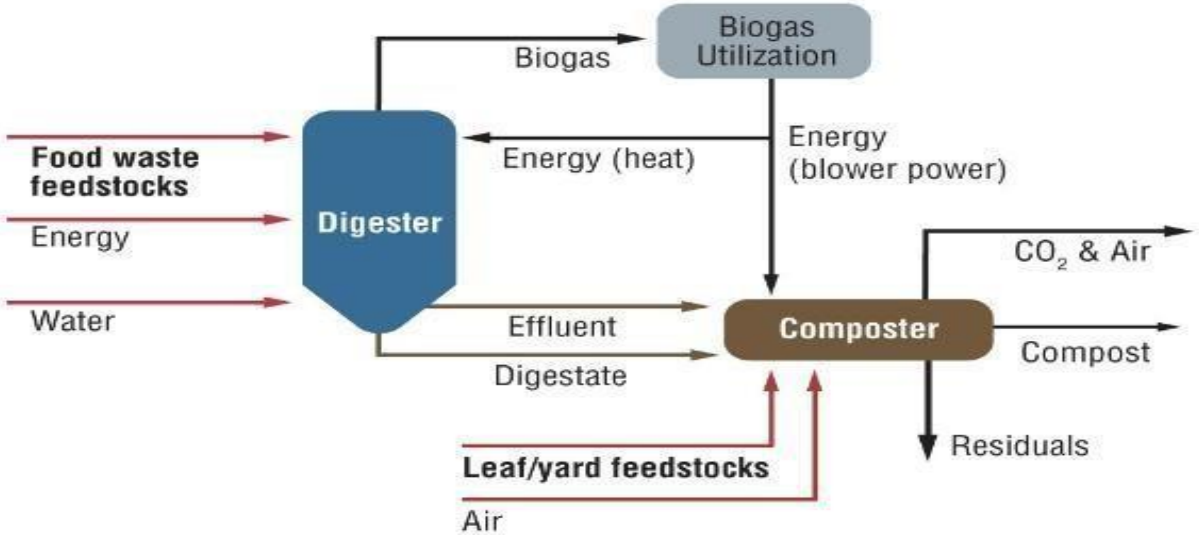
- There is usually some level of feedstock preparation (i.e. size reduction, mixing etc.)
- This is a pile or windrow of composting material that receives minimal turning (i.e. 1-4 turnings) and aeration.
- It takes longer to produce a finished compost product than with other technologies.

3. Invesselcompostingsystem

- composting takes place in a purpose built container or tunnel.
- one or a number of containers.
- Aeration is provided via a mechanical aeration system.
- All in-vessel systems will include some level of feedstock preparation (i.e. size reduction, mixing



Anaerobiccomposting



EN8591-MUNICIPALSOLIDWASTEMANAGEMENT

Compostingprocess

Biologicalprocess

- ✓ Mesophilicormoderatetemperaturephase
- ✓ Thermophilicorhightemperaturephase
- ✓ Coolingphase
- ✓ Maturingorcuringphase

Chemical processes

- ✓ Carbon/energysource
- ✓ Moisture
- ✓ Nutrients
- ✓ Oxygen
- ✓ pH

Physical processes

- ✓ Particlesize
- ✓ Temperature
- ✓ Mixing

CompostingplantsforIndianmunicipalsolidwaste

- ✓ Assessmentanddevelopmentofmarket
- ✓ Selectionofsite
- ✓ Pilotstudies
- ✓ Flowsheet
- ✓ Environmentalcontrol

Biomethanation

- ✓ Pre-treatment
- ✓ Wastedigestion
- ✓ Gas recovery
- ✓ Residuetreatment

Importantoperatingparametersforbiomethanation

- ✓ Temperature
- ✓ pH
- ✓ Moisture
- ✓ Toxicity
- ✓ C/Nratio
- ✓ Organicloadingrate
- ✓ Retentiontime

Thermalprocessingoptions

- ✓ Incineration
- ✓ Gasification
- ✓ Pyrolysis

Incineration

- ✓ Incinerationis awastetreatmentprocessthat involvesthecombustionof organic substances contained in waste materials.
- ✓ Incinerationofwaste materialsconvertsthewasteintoash,flue gasand heat.
- ✓ Theashis mostlyformed bythe inorganicconstituentsofthewasteand may take the formof solid lumps or particulates carried bythe flue gas.

- ✓ The flue gases must be cleaned of gaseous and particulate pollutants before they are dispersed into the atmosphere.
- ✓ Thefluegasesmaycontain particulatematter, heavymetals, dioxins, furans, sulfur dioxide, and hydrochloric acid.
- ✓ **Particulates** – also known as **atmospheric aerosol particles**, **atmospheric particulate matter**, **particulate matter** (**PM**), or **suspended particulate matter** (**SPM**) –

  aremicroscopicparticlesofsolidorliquidmattersuspendedintheair.
- ✓ **Heavymetals** aregenerallydefinedas metalswithrelatively high densities, atomic weights, or atomic numbers.
- ✓ **Polychlorinated dibenzodioxins** (**PCDDs**), or simply **dioxins**, are a group of polyhalogenatedorganic compoundsthat are significant environmental pollutants.
- ✓ Dioxins occur as by-products in the manufacture of some organochlorides,in the incineration of chlorine-containing substances such as polyvinylchloride(PVC), in the chlorine bleachingofpaper, and from natural sources such as volcanoes and forest fires.[
- ✓ **Furan**isaheterocyclicorganiccompound,consistingofafive- membered aromaticring with four carbon atoms and one oxygen. Chemical compounds containing such rings are also referred to as furans.
- ✓ Furanisfoundinheat-treatedcommercialfoodsandisproduced through thermal degradationof natural food constituents. It can be found in roasted coffee, instant coffee, and processed baby foods.
- ✓ **Sulfur dioxide** or **sulphur dioxide** is the chemical compoundwith the formula SO_2. It is a toxic gasresponsible for the smell ofburnt matches.

- ❑ Incineration with energy recovery is one of several waste-to-energy technologies such as gasification, pyrolysis and anaerobic digestion.

- While incineration and gasification technologies are similar in principle, the energy produced from incineration is high-temperature heat whereas combustible gas is often the main energy product from gasification.

Incinerationobjectives

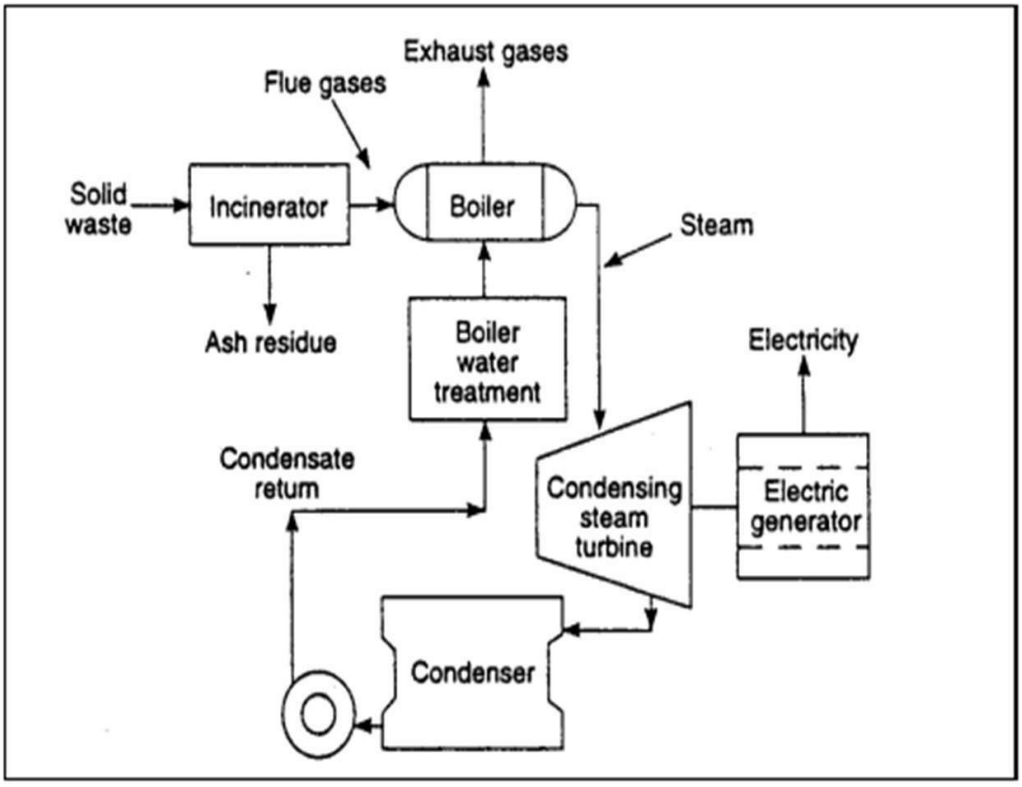
- ✓ Volumereduction
- ✓ Stabilizationofwaste
- ✓ Recoveryofenergyfromwaste
- ✓ Sterilizationofwaste

Planninganincinerationfacility

- Facilityownershipandoperation
- Energymarket
- Marketingsteam
- Marketingelectricity
- Facilitysiting
- Faciltysizing
- Facilityfinancing

Energyrecoveryfromincineration

- Generationofelectricity
- Steamgeneration
- Co-generation



Airemissionfromincineration

Gaseouspollutants

- ✓ Carbondioxide
- ✓ Carbonmonoxide
- ✓ Sulphuroxides
- ✓ Nitrogenoxides
- ✓ Particulates
- ✓ Hydrochloricacid
- ✓ Hydrogenfluoride
- ✓ Heavymetals
- ✓ Dioxinsandfurans

Gascleaningequipment:

- Electrostaticprecipitators
- Fabricfilters
- Scrubber

- An **electrostatic precipitator** (**ESP**) is a filtration device that removes fine particles, like dust and smoke, from a flowing gas using the force of an induced electrostatic chargeminimally impeding the flow of gases through the unit.

- Dust collectors that use liquid are known as wet scrubbers. Inthesesystems, the scrubbing liquid (usually water) comes into contact with a gas stream containing dust particles. Greater contact of the gas and liquid streams yields higher dust removal efficiency.

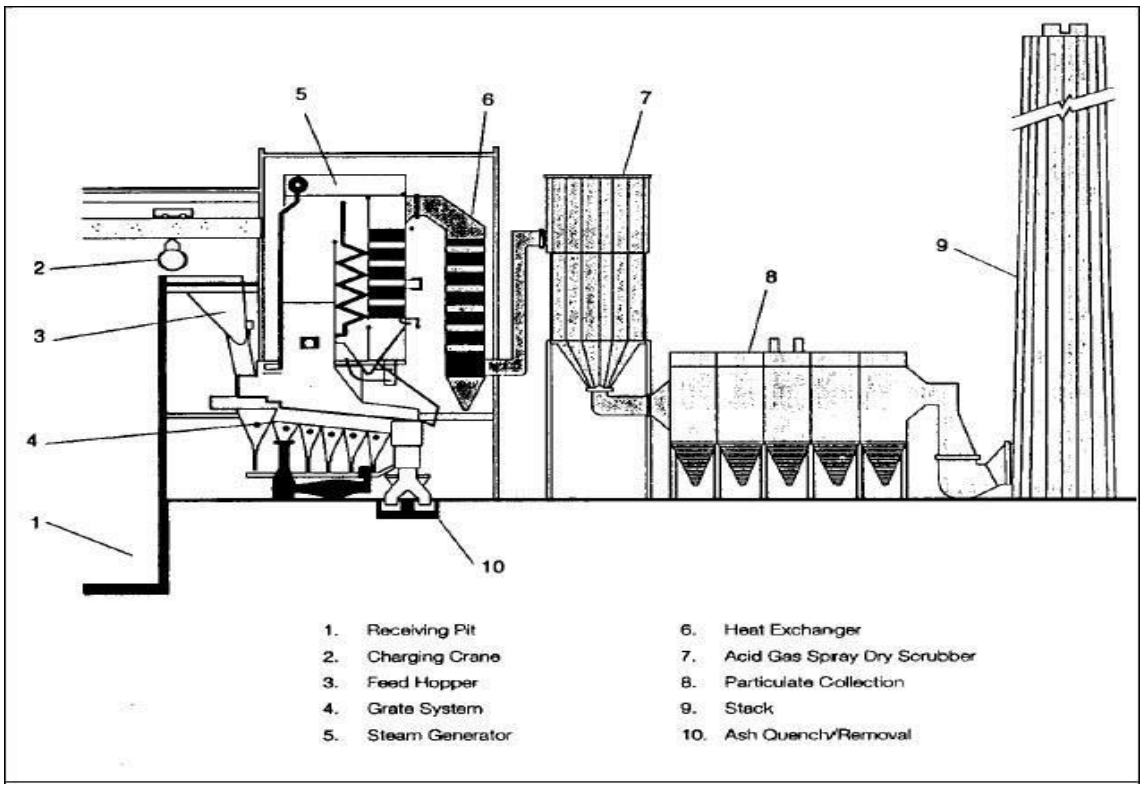
- Fabricfilterscommonlyknownas baghouses,isan airpollutioncontroldevice and dust collectorthat removes particulatesor gas released from commercial processes out of the air. It can achieve a collection efficiency of more than 99% for very fine particulates.

- Dust-laden gases enter the baghouse and pass through fabric bags that act as filters. The bags can be of woven or felted cotton, synthetic, or glass-fiber material in either a tube or envelope shape.

Incinerationtechnologies:

- Massburningsystem
- RefuseDerivedFuel(RDF)system
- Modularincineration
- Fluidisedbedincineration

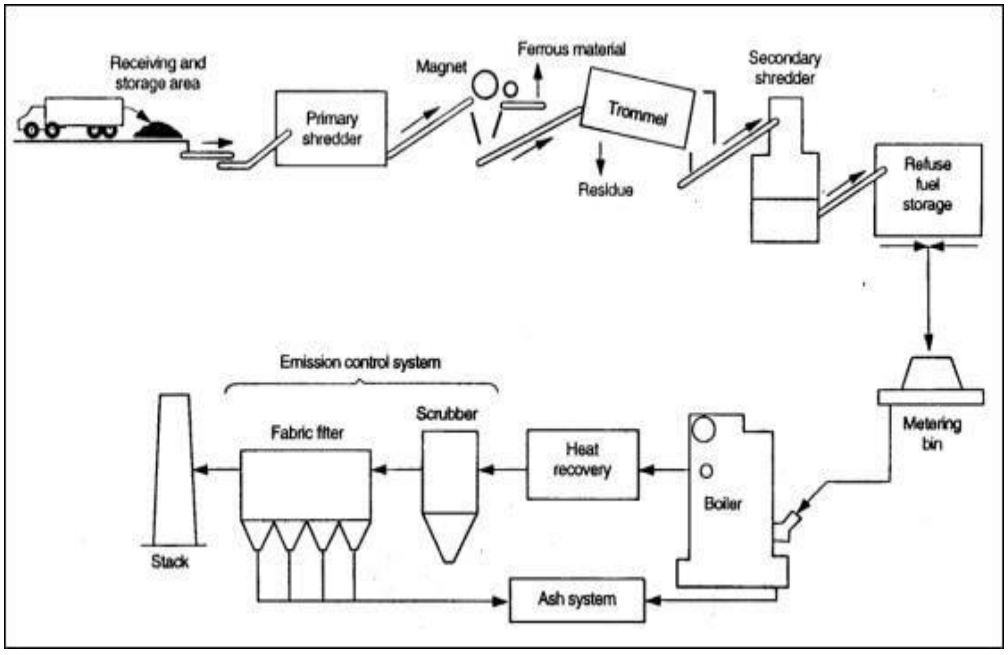
❑ Massburningsystem



- ✓ A Mass burn facility typically consists of a reciprocating grate combustion system and a refractory-lined, water-walled steam generator.
- ✓ Mass-burnsystems generallyconsist ofeither two or three incineration units ranging in capacity from 50 to 1,000 tonnes per day.
- ✓ Because of the larger facility size, an incineration unit is specially designed to efficiently combust the waste to recover greater quantities of steam or electricity for revenue.
- ✓ To achieve this greater combustion and heat recovery efficiency, the larger field-erected incinerators are usually in-line furnaces with a grate system.
- ✓ The steam generator generally consists of boiler as an integral part and refractory-coated water wall systems, i.e walls comprised of tubes through which water circulates to absorb the heat of combustion.
- ✓ Mass-burningofwastecanalsobeachievedbytheuseofarotarykiln.

- ✓ Rotary kilns use a turning cylinder, either refractor or water wall design, to tumble the waste through the system.
- ✓ The kiln is reclined, with waste entering at the high elevation end and ash and non-combustibles leaving at the lower end.
- ✓ The waste intake area usually includes a tipping floor, pit, crane and sometimes conveyors.
- ✓ At least two combustor units are included to provide a level of redundancy and to allow waste processing at a reduced rate during periods of scheduled and unscheduled maintenance.
- ✓ Mass-burn facilities today generate a higher quality of steam (i.e., pressure and temperature), which is then passed through a turbine generator to produce electricity or through an extraction turbine to generate electricity as well as provide process steam for heating or other purposes.

Refusederivedfuelsystem



- ✓ Refuse-derived fuel (RDF) refers to solid wastes in any form that is used as fuel.
- ✓ The term RDF, however, is commonly used to refer to solid waste that has been mechanically processed to produce a storable, transportable and more homogeneous fuel for combustion.
- ✓ RDF systems have two basic components: RDF production and RDF incineration.
- ✓ RDF production facilities make RDF in various forms through material separation, size reduction and pelletising.
- ❑ It is shredded into a uniformgrainsize, oralso pelletized inorderto produce a homogeneous material which can be used as substitute for fossil fuels.
- ❑ RDF can be used in a variety of ways to produce electricity. It can be used alongside traditional sources of fuel in coal power plants.

Therearetwoprimarytypesofsystemsinoperation,andtheseare:

(i) Shred-and-burnsystems:

The process system typically consists of shreddingthe MSW to the desired particle size that allows effective feeding to the combustor and magnetic removal of ferrous metal, with the remaining portion delivered to the combustor. This, in essence, is a system with minimal processing and removal of non combustibles.

(ii) Simplifiedprocesssystems:

This is a system that removes a significant portion of the non-combustibles. A simplified process system involves processing the MSW to produce an RDF with a significant portion of the non-combustibles removed before combustion.

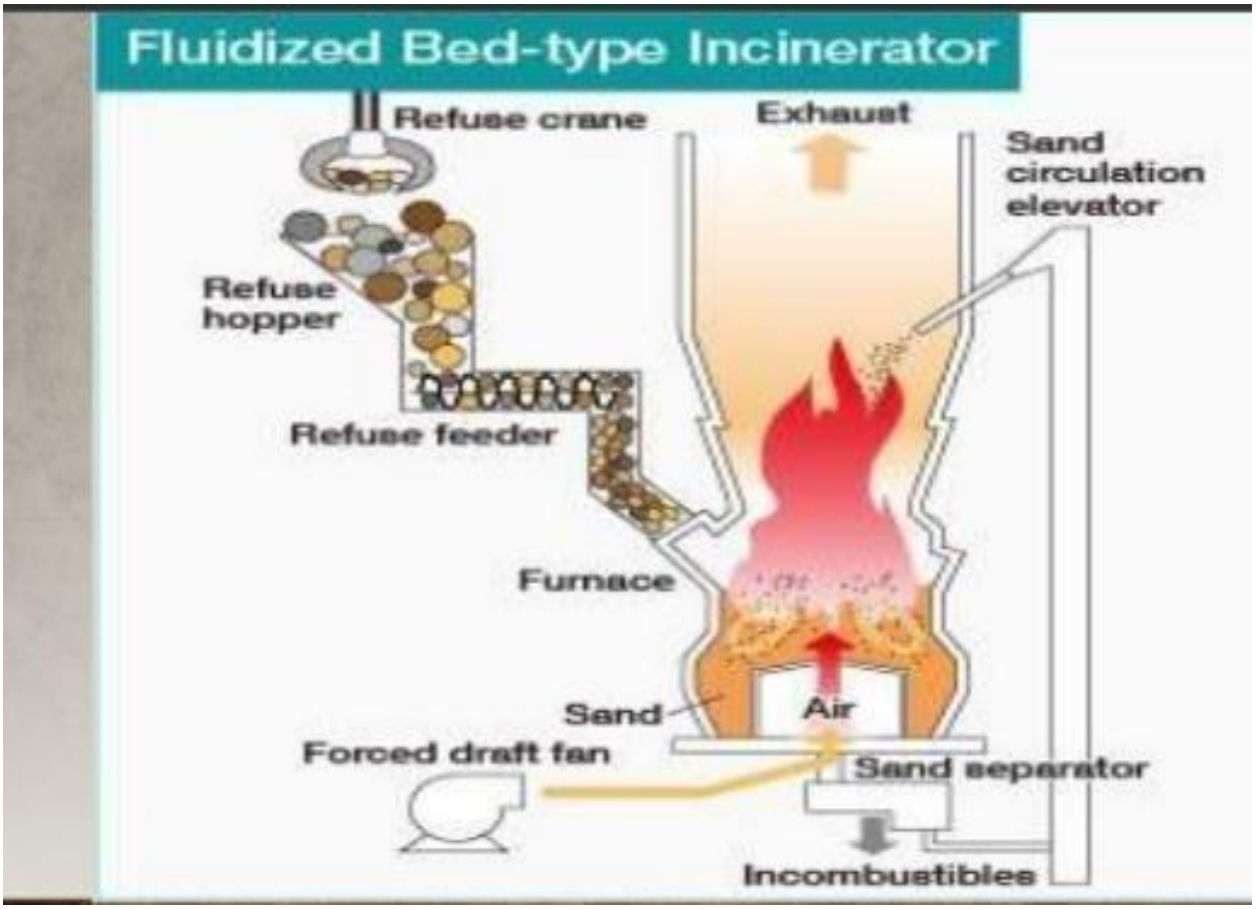
The MSW process removes more than 85% ofthe ferrous metals,asignificantpercentageoftheremainingnon-combustible (i.e.,glass,nonferrousmetals,dirt,sand,etc.),andshredsthematerial to a

nominal particle top size of 10 to 15 cm to allow effective firing in the combustion unit.

Depending on the type of combustor to be used, a significant degree of separation can be achieved to produce a high-quality RDF (i.e., low ash), which typically results in the loss of a higher percentage of combustibles when compared to systems that can produce a low-quality fuel (i.e., slightly higher ash content) for firing in a specially designed combustor.

These types of systems recover over 95% of the combustiblesinthefuelfraction.

- Fluidisedbedincineration



✓ Fluidised-bed incineration of MSW is typically medium scale, with processing capacity from 50 to 150 tonnes per day.

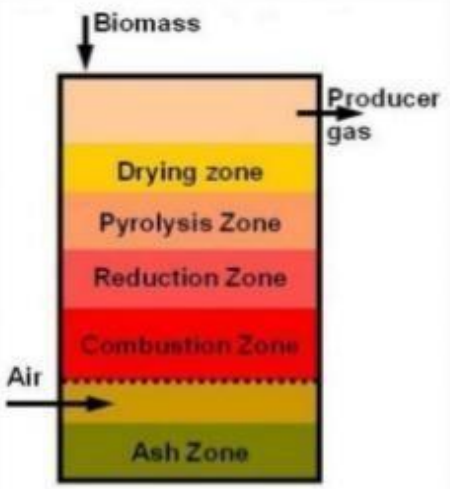
- ✓ In this system, a bed of limestone or sand that can withstand high temperatures, fed by an air distribution system, replaces the grate.
- ✓ The heating of the bed and an increase in the air velocities cause the bed to bubble, which gives rise to the term *fluidised*.
- ✓ There are two types of fluidised-bed technologies, viz., bubbling bed and circulating bed.
- ✓ The differences are reflected in the relationship between air flow and bed material, and have implications for the type of wastes that can be burned, as well as the heat transfer to the energy recovery system.

❑ ModularIncineration

- ✓ Modular incinerator units are usually prefabricated units withrelatively small capacities between 5 and 120 tonnes of solid waste per day.
- ✓ Themajorityofmodularunitsproducesteamasthesoleenergyproduct.
- ✓ Due to their smallcapacity, modular incinerators are generally used insmall communities or for commercial and industrial operations.
- ✓ Theirprefabricateddesigngives modularfacilitiestheadvantageofashorter construction time.

Gasification

- Gasification process is a process of conversion of solid fuel into gaseous fuel for wide applications.
- It produces gaseous fuels like H_2,CO,CH_4,N_2 of low calorific value.
- Biomass Gasification converts biomass into electricity and products, such as ethanol, methanol, fuels, fertilizers, and chemicals.
- In this operation feedstock is heated to high temperatures, producing gases which can undergo chemical reactions to form a synthesis gas.



Basic gasification process with different zone.

Pyrolysis

- Pyrolysis is the process which converts biomass directly into solid (charcoal), liquid (bio oil), and gaseous (fuel gas) products by thermal decomposition of biomass in the absence of oxygen.
- The relative amounts of the three co-products depend on the operating temperature and the residence time used in the process.
- Pyrolytic oil may be used directly as a liquid fuel for boiler, diesel engine, gas turbine for heat and electricity generation, or catalytically upgraded to transport grade fuels.
- In all thermo-chemical conversion processes, pyrolysis plays a key role in the reaction kinetics .

UnitV

Waste

Disposal

Land disposal of solid waste - Sanitary landfills – site selection, design and operation of sanitary landfills – Landfill liners – Management of leachate and landfill gas- Landfill bioreactor – Dumpsite Rehabilitation

Disposal

- ✓ ItisthefinalelementintheSolidWasteManagementsystem.
- ✓ The semi-solid or solid matters created by human or animal beings whichare useless and hazardous are disposed in the landfill.

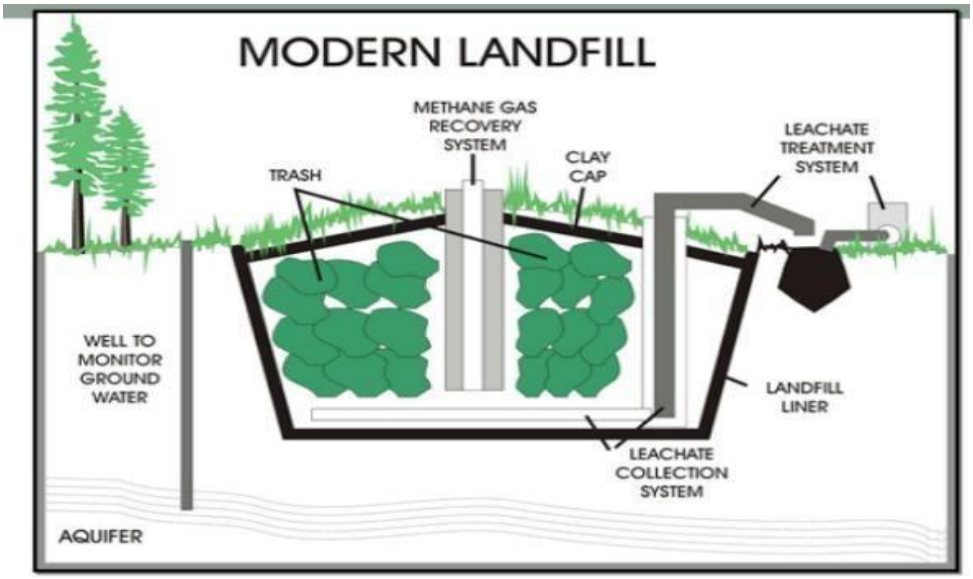
Mostcommondisposaloptions

- ✓ Uncontrolleddumpingornon-engineereddisposal
- ✓ Sanitarylandfill
- ✓ Composting
- ✓ Incineration
- ✓ Gasification
- ✓ Refusederivedfuel
- ✓ Pyrolysis

Landfill/SanitaryLandfill

- ❑ Landfill generally refers to an engineered deposit of wastes either in pits/trenches or on the surface.
- ❑ Sanitary landfill is essentially a landfill, where proper mechanisms are availabletocontroltheenvironmentalrisksassociatedwith the disposal of wastes and to make available the land, subsequentto disposal,for other purposes.

- Variousgasesgeneratedinsanitarylandfill,
  - ✓ Methane(50-60%)
  - ✓ Carbondioxide(30-40%)
  - ✓ Oxygen
  - ✓ Nitrogen
- Thepurposeoflandfillingistoburyoralterthechemical composition of the wastes so that they do not pose any threat to the environment or public health.
- Landfillsarenothomogeneousandareusuallymadeupofcellsin 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), whichrestrictsdownwardor lateralescapeofthewasteconstituentsor leachate.
- An environmentally sound sanitary landfill comprises appropriate liners for protectionofthegroundwater(fromcontaminatedleachate),run-offcontrols,leachatecollectionandtreatment,monitoringwells andappropriate final cover design.



Lifecycleoflandfillare,

- ❑ Planningphase
- ❑ Constructionphase
- ❑ Operationphase(5-20years)
- ❑ Completedphase(20-100years)
- ❑ Finalstoragephase

1. **Planning phase** –involves Preliminaryhydro-geologicaland geo-technical site investigations as a basis for actual design.

2. **Construction phase** – involvesEarthwork, road and facility construction and preparation (liners, drains) of the fill area.

3. OperationPhase(5-20years)

- ✓ Involvesworkatthefrontofthefillarea
- ✓ Operationofenvironmentalinstallations
- ✓ Completionoffinishedsections
- ✓ Hasahightraffic intensity

4) Completedphase(20-100years)

- ✓ Itinvolvesterminationofactualfillingtothetimewhenenvironmental installations need no longer to be operated.
- ✓ Theemissionsmayhavedecreasedtoalevelwherethey donotneedany further treatment and can be discharged freely into the surroundings.

5) Finalstoragephase

- ✓ Inthisphasethelandfillisintegratedintothesurroundingsforthe further purpose, no longer needs special attention.

LANDFILLOPERATIONISSUES

❑ General

Importantissuestobelookedintoregardare,

- ✓ Landrequirements
- ✓ Typesofwastesthatarehandled
- ✓ Evaluationofseepagepotential
- ✓ Designofdrainageandseepagecontrolfacilities
- ✓ Developmentofgeneraloperationplan
- ✓ Designofsolidwastefilling plan
- ✓ Determinationofequipmentrequirements

❑ Designandconstruction

- ✓ Siteinfrastructure
- ✓ Earthworks
- ✓ Lininglandfillsites
- ✓ Leachateandlandfillgas management
- ✓ Landfillcaping

❑ OPERATION

Tosecurepublicacceptabilitylandfilloperationsrequirecarefulplanning and determination of the extent of environmental effects.

1. Methodsoffilling

- ✓ Trenchmethod
- ✓ Areamethod
- ✓ Canyon/depression

- ✓ Cellmethod

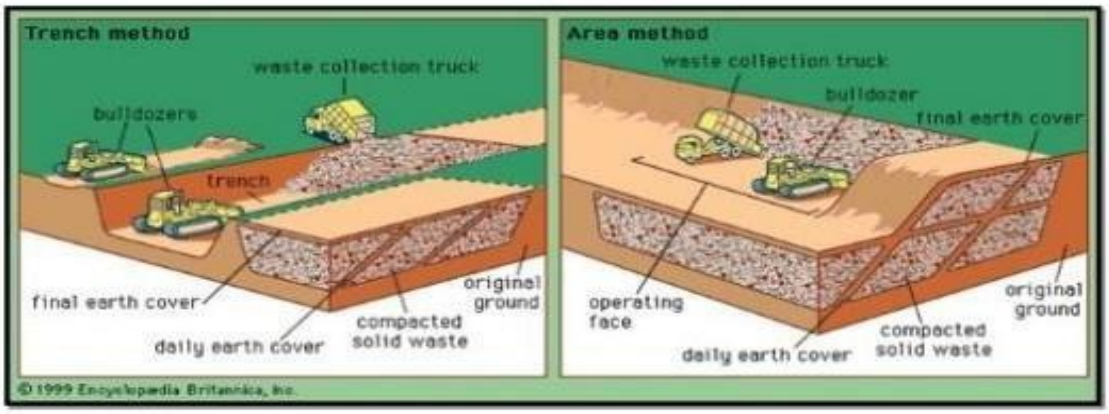
2. Refuseplacement
3. Coveringofwaste
4. Siteequipmentandworkforceorientation

Trenchmethod

- ✓ Ideallysuitedtoareaswhereanadequatedepthofcover materialisavailable at the site and water table is not near the surface.
- ✓ SWareplacedincells/trenchesexcavatedinthesoil.
- ✓ Soilexcavatedfromthesiteisused fordailyandfinalcover.
- ✓ Excavated cells are lined with synthetic membrane liners/ low permeability clay/combination of two to limit the movement oflandfill gas and leachate.

Areamethod

- ✓ Used when terrain is unsuitable for excavation of cells/ trenches and GW table is high. Site preparation includes installation of liners and leachate management system.
- ✓ Covermaterialmustbeobtainedfromadjacent land/burrow,pitareas.
- ✓ Since there is limited material for covering, compost, foundrysand has been utilized as intermediate cover material.
- ✓ Temporary cover material of soil and geosynthetic blankets placed temporarily over completed cell and removed before next lift is began.
- ✓ Leachategenerationmayoccurandmaybedifficulttocontrol.



Methods of Landfilling

Canyon/depressionmethod

- ✓ Technique involves placement and compaction of SW in canyon/ depression.
- ✓ It differs with geometry of site, characteristics of available cover material,hydrology, geology of the site.
- ✓ Controlofsurfacedrainageisoftenacriticalfactorinthismethod.
- ✓ Filling starts at the headed of canyon and ends at mouth, to prevent accumulation of water behind the landfill.

Cellmethod

- ✓ This methodinvolvesthedepositionofwasteswithinpre-constructed bounded area.
- ✓ Itisnowthepreferredmethodintheindustrializedworld,sinceit encourages the concept of progressive filling and restorations.

- ✓ Operating a cellular method of filling enables wastes to be deposited in atidy manner, as the cells serve both to conceal the tipping operation and trap much of the litter that has been generated.

Refuseplacement

- ✓ The working space should be sufficiently extensive to permit vehicles to manipulate and unload quickly and safely.
- ✓ Depositing of waste in thin layers and using a compactor enables a high waste density to be achieved.
- ✓ Eachprogressivelayershouldnotbemorethan30cmthick.
- ✓ The number of passes by a machine over the waste determines the level of compaction.

Coveringofwaste

- ✓ At the end of each working day working space should be covered with a suitable inert material to a depth of at least 15cm.
- ✓ Itisessentialasitreduceswindblownlittersandhelpreduceodours.
- ✓ Cover material may be obtained from on-site excavations or inert materials coming to the site.
- ✓ Pulverised fuelashorsewagesludgecanalsobeusedforthispurpose.

Siteequipmentandworkforceorientation

- ✓ The equipment used on landfill sites include steel wheeled compactors, tracked dozers, loaders, earth movers and hydraulic excavators.
- ✓ Scrapersareusedforexcavatingandmovingcovermaterials.

❑ Monitoring

- ✓ Leachategas
- ✓ Groundwater

AdvantagesofLandfilling

- ✓ Incinerationisacostlyprocess,residuerequiresultimatedisposalonland.
- ✓ Compostingisaseasonaloption.
- ✓ ItisnotpossibletoreclaimandrecycleallSWmaterial.
- ✓ Thuslandfillingisthemostconvenientoption.

Disadvantages

- ✓ Difficulttofindsuitablesitewithineconomicallyfeasibledistance.
- ✓ It is not possible to build a completelysafe and secure SW landfill. Some of the pollutants may escape in the environment in the form of leachate.
- ✓ Potentialharmtopublichealthduetoair,soil,waterandnoisepollution
- ✓ Damagetolocalecosystem.
- ✓ Public oppose

LandfillSettlingprocess

It consists of three stages

1. Primaryconsolidation
2. Secondarycompression
3. Decomposition

2. Primaryconsolidation

- ✓ Substantialamountofsettlingoccursatthisstage.
- ✓ Itiscausedby weightof thewastelayers,truckmovements,bulldozers, mechanical compactors.
- ✓ Afterthisstageaerobicdegradationofwaste occurs.

2. Secondarycompression

- ✓ Rateofsettlingis muchlowerthanfirststage.
- ✓ Settlingoccursthroughcompression.

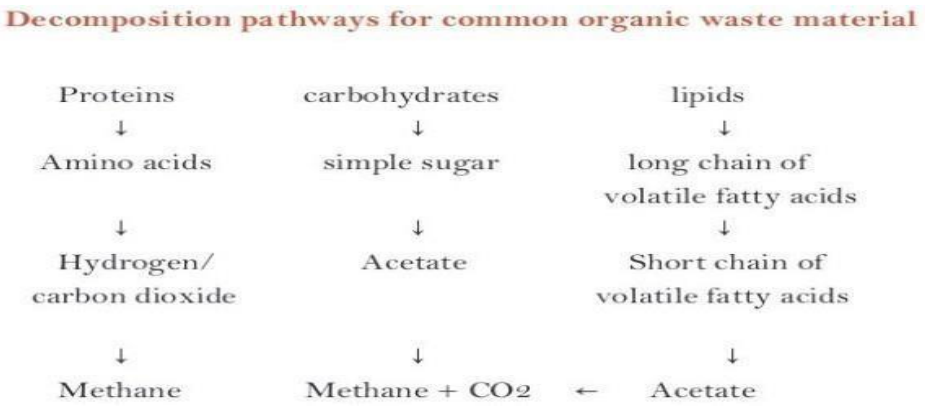
3. Decomposition

- ✓ It is the degradation process. Organic material is converted to gas and leachate.
- ✓ Settling rate increases as compare to secondary stage, but with the passage of time it gradually decreases.
- ✓ Itcontinuestilltheorganicmatterisdegraded.

MicrobialDegradationProcess

- ✓ Biological process is most important aspect in landfilling which determines the quantity and quality of leachate and gas.
- ✓ After the disposal, large part of waste becomes anaerobic(du to absence of oxygen. Microbial activity degrade the solid organic carbon and produces methane and carbon dioxide.
- ✓ In an anaerobic process solid and dissolved organic compounds are hydrolyzed and fermented to volatile fatty acids, alcohols, hydrogen and carbon dioxide.

Themethanogenicbacteriaconvertaceticacidtomethaneandcarbondioxide.
Hydrogenophilic bacteria convert hydrogen and carbon dioxide to methane.



Composition Of Landfill Gas

Gases	% dry volume basis
Methane	45-60
Carbon dioxide	40-60
Nitrogen	2-5
Ammonia	0.1- 1
Oxygen	0.1- 1
Hydrogen	0-0.2
Carbon monoxide	0-0.2

FactorsAffectingTheLandfillGasAndLeachateGeneration

- ✓ **Nature of was**te – amount of gas depends on the content of biodegradable matter in the waste.
- ✓ **Moisture content** – microorganisms require minimum 12% moisture for growth, thus it is important factor in determining gas production.
- ✓ **pH**– methanogensgrowonlyat lowpHaround neutrality.%ofgasdepends on pH.
- ✓ **Particle size and density** – particle size affects density achieved by compaction that affects surface area and hence volume. This affects the moisture absorption and thus the biological degradation.
- ✓ **Temperature** – Increase in temperature tends to increase in gas production. It affects microbial activity.

LandfillGasHazards

- ✓ Explosionandfire
- ✓ Tracecomponents
- ✓ Globalwarming
- ✓

Migration

- ✓ The movement oflandfill gas fromhighpressure area to low pressure area is called migration.

Factorsaffectinggasmigration:

- ✓ Environmentalconditions
- ✓ Geophysicalconditions
- ✓ Climaticconditions

Control:

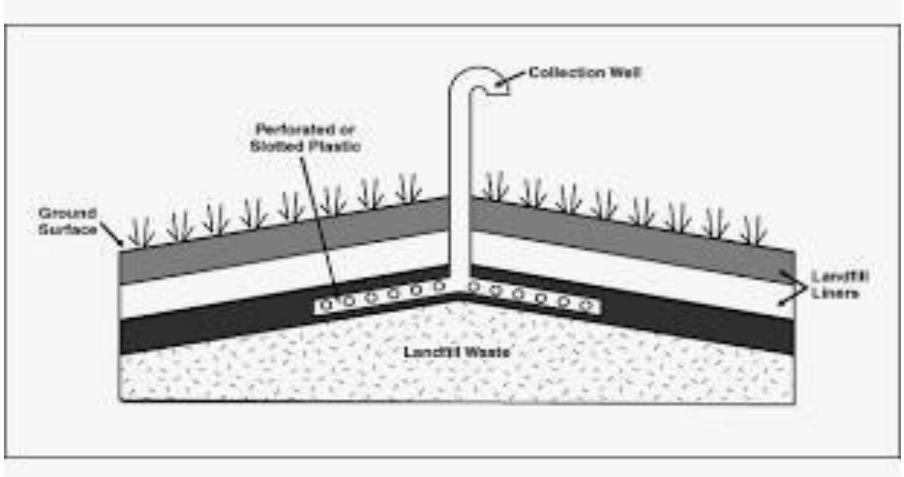
Tocontrolgasemissionitisnecessarytocontrolthefollowing

- ✓ Wasteinputs
- ✓ Processeswithinthewaste
- ✓ Migrationprocess

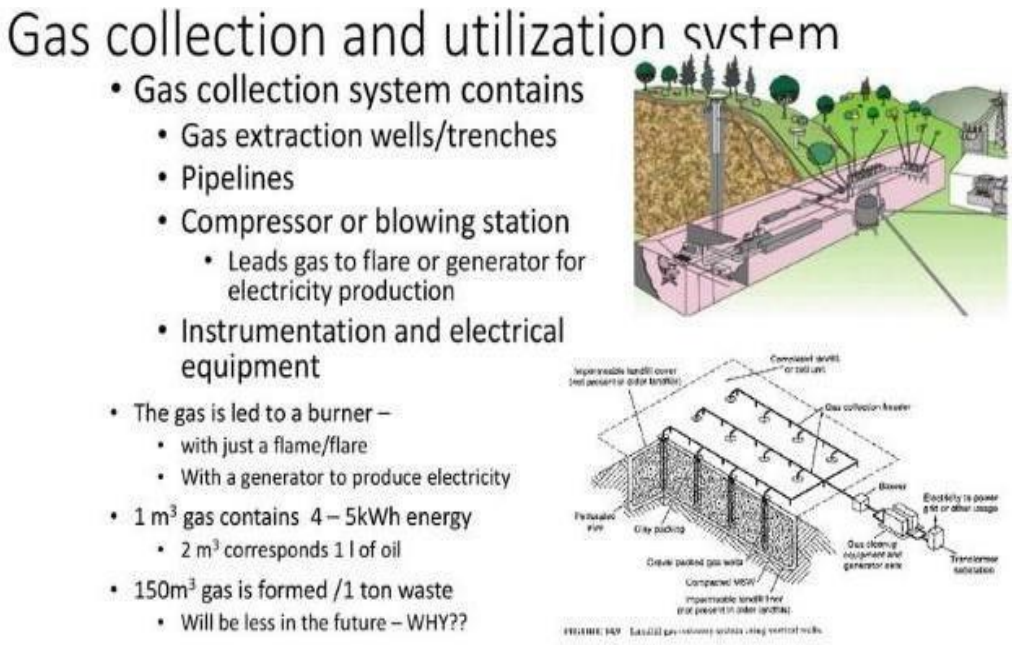
Landfillgasmanagement

1. Controlledpassiveventing
2. Controlledactivecollectionandtreatment/reuse

Controlledpassiveventing



Controlledactivecollectionandtreatment/reuse



LEACHATE

The generation of leachate is caused principally byprecipitation percolating through waste deposited in a landfill.

LeachateFormation

- Leachatecanpollutebothgroundwaterandsurfacewatersupplies.
- 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.

Compositionandproperties

Leachate comprises soluble components of waste and its degradation products enter water, as itpercolatesthroughthelandfill.

Theamountofleachategenerateddepends on:

- wateravailability;
- landfillsurfacecondition;
- refusestate;
- conditionofsurroundingstrata.

The major factor, i.e., water availability , is affected by precipitation, surface runoff,wastedecomposition andliquidwastedisposal.

Control

Thebestwaytocontrolleachateisthroughprevention,whichshouldbe integral to the site design by providing liners.

Naturalliners: Theserefertocompactedclayorshale,bitumenorsoil 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 highor 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

- Concentrationsofvarioussubstancesoccurringinleachatearetoohightobe discharged to surfacewaterorintoasewer system.
- These concentrations, therefore, have to be reducedbyremoval,treatment or both.

Thevarioustreatmentsofleachateinclude:

1. Leachaterecirculation:

- ✓ Itisoneofthesimplestformsoftreatment.
- ✓ Recirculation of leachate reduces the hazardous nature ofleachateandhelps wet the waste, increasing its potential for biological degradation.

2. Biologicaltreatment:

- ✓ ThisremovesBOD,ammoniaandsuspendedsolids.Leachatefrom landfilledwastecanbereadilydegraded by biological means,dueto highcontent of volatile fattyacids (VFAs).
- ✓ Thecommonmethodsareaeratedlagoons(i.e.,special devices which enhance the aerobic process es of degradation of organic substances over the entire depth of the tank) and activated sludge process, whichdiffersfrom aeratedlagoonsinthatdischargedsludgeis recirculatedand is often used for BODand ammonia removal.
- ✓ Whileunder 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.
- ✓ Inananaerobictreatmentsystem,complexorganic moleculesarefermented in filter.
- ✓ Thecommontypesareanaerobicfilters,anaerobiclagoonanddigesters.

3. Physicochemicaltreatment:

- ✓ Afterbiologicaldegradation,effluents stillcontainsignificantconcentrations of different substances.
- ✓ Physicochemical treatment processes could be installed to improve the leachate effluent quality.
- ✓ Some of these processes are flocculation-precipitation. The 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.

LeachateManagement

- ❑ Leachatecollectionsystems
- ❑ Leachatereduction
- ❑ Leachateevaporation
- ❑ Leachatedisposal
- ❑ Leachatetreatment

Bioreactorlandfill

- ✓ A bioreactor landfill is a municipal solid waste landfill (MSWLF) in which liquids are added to help bacteria break down the waste.
- ✓ The increase in waste degradation and stabilization is accomplished through the addition of liquid and air to enhance microbial processes.
- ✓ This bioreactor concept differs from the traditional "dry tomb" municipal landfill approach.
- ✓ Bioreactor landfills are expected to reduce the amount and costs associated with the management of leachate to increase the rate of production of methane gas forcommercialpurpose and reduce the amount ofland required for landfills.

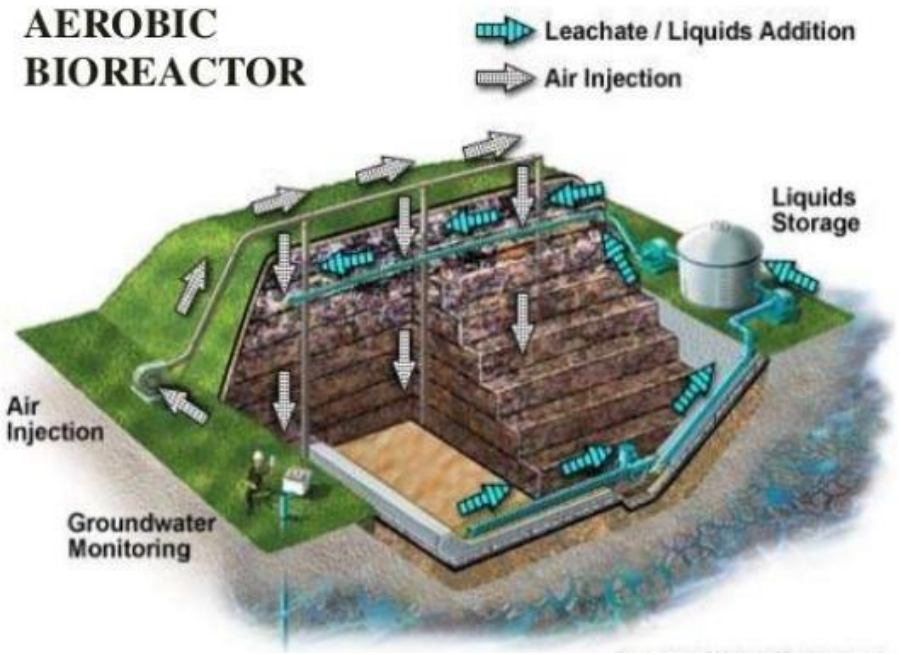
Typesofbioreactorlandfill

- Aerobicbioreactor
- Anaerobicbioreactor
- Aerobic-anaerobic(hybrid)bioreactors

- **Hybrid** bioreactors subject the upper portions of the landfill throughaerobic-anaerobic cycles to increase decomposition rate while methane is produced by the lower portions of the landfill.
- Bioreactor landfills produce lower quantities of VOCs than traditional landfills, except H_2S. Bioreactor landfills produce higher quantities of H_2S.

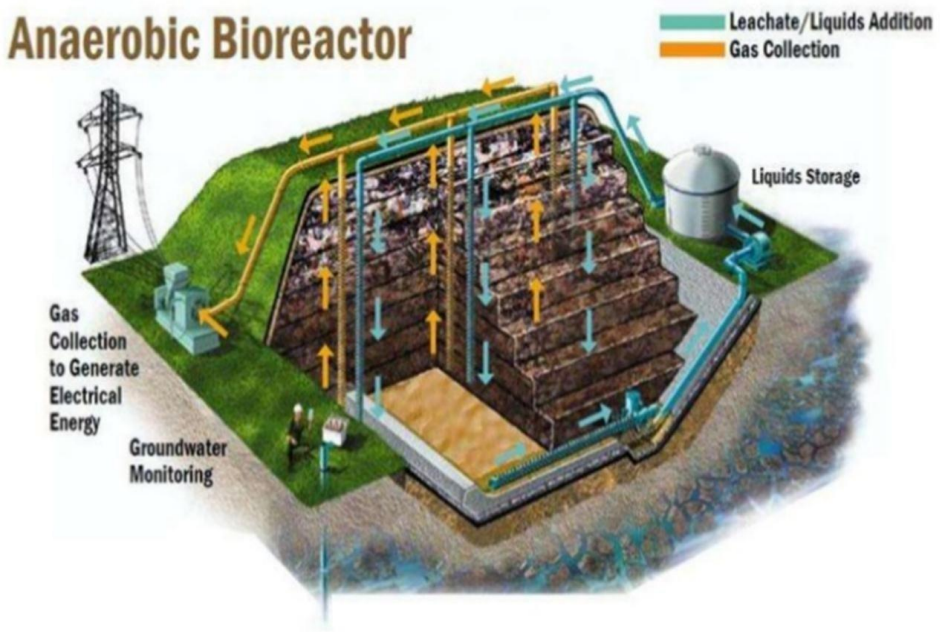
Aerobicbioreactor

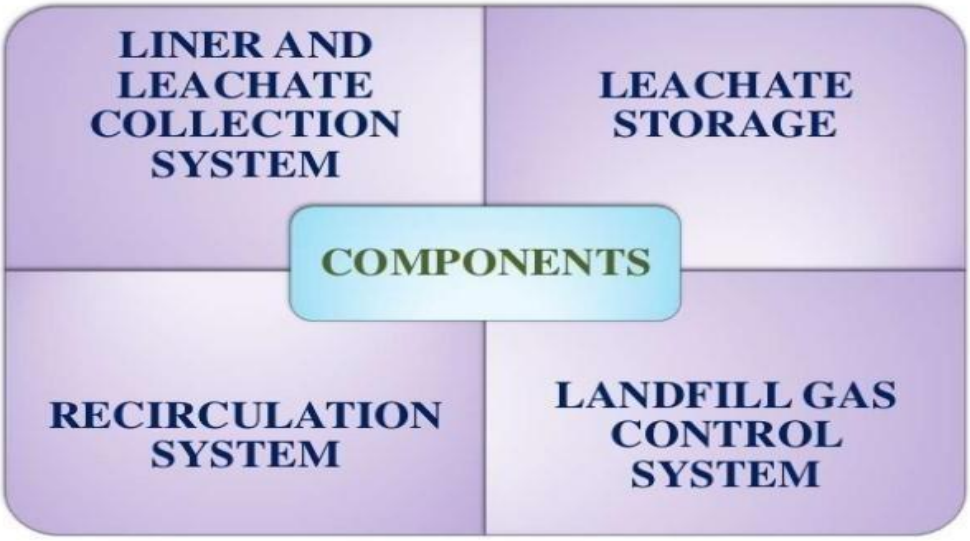
- ✓ In aerobic bioreactors air is pumped into the landfill using either vertical or horizontal system of pipes.
- ✓ The aerobic environment decomposition is accelerated and amount of volatileorganiccompounds,toxicityofleachateand methaneare minimised.



Anaerobicbioreactor

- ✓ Inanaerobic bioreactors with leachate beingcirculated the landfillproduces methane at a rate much faster and earlier than traditional landfills.
- ✓ The high concentration and quantity of methane allows it to be used more efficiently for commercial purposes while reducing the time that the landfill needs to be monitored for methane production.





Workingofabioreactorlandfill

- ✓ All three mechanisms involve the re-introduction of collected leachate supplemented with water to maintain moisture levels in the landfill.
- ✓ Inaerobic bioreactors air is pumped into the landfill usingeither vertical(or) horizontal system of pipes.
- ✓ The aerobic environment decomposition is accelerated and amount of toxicity of leachate and methane are minimised .

Advantagesofbioreactorlandfills

- ✓ Createsmorespacefordumpinggarbage.
- ✓ Expected to increase the rate of decomposition and save up to 30% of space needed for landfills.
- ✓ Bioreactor landfill can thus provide a significant way of maximising landfill space.
- ✓ This is not just cost effective, but since less land is needed for the landfills, this is also better for the environment.

  Less time andenergy is required toprocess theleachate, makingthe processmore efficient.

Disadvantagesofbioreactorlandfills

- ✓ Bioreactor landfills are a relatively new technology. For thenewly developed bioreactor landfills initial monitoring costs are higher to ensure that everything important is discovered and properly controlled. This includes gases, odours and seepage of leachate into the ground surface.
- ✓ The increased moisture content of bioreactor landfill may reduce the structural stability of the landfill by increasing the pore waterpressure within the waste mass.
- ✓ Since the targetofbioreactor landfills is tomaintaina highmoisture content, gas collection systems can be affected by the increased moisture content of the waste.

DumpsiteRehabilitationispracticedwiththefollowingmethods,

- ✓ Phytoremediation
- ✓ Soil/earthreinforcement/stabilization
- ✓ Anti-termitetreatment
- ✓ Dewatering

Phytoremediation

- ✓ It is an emerging green technology in which some plant species are used to remediate and solve environmental problems.
- ✓ It is the use of living green plants for insitu risk reduction and or removal of contaminants from contaminated soil, water, sediments and air.

Soil/earthreinforcement/stabilization

Itisamethodofimproving soil propertiesby blending and mixingother materials.

- ✓ Soilstabilizationwithcement
- ✓ Soilstabilizationusinglime
- ✓ Soilstabilizationwithbitumen
- ✓ Chemicalstabilizationofsoil
- ✓ Electricalstabilizationofclayeysoils
- ✓ Soilstabilizationbygrouting
- ✓ Soilstabilizationbygeotextilesandfabrics

Anti-termitetreatment

- ✓ It is a technique in which some chemical solutions or emulsions are requiredtobedisperseduniformly inthesoiltotherequiredstrengthsoas to form an effective chemical barrier which is repellant to termites.

Dewatering

- ✓ It is the removal of water from solid material or soil by wet classification, centrifugation, filtration, or similar solid-liquidseparation processes, such as removal of residual liquid from a filter cake by a filter process.