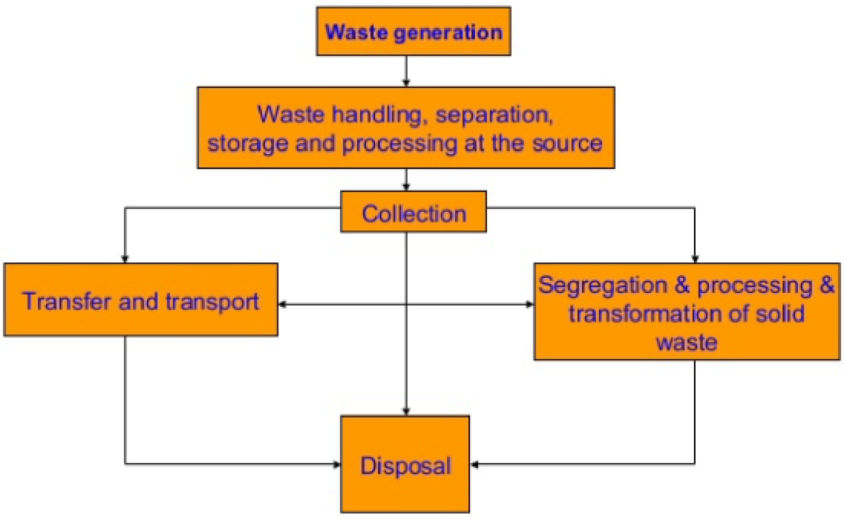
Solution

BE examination 2017-18

Solid Waste Management – 10CV757

1. a) The activities involved with the management of solid wastes from the point of generation to the final disposal can be grouped into six functional elements as shown in the flowchart.



1. Waste Generation

Includes the activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal. Limiting the quantity of waste generated by manifest systems helps in controlling the waste generated.

2. On site handling, storage and processing

Involves those activities associated with management of wastes until they are placed in storage containers for collection. Segregation of waste is an important step here as reuse and recycling can be effectively implemented through this. Processing at source involves activities like compaction and composting.

3. Collection

Activities associated with gathering of solid wastes and hauling of wastes after collection to the location where collection vehicle is emptied. This involves significant economic implications if wastes need to be hauled over long distances in case of large cities.

4. Separation, processing and transformation of solid waste

Transformation processes are used to reduce the volume and weight of wastes requiring disposal and to recover conversion products and energy. Processing includes separation of waste components by size using screens, size reduction by shredding, separation of ferrous materials using magnets, volume reduction by compaction. The organic fraction of wastes can be transformed by biological processes like composting. Chemical transformation processes like combustion helps in recovery of energy in form of heat.

5. Transfer and transport

The activities associated with (1) transfer of wastes from small collection vehicles to larger transport equipment and (2) the subsequent transport of the wastes usually over long distance to the disposal site. At transfer stations the wastes unloaded from collection vehicles are reloaded into large trucks.

6. Disposal

Activities associated with ultimate disposal of solid wastes. This includes waste transported directly to landfill site, sludge from waste treatment plants, incinerator residue, compost etc.

1. b)

Component	**% mass**	**% miosture**	**Energy (KJ/kg)**	**Total mass**	**Energy (KJ)**	**Mass of water**
Food	15	70	4650	150	697500	105
Paper	45	6	16750	450	7537500	27
Cardboard	10	5	16300	100	1630000	5
Plastic	10	2	32600	100	3260000	2
Garden trim	10	60	6500	100	650000	60
Wood	5	20	18600	50	930000	10
Tin	5	3	700	50	35000	1.5
				1000	14740000	210.5

Let total mass of waste be 1kg

Mass of each component **= Total mass of waste ×Mass %**

= 1000×15/100

= **150kg**

Total energy produced by each component **= Mass of component × Energy value**

=150×4650

=**697500KJ**

Energy content of solid waste **=Total energy/total mass**

=14740000/1000

=14740KJ/kg

Energy Content on **dry basis** (KJ/kg) = Energy Content **as discarded** (KJ/kg) × $\frac{100}{100-\%\ moisture}$

Percentage moisture = Total Mass of water/Total Mass

Mass of water in each component= Mass of each component * Percentage moisture

Percentage moisture = (210.5/1000) *100 =**21.05%**

Energy Content on dry basis (KJ/kg) = 14740×100/(100-21.05) = **18670.0443 KJ/kg**

Energy Content on ash free dry basis (KJ/kg) =

Energy Content **as discarded** (KJ/kg) × $\frac{100}{100 - \%ash - \%\,moisture}$

=18670.0443 ×100/(100-21.05-5)**=19932.3867 KJ/kg**

1. c) The quantity of solid waste generated is important in the design and operation of SWM systems. Knowing the exact quantities of waste generated will help in effective collection of waste as well proper design of transfer stations and disposal sites. Following methods are recommended in quantification.

i) Load count analysis –

In this method the number of individual loads delivered to transfer station or landfill and the corresponding volume and waste characteristics are noted over a specified period of time. But here estimates regarding wastes recycled or stored in generators premises are not accounted as data collection is made only on the basis of load arriving at transfer stations.

ii)Weight volume analysis –

This method of analysis is similar to the above method with the added feature that mass of each load is also calculated apart from volume of the waste. Hence idea regarding specific weight (mass/volume) of wastes can also be derived here.

iii) Materials mass balance analysis –

The quantities of waste generated and their movement can be analyzed with more reliability using this method. Here a detailed material balance analysis is performed for each generation source (individual home or commercial place or industry).

Steps involved in mass balance analysis are given below.

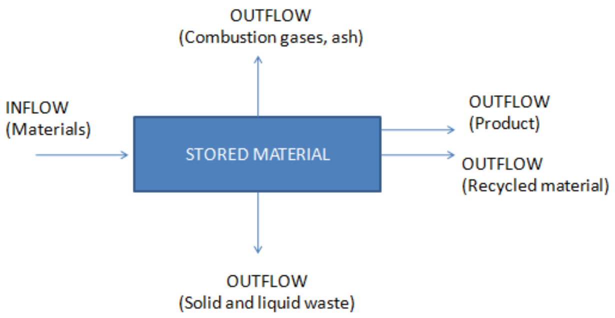
1) Identify boundary of the system or source for which mass balance is to be performed

2) Identify all activities within the system or across it that affects waste generation

3) Identify rate of waste generation associated with each of these activities

4) Use following mathematical relationship between quantity of waste generated, collected, stored and moved from the system for performing mass balance

Material Stored = Inflow – Outflow - Waste Generation

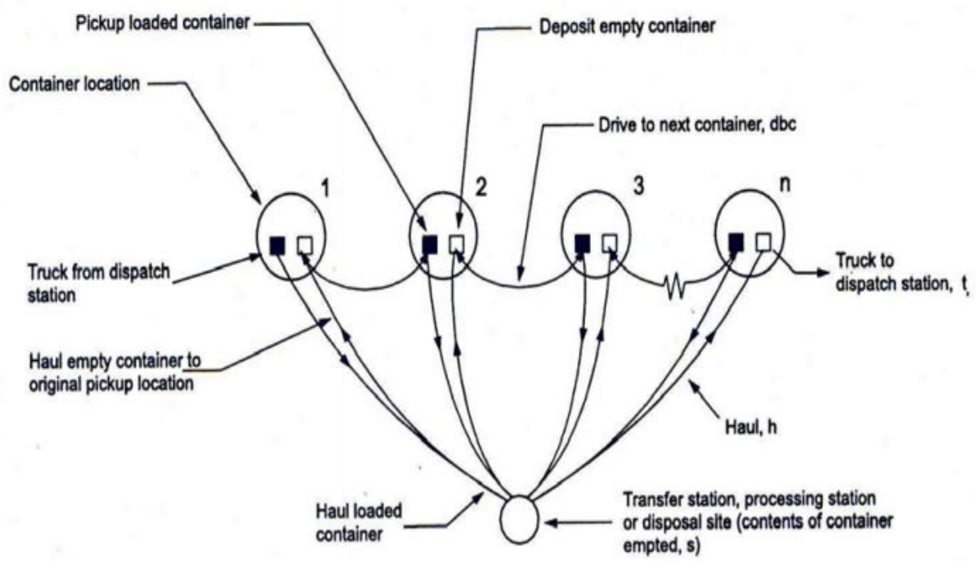


2. a) <u>Hauled container system-</u>Here the containers used for storage of wastes are hauled to the disposal site/transfer station emptied and returned to their original location or some other location.

   Advantages:

   - Ideally suited for removal of wastes from sources where generation rate is high as relatively large containers are used here.
   - Reduces handling time, unsightly accumulations and unsanitary conditions associated with numerous large containers.
   - Requires only one truck and one driver

   But manual filling of these large containers may often lead to low utilization rate, hence these must be equipped with mechanical loading aids.



Hauled container system

Hoist truck, Tilt frame container and trash trailer containers are used for hauled container systems. Tilt-frame hauled container system has become widespread because of large volume that can be hauled but trash trailer is better for the collection of especially heavy rubbish. The application of both tilt -frame container and trash-trailer are similar, where the collector is responsible for driving the vehicles, loading full containers, and unloading empty containers, and emptying the contents of the container at the disposal site.

2. b) The present and future quantity and composition of solid waste is affected by several factors which are listed below.

1. Geographic location- The climate of the area decides the amount and characteristics of certain solid waste generated. This is because the lifestyle practices vary with climate. Thereby wastes generated from different geographical location must be quantified properly.

2. Seasons: Seasons of the year have implications for the quantities and composition of certain types of solid wastes. For example, the growing season of vegetables and fruits affect the quantities and composition of food wastes.

3. Collection frequency: In localities, where there are more frequent collection services, more wastes are collected. If a homeowner has access to only one or two containers per week, due to limited container capacity, he or she will store newspapers or other materials in some specified storage area. However, the same homeowner will tend to throw them away, if there is access to unlimited container services. The reuse practices may be decided by collection frequency.

4. Population diversity: The characteristics of the population influence the quantity and composition of waste generated. The amount of waste generated is more in high-income areas compared to that in low-income areas. Similarly, the composition differs in terms of paper and other recyclables, which are typically more in high-income areas as against low income areas.

5.Extent of salvaging and recycling: The existence of salvaging and recycling operation within a community definitely affects the quantity of wastes collected. By promoting source reduction activities from generators helps in reducing waste generated.

6. Public attitude: Significant reduction in the quantity of solid waste is possible, if and when people are willing to change – on their own volition – their habits and lifestyles to conserve the natural resources and to reduce the economic burden associated with the management of solid wastes.

7. Legislation: This refers to the existence of local and state regulations concerning the use and disposal of specific materials and is an important factor that influences the composition and generation of certain types of wastes.

2.c) Total mass of waste to be collected on **Wednesday** morning = [0.11×881 + (3.6×30)/5]×3

(*Waste generated on Friday, Monday, Tuesday*)	= **355.53 kg**
Density of waste	=120kg/m^3
Volume of waste to be collected	= 355.53/120 = **2.96**$\mathbf{m^3}$
Total mass of waste to be collected on **Friday** morning	= [0.11×881 + (3.6×30)/5]×2
(*Waste generated on Wednesday, Thursday*)	= **237.02 kg**
Density of waste	=120kg/m^3
Volume of waste to be collected	= 237.02/120 = **1.98**$\mathbf{m^3}$
Size of container required	**= 3** $\mathbf{m^3}$

3. a) **Factors affecting selection of transfer stations**

1) Type of transfer operation –direct, storage or combined

2) Capacity requirements – Capacity must be such that the collection vehicles need not have to wait so long. Because of the increased cost of transport equipment, a trade off analysis must be made between transfer station capacity and cost of transport operation.

3) Equipment and accessory requirement – The types and the amounts of equipment required vary with the capacity of the station and its function in the waste management system.

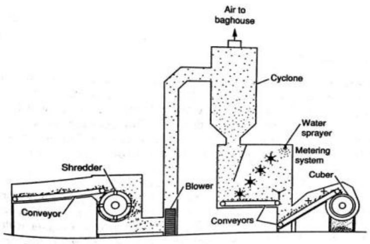
4) Environmental requirement – Transfer stations must designed in such a way that they are enclosed and constructed of materials that can be maintained and cleaned easily. Wind screens or other barriers must be used to prevent blowing papers.

3. b) **Mechanical Volume Reduction (Densification):** Densification also known as compaction is a unit operation that increases the density of waste materials so that they can be more efficiently stored and transported. The equipments used for densification are discussed below.

1. Stationary Compactors – When wastes are brought into and loaded into the compactor, the compactor is stationary. Compaction mechanism used to compress wastes in a collection vehicle is an example for stationary compaction.(On the contrary the wheeled and tracked equipment used to place and compact solid wastes in a sanitary landfill is called a movable one). Rotary compactor, bag compactor, under counter compactor, low pressure and high pressure stationary compactors are the commonly used ones.

2. **Bailing Equipment** – These are an alternative to stationary compactors. Operating under high pressure, they produce relatively small, compact ‘bales’ of solid waste or recovered materials.Their small sizes enable shipping to be done economically due to their high bulk density. Predominant use of bailing is in preparation of recovered materials for shipment to buyers of recycled materials.

3. Cubing and pelleting equipment – Here the shredded waste is bonded together to form small cubes and pellets. The system requires a shredder, conveyor and a moisture control system. This technology is commonly used to produce densified refuse driven fuels for combustion.



Chemical Volume Reduction – Chemical volume reduction is a method, wherein volume reduction occurs through chemical changes brought within the waste either through an addition of chemicals or changes in temperature. Incineration is the most common method used to reduce the volume of waste chemically, and is used both for volume reduction and power production. These other chemical methods used to reduce volume of waste chemically include pyrolysis, hydrolysis and chemical conversions.

Combustion - Biomass combustion refers to burning fuel in a boiler, furnace or stove to produce heat. The heat can be utilized as hot air, hot water, steam or electricity. Wood, agricultural residues, wood pulping liquor, municipal solid waste (MSW) and refuse derived fuel are examples of feedstocks for combustion. Combustion requires high temperatures for ignition, sufficient turbulence to mix all of the components with the oxidant, and time to complete all of the oxidation reactions. The moisture content of the feedstock should be low and pre-drying may be necessary in some cases. Biomass combustion starts by heating and drying the feedstock. After all of the moisture has been removed, temperature rises for pyrolysis to occur in the absence of oxygen. The major products are hydrogen, CO, CO_2, CH_4 and other hydrocarbons. In the end, char and volatile gases are formed and they continue to react independently. The volatile gases need oxygen in order to achieve complete flame combustion. Mostly CO_2 and H_2O result from complete combustion.

Pyrolysis - In pyrolysis, biomass is heated in the absence of air. The process results liquid, solid and gaseous fractions, mainly gases, bio-oil and char. The gases and the bio-oil are from the volatile fraction of biomass, while the char is mostly the fixed carbon component. In the first step, temperature is increased to start the primary pyrolysis reactions. As a result, volatiles are released and char is formed. Finally, after various reactions, pyrolysis gas is formed.

Gasification - By gasification, the biomass is broken down into combustible gas, volatiles and ash. A partial oxidation can be obtained with air, O2, H2O or CO2, for example. Gasification is carried out in two steps. First, the biomass is heated to around 600 degrees. The volatile components, such as hydrocarbon gases, hydrogen, CO, CO2, H2O and tar, vaporize by various reactions. The remaining by-products are char and ash. For this first endothermic step, oxygen is not required. In the second step, char is gasified by reactions with oxygen, steam and hydrogen in high temperatures. The endothermic reactions require heat, which is applied by combusting some of the unburned char. Main products of gasification are synthesis gas, char and tars.

3. c) The process of incineration is complex in nature and multiple parameters affect the combustion efficiency. Out of these several parameters, time, turbulence and temperature are referred to as 3 Ts of combustion. It is very important to control and optimise these 3 Ts to get maximum out of the combustionprocess.

1. Time

When a fuel is being burned, it is important that sufficient time is available so that the fuel burns completely. 100% combustion means that the fuel is fully oxidized and full oxidation of the carbon, hydrogen and other combustible elements has taken place. If fuel remains in the combustion zone for a time lesser than necessary, it will be partially burned which increases the un-burnt losses. On the other hand, if it remains for a time higher than the required, the power output of the boiler will drop as new fuel will not be able to come in and get burned. Ideally, the fuel should stay for a time sufficient for the complete combustion and then replaced by the fresh fuel. Thus, the time plays a very important role in determining the combustion efficiency.

2. Turbulence

Oxygen makes an essential part of the process of combustion. While burning the fuel, it is essential that it is broken down in small particles. This increases the surface area of the fuel and ensures that sufficient air i.e. oxygen is made available. Turbulence ensures a thorough mixing of the air and the fuel. If turbulence is not maintained, certain part of the fuel will have excess oxygen available for the combustion while the remaining having too little. This will result in incomplete combustion of carbon forming carbon monoxide instead of carbon dioxide. If proper turbulence is not maintained, some part of the fuel will go out of the chimney without even getting oxidized. This will increase the un-burntlosses.

3. Temperature

During the combustion, if the temperature is not sufficiently high, fuel will take some time to ignite thus increasing the time of the combustion. This will affect the heat output. Hence, it is very important to maintain correct temperature which ensures that fuel is quickly burnt releasing the complete energy.

4. a) **Component separation**

Mechanical separation of waste materials can be achieved based on **size, density or electric magnetic properties** of materials.

1. Size separation - Unit operation in which materials are separated by size characteristics, most commonly by use of screens. A mixture of materials is separated into two or more portions by means of one or more screening surfaces. The commonly used screen types are Vibrating screens, Trommel screens and Disc screens.

a.) Vibrating screens – Mostly used for separating relatively dry materials such as glass or metals. Also used for separating wooden chips as well as broken pieces of concrete from construction debris.

b.) Trommel screens – One of the most versatile types of screens for solid waste processing. It consists of a large diameter screen, formed into a cylinder rotating on a horizontal axis. Mainly used for removing large sized materials like cardboard, paper etc. The design of trommel screen is mainly based on parameters like diameter, length, rotational speed, angle of inclination and particle size distribution. The rotational speed is a function of critical speed: the speed at which materials centrifuge or stick to the screening surface.

c) Disc screens – They are alternative to vibrating screens. A disc screen consists of sets of parallel, interlocking rotating discs. The materials to be separated falls between the spaces and oversized materials are carried over the top of the discs as in a conveyor belt. The advantages of discs over vibrating screens is that it has self cleaning ability and capability of adjusting screening sizes by varying the spacing of discs. Design of these screens is based on volumetric loading, disc spacing, disc rotation speed and surface area.

2. Density separation- It is a technique used to separate materials based on their density and aerodynamic characteristics. During this process the shredded municipal waste is separated into two components i) ***Light fraction*** composed primarily of paper, plastics and organics and ii) ***Heavy fraction*** containing metals, woods and other relatively dense inorganic materials. The techniques used for density separation are listed below.

a) Air classifiers – Here the shredded solid wastes are dropped into a vertical chute. Air moving upward from the bottom of the chute is used to transport lighter materials to the top of the chute. Since the upward airflow is insufficient to transport heavier materials in the wastes, the heavier materials drop to the bottom. Control of the percentage split between the light and heavy fractions is accomplished by varying the waste loading rate, airflow rate and cross sectional area of the chute. Different types of air classifiers are i) straight ii) zig zag and iii) stacked triangle. The zigzag flow path creates turbulence in the airstream which in turn causes the waste to get separated.

b) Stoners – These are used for separating heavy materials from solid waste. It consists of a vibrating porous deck sloped slightly through which air is blown in upward direction. The deck vibrates in the upward direction. On introducing the mixed waste to the deck, the lighter materials gets lifted up by the air and moves downhill whereas the heavier material remains on the deck surface and is conveyed uphill by the vibration action of the deck. Important operational parameters here are the deck slope and air volumes.

c) Floatation – This is a unit operation which employs a fluid to separate two components of different densities. The mixed waste is immersed in a fluid when the heavy materials will sink to the bottom and the lighter materials will float on the surface. Heavy media separation is a floatation technique where a fluid of high specific gravity is used which keeps the required material in floating condition.

3. Magnetic and electric field separation – Here the electrical and magnetic properties of the materials is made use of. ***Magnetic separation*** is the most commonly used technology for separating ferrous from non ferrous metals. ***Electrostatic separation*** can be used to separate plastics from paper based on differing surface charge characteristics of the two materials. ***Eddy current separation*** is a technique in which varying magnetic fields are used to induce eddycurrents in non ferrous metals like aluminium to form aluminium magnet.

4. b) A typical municipal incinerator consists of three components: the furnace chamber, the heat recovery boiler, and the flue gas treatment plant.

Incinerator Furnace Chamber

In a municipal solid waste (MSW) incinerator, waste material is usually burned in a refractory-lined furnace chamber as a moving bed on a grate with underfire air. The waste material is very homogeneous, and various techniques are used to mix the burning material on the grate as it progresses along the chamber. A reciprocating grate or steps allowing the material to fall and disperse may be used. Other mixing techniques used include rotary kilns and fluidized beds.

Heat Recovery Boiler

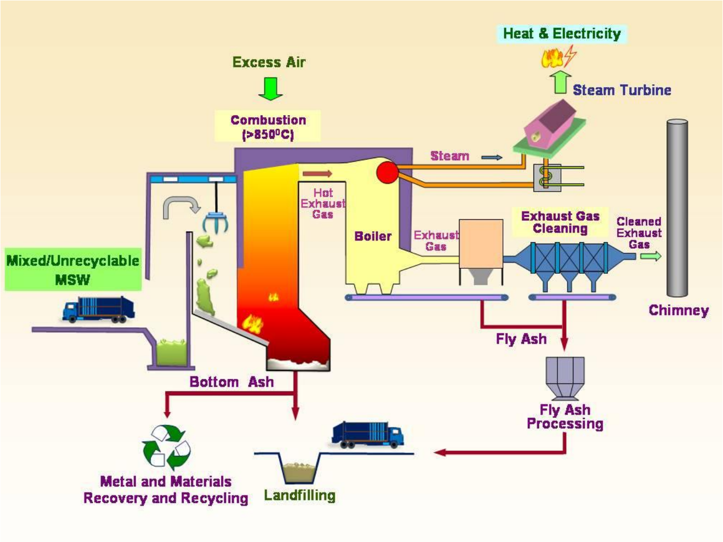
The heat recovery boiler consists of two stages. In the first stage, the gases are cooled by the radiation of heat to the walls whilst in the second, gases are further cooled by convective heat transfer to tubes located in the flow.

Flue Gas Treatment Plant

To minimize the emission of *pollutants*, the first stage of flue gas treatment is achieved in the furnace and boiler by ensuring that there is sufficient excess air and residence time to complete the combustion process.

The removal of pollutants such as particles and acid gases from the incinerator flue gases is accomplished in a flue gas treatment plant. This follows well-established chemical engineering design principles, and consists of components such as venturi and tower **Scrubbers**, **Heat Exchangers**, **Electrostatic** and bag **Filters**, **Fans** and **Pumps**.

Although *dioxins* can be destroyed in an incinerator, they can be formed in the flue gas treatment plant. The minimization of dioxins may be achieved by ensuring that the optimum temperature/composition/time history of the flue gases is satisfied.



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PART B

5. a)

Table 12-4 Important design considerations for anaerobic digestion

Item	Comment
Size of material shredded	Wastes to be digested should be shredded to a size that will not interfere with the efficient functioning of pumping and mixing operations.
Mixing equipment	To achieve optimum results and to avoid scum buildup, mechanical mixing is recommended.
Percentage of solid wastes mixed with sludge	Although amounts of waste varying from 50 to 90+ percent have been used, 60 percent appears to be a reasonable compromise.
Hydraulic and mean cell-residence time, $\theta_h = \theta_c$	Washout time is in the range of 3 to 4 d. Use 7 to 10 d for design, or base design on results of pilot-plant studies.
Loading rate	0.6 to 1.6 $kg/m^3 \cdot d$ (0.04 to 0.10 $lb/ft^3 \cdot d$). Not well defined at present time. Significantly higher rates have been reported.
Temperature	Between 328 and 333 K (55 and 60 C).
Destruction of volatile solid wastes	Varies from about 60 to 80 percent; 70 percent can be used for estimating purposes.*
Total solids destroyed	Varies from 40 to 60 percent, depending on amount of inert material present originally.
Gas production	0.5 to 0.75 m^3/kg (8 to 12 ft^3/lb) of volatile solids destroyed (CH_4 = 60 percent; CO_2 = 40 percent).

5.b) Bangalore method

1. This is an anaerobic method conventionally carried out in pits.
2. Initially, a layer of coarse municipal solid waste is placed at the bottom of a pit to a depth of 15 to 25cm and is made 7.5cm thicker for 25cm width towards both the edges of the pit. Night soil is put in the depressed portion to a thickness of 5cm and the elevated edges prevent it from draining to the side.
3. A layer of solid waste is put on top so that the night soil layer is sandwiched between the two layers of municipal solid waste. Solid waste and night soil are put in alternate layers till it rises to a height of 30cm above the pit edge.
4. The final layer of solid waste is at least 25 to 30cm thick. The top of the deposited material is rounded off to avoid rain water entering into the pit.

5. After 4 to 6 months of decomposition the material is stabilized and is taken out and used as compost.

Indore method

1. The Indore method of composting in pits involves filling of alternate layers of similar thickness as in the Bangalore method.
2. However, to ensure aerobic condition the material is turned at specific intervals for which a 60cm wide strip on the longitudinal side of the pit is kept vacant.
3. The first turn is manually given using long handed rakes 4 to 7 days after filling. The second turn is given after 5 to 10 days. Further turning is normally not required and the compost is ready in 2 to 4 weeks.
4. Aerobic composting of solid waste and night soil can be carried out in windows of more or less the same dimensions as the pits.
5. However, aerobic composting in windows on more commonly used while composting municipal solid waste alone.

5. c) Question data error: Anaerobic equation given for aerobic problem.

6. a) **Landfill site selection considerations**

Factors that must be considered in evaluating potential sites for long term solid waste disposal is listed below.

1. Haul Distance – Minimal haul distances are desirable and length of haul significantly affects the overall design and operation of landfill. If land areas of suitable size are not available near existing roadways, construction of access roadways and even rail lines are practiced for transporting wastes to the remote sites.

2. Location restrictions – Restrictions specified by Solid Waste Manual 2016 is given below.

S.NO	PLACE	MINIMUM SITING DISTANCE
1	Coastal regulation, wetland, critical habitat areas, sensitive eco-fragile areas, and flood plains as recorded for the last 100 years	Sanitary landfill site not permitted within these identified areas
2	Rivers	100 metres (m) away from the flood plain
3	Pond, lakes, water bodies	200 m
3	Non-meandering water channel (canal, drainage, etc.)	30 m
4	Highway or railway line, water supply wells	500 m from center line
5	Habitation	All landfill facilities: 500 m
6	Earthquake zone	500 m from fault line fracture*
7	Flood prone area	Sanitary landfill site not permitted
8	Water table (highest level)	The bottom liner of the landfill should be above 2 m from the highest water table
9	Airport	20 km**

3. Available land area – Area requirement for a city can be calculated using solid waste generation rate, population of city, life of landfill as well as extend of compaction. Additional land required for buffer zone, office and service buildings, access roads, utility access must also be considered. Site can then be identified based on this area requirement.

4. Soil conditions and topography – The amount and characteristics of the soil must be identified as it is needed for daily cover as well as for final cover. The local topography affects the type of landfill operation to be used, equipment requirements and extends of work needed to make land usable.

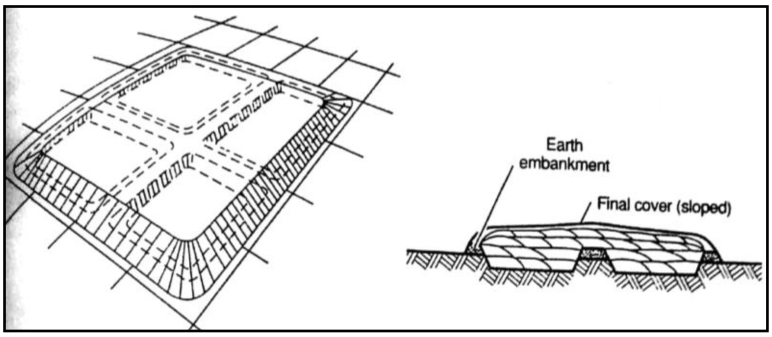
5. Climatologic conditions – Winter may affect access to sites. Wet weather may necessitate the use of separate landfill areas. Where freezing is severe, alternate cover material must be made available. Wind strength must be considered and windbreaks must be provided to avoid flowing debris.

6. Surface water hydrology – Important in establishing the existing natural drainage. Conditions of flooding must also be identified. Mitigation measures should be adopted to divert surface runoff from landfill site if required.

7. Geologic and hydro geologic conditions – Most important factor in establishing the environmental suitability of area for landfill. Preliminary assessment must be done to ensure that the movement of leachate from landfill will not impair quality of groundwater or other subsurface aquifers.

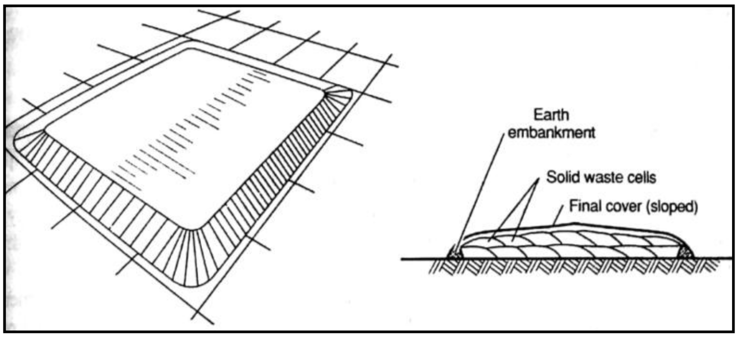
6. b) Trench/excavated cell method

Suitable for areas where water table is not near the surface and adequate depth of cover material is available at site. Solid wastes are placed in trenches/cells excavated in the soil. The trenches are lined with synthetic membrane liners and low permeability clay. The soil excavated from the site is used for daily and final cover. The cells are typically square upto 300m in width and length with side slopes 2:1.



Area method

This method is used when the terrain is unsuitable for excavation of trenches or cells. High water table is one case when this method is adopted. Here cover material need to be hauled from adjacent land or alternate materials like compost must be made use of.



6. c) Total solid waste generated per day = 50000× 0.36 kg/day = 18000kg/day

   Compacted density of landfill = 504 kg/m^3

   Volume of landfill required = 18000/504 = 35.7 m^3 /day

   Area required = 35.7/3 = **11.9 m^2 area per day**

7. a)

   Landfill gas is composed of a mixture of a number of gases. Gases present in large amounts like Carbon dioxide, Methane, Nitrogen, Oxygen and Ammonia are known as principle gases. The gases present in small amounts are known as trace gases. These are mainly certain Volatile Organic Compounds (VOCs).

   Control measures

   The movement of landfill gases is controlled to reduce atmospheric emissions, to minimize the release of odorous emissions, to minimize subsurface gas migration and to allow for the recovery of energy from methane. Control systems may be classified as active or passive.

   Passive – Here the pressure of gas generated within the landfill serves as the driving force for the movement of gas. This method is used when the principle gases are produced at a high rate. Gas movement is achieved by providing paths of high permeability to guide the gas flow in the desired direction. For example a gravel packed trench can serve to channel the gas to a vent system.

   Active – Here energy in the form of induced vacuum is used to control the flow of gas. This method is used when the production of principle gases is limited. The driving force is molecular diffusion here.

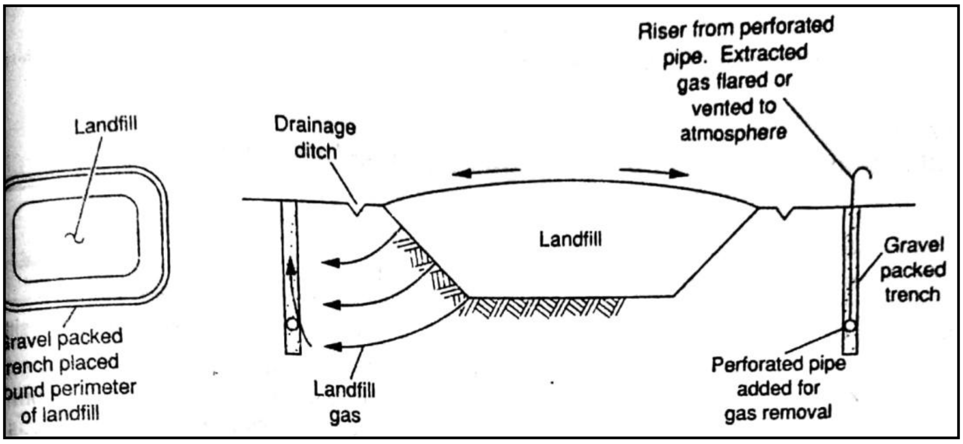
   Passive control methods

   Pressure relief vents

   Here vents are installed through the final landfill cover extending down into the solid mass. Hence the lateral migration of gases can be reduced by relieving gas pressure within the landfill interior.

Perimeter interceptor trenches

This is a perimeter trench system consisting of gravel filled interceptor trenches containing horizontal perforated plastic pipes. The perforated pipe is connected to vertical risers through which the landfill gas that collects in the trench backfill can be vented to atmosphere.



Perimeter barrier trench

Barrier trenches are filled with relatively impermeable materials such as clay slurries. Here trench acts as a physical barrier to the gas movement. Landfill gas is removed from the inside face of the barrier with gas extraction wells. The problem with slurry trench is that they may be subjected to desiccation cracking when allowed to dry out.

Impermeable barriers within landfill

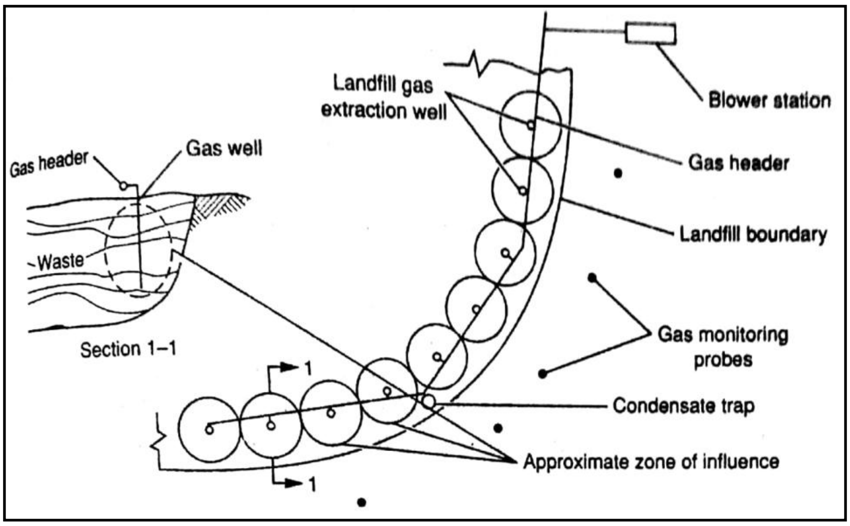
Low permeable clay is used as a barrier in modern landfills to prevent the migration of gases. Geomembranes if used give added protection against the movement of gases.

Active control methods

Here the lateral movement of gases is controlled by using perimeter gas extraction wells and trenches and by creating a partial vacuum, which induces a pressure gradient towards the extraction well.

Perimeter gas extraction wells

Used in landfills with depth of atleast 7.5m, where the distance between the landfill and offsite development is relatively small. Consists of a series of vertical wells installed either within the landfill edge or between landfill edge and site boundary. These wells are then connected by a common header pipe that in turn is connected to an electrically driven centrifugal blower which induces vacuum in the wells. When vacuum is applied, a zone of radius of influence is created that extends into the solid waste mass surrounding each well and within which the gas that is generated is drawn into the well.



<u>Perimeter gas extraction trenches</u>

Used in shallow landfills with depths less than 7.5m. Usually installed in native soil adjacent to landfill perimeter. The trenches are gravel filled and contain perforated plastic pipes that are connected through laterals to a collection header and centrifugal suction blower. The blower creates negative pressure and helps in migration of landfill gas through perforated plates and collection header and finally vented off.

<u>Vertical gas extraction wells</u>

Consists of a series of vertical wells connected to gas collection header and to blower. The wells must be spaced in such a way that their radii of influence overlap. The blower helps in migration of landfill gases through wells and gas collection headers.

<u>Horizontal gas extraction wells</u>

This is an alternative to vertical gas extraction wells. These are installed when two or more lifts are completed. Gravel trench is prepared horizontally inside which perforated pipes are placed which helps in gas collection. The entire system is then collected to a blower which helps in gas movement towards the trenches and pipes.

7.b)

Leachate may be defined as liquid that has percolated through solid waste and has extracted dissolved or suspended materials. It is composed of liquid that has entered landfill from external sources (surface drainage, rainfall, ground water) and liquid produced by decomposition of wastes.

Chemical composition of leachate varies greatly depending on the **age of landfill and events preceding time of sampling**. pH changes takes place during various phases of landfilling. If collected during acid phase of decomposition, pH will be low but BOD, COD, heavy metals and nutrients will be high. While during methane fermentation stage, pH will be high but BOD, COD, heavy metals and nutrients will be lower. BOD/COD ratio is greater in the initial stages and hence is biodegradable whereas it drops to 0.2 in the later stages. pH also depends upon partial pressure of CO_2 in the landfill.

7.c) **Open Dumping**

Some components of solid waste such as street sweepings, ashes and non combustible rubbish are suitable for open dumping. Garbage and any other mixed solid wastes are not fit or suitable because of nuisance and health hazard creation. Generally, solid waste is spread over a large area, providing sources of food and harborage for flies, rats and other vermin. It causes unsightly odor and smoke nuisance and hazards. Carefully selected rubbish must be disposed in order to prevent fire accidents that might occur. The location of open dumping must be carefully chosen so that there will be a minimum chance of complaints from nearby residents.

Advantage of open dumping

- Can take care of all types of solid wastes except garbage
- It causes less health problem if proper site is selected.
- Needs less labor and supervision

Disadvantage of open dumping

- Attraction of flies, mosquitoes and other insects as well as stray dogs, rats, and other animals.
- Creation of breeding sites for rodents, arthropods and other vermin
- Creation of smoke, odor and nuisance
- It makes the lands and other surrounding areas useless.
- It leads to cuts and wounds.
- It attracts scavengers, both humans and animals.

Ocean Dumping

Advantages

- Ocean disposal can pose less risk to human health than does land disposal or incineration.
- Disposal in the deep ocean may have minimal effects on coastal fisheries and communities.
- Oceans are large in size with relatively high assimilative capability.
- If disposal sites are properly chosen and dumping methods are properly designed, wastes can either be concentrated and confined to a small area in the deep ocean, or dispersed throughout a large volume.
- Aerobic conditions and extensive flora and fauna will result in degradation of some wastes.
- For coastal communities, ocean disposal appears to be the most economical alternative.

Disadvantages

- While near Shore Ocean dumping may be economical for some communities, it is not economical to transport wastes for dumping in the deep ocean.
- Limited knowledge of effects, particularly long term.
- Biomagnification of toxins may significantly impact coastal communities even if wastes are disposed of in Deep Ocean. If toxins are dumped and the intent is containment, ocean dumping offers less control than current landfills.
- If organic waste is concentrated, O_2 may be depleted. The residence time of ocean water is very high, so if we damage a particular area, it can take a long time before it can repair itself.

8 a) Once discarded, plastic materials can take centuries to break down. They clog up landfills and overburden waste-processing facilities. By turning bottles, packaging and other plastic refuse into new goods, recycling helps the environment and creates new economic opportunities. Plastics recycling keep still-useful materials out of landfills and encourage to develop new and innovative products made from them.

While some plastics can be recycled once or twice, others are hard to recycle for technical and economic reasons. For example, recyclers typically do not accept Styrofoam, as its lightweight foam structure makes it cumbersome to deal with. Polystyrene products, such as plastic forks and compact disc cases, however, are recyclable. Other common recyclable plastic goods include vinyl packaging, medicine bottles made of polypropylene, low-density polyethylene disposable drink cups and high-density polyethylene milk bottles. Everyday examples of goods made with recycled plastics include shampoo bottles, traffic cones, floor tiles and oil funnels.

Plastic goods are useful because they are durable, but this becomes a disadvantage when items are discarded. The natural processes that degrade paper, cardboard and wood products in a few months don't affect plastic materials as much. In landfills, plastics accumulate, creating a volume of refuse that never seems to go away. In nature, plastic bits and pieces become unsightly nuisances and hazards to animals. Diverting discarded plastics from the refuse stream and turning them into new goods keeps these persistent materials out of landfills and the natural environment.

The use of recycled plastics in products requires creative thinking on the part of designers, technicians and manufacturers. Innovations include construction decking made from recycled plastic, which never rots; types of sports clothing; and vehicle interiors. Artists have turned to recycled plastics for thought-provoking art projects. Although the amount of plastics they use is small compared to commercial uses, they help raise environmental awareness and inspire creative thinking.

Recycling plastics also helps reduce fossil fuel consumption.

b)

[1][Waste Category No.]	Waste Category [2][Type]	Treatment and Disposal [3][Option +]
Category No.1	**Human Anatomical Waste** (human tissues, organs, body parts)	Incineration@/deep burial*
Category No.2	**Animal Waste** (animal tissues, organs, body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals, colleges, discharge from hospitals, animal houses)	Incineration@/deep burial*
Category No.3	Microbiology & Biotechnology Wastes (Wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of bio-logicals, toxins, dishses and devices used for transfer of cultures)	local autoclaving/micro-waving/incineration@
Category No.4	**Waste sharps** (needles, syringes, scalpels, blades, glass etc. that may cause puncture and cuts. This includes both used and unused sharps)	disinfection (chemical treatment@@/auto claving/ microwaving and multilation /shredding ##
Category No.5	Discarded Medicines and Cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)	incineration@/destruction and drugs disposal in secured landfills
Category No.6	**[4][Soiled] Waste** (Items contaminated with blood, and body fluids including cotton, dressings, soiled plaster casts, lines beddings, other	incineration @ autoclaving/microwaving

	material contaminated with blood)	
Category No.7	**Solid Waste** (wastes generated from disposable items other than the waste [5][sharps] such as tubing's, catheters, intravenous sets etc.)	disinfection by chemical treatment@@ autoclaving/ microwaving and mutilation/shredding##
Category No.8	**Liquid Waste** (waste generated from laboratory and washing, cleaning, house-keeping and disinfecting activities)	disinfection by chemical treatment @@ and discharge into drains.
Category No.9	**Incineration Ash** (ash from incineration of any bio-medical waste)	disposal in municipal landfill
Category No.10	**Chemical Waste** (Chemicals used in production of biologicals, chemicals used in disinfection, as insecticides etc.)	Chemical treatment @@ and discharge into drains for liquids and secured landfill for solids