Part – B

UNIT – 5

Composting

Composting is a process in which organic materials undergo biological degradation to a stable nuisance free humus like end product.

The general objectives of composting are

- To transform the biodegradable organic materials into a biological stable materials and to reduce the original volume of waste.
- To destroy pathogens, insect eggs and other unwanted organism and weed seeds that may be present in waste.
- To retain the maximum nutrients content (nitrogen, phosphorous and potassium)
- To produce a product that can be used to support plant growth and as soil amendment.

➢ Aerobic Composting

Aerobic composting is the most commonly used biological processes for the conversion of the organic portion of solid waste to a stable humus like material known as compost. All aerobic composting processes are similar in that they all incorporate three basic steps.

- Preprocessing of the solid waste
- Aerobic decomposition of the organic fraction of the solid waste
- Product preparation and marketing.

a. Aerobic composting is defined as a process in which, under suitable environmental condition, aerobic organisms principally thermophilic, utilize considerable amount of oxygen in decomposing organic matter to a fairly stable humus.
b. With the exception of plastic, rubber, and leather components, the organic fraction of most solid waste can be considered to be composed of carbohydrates, proteins, lipids, amino acids, cellulose, lignin and ash. If these organic materials are subjected to aerobic micro bacterial decomposition, the end product remaining after the microbial activity has essentially ceased is a humus material commonly known as compost.

Aerobic composting microbiology

- During composting process a succession of facultative and obligate aerobic micro organisms is active.
- In the beginning phases of composting process, mesophilic bacteria are most prevalent. After the rise in temperature of compost site, a thermophilic bacterium becomes predominate leading to thermophilic fungi which appear after 5 – 10 days.

- In final stages or curing period as it is sometimes known, actinomycetes appear. Because significant concentrations of these microorganisms may not be present in some types of biodegradable waste, it may be necessary to add them to the composting material as additive.
- Critical parameters in the control of aerobic composting processes include moisture content, c/n ratio and temperature.
- For most biodegradable organic wastes, once the moisture content is brought to a similar level (50 to 60%) and the mass is aerated, microbial metabolism speeds up.
- The aerobic microorganisms which utilize oxygen, feed upon the organic matter and develop cell tissue from nitrogen, phosphorous, some of the carbon and other required nutrients.
- Much of the carbon serves as a source of energy for the organism and is burns up and respired as carbon dioxide.

➢ Anaerobic Composting

Anaerobic composting is the putrefactive break down of the organic matter by reduction in the absence of oxygen leading to the production of methane and carbon dioxide.

Process Microbiology

- The biological conversion of the organic fraction of solid waste under anaerobic condition is thought to occur in three steps.

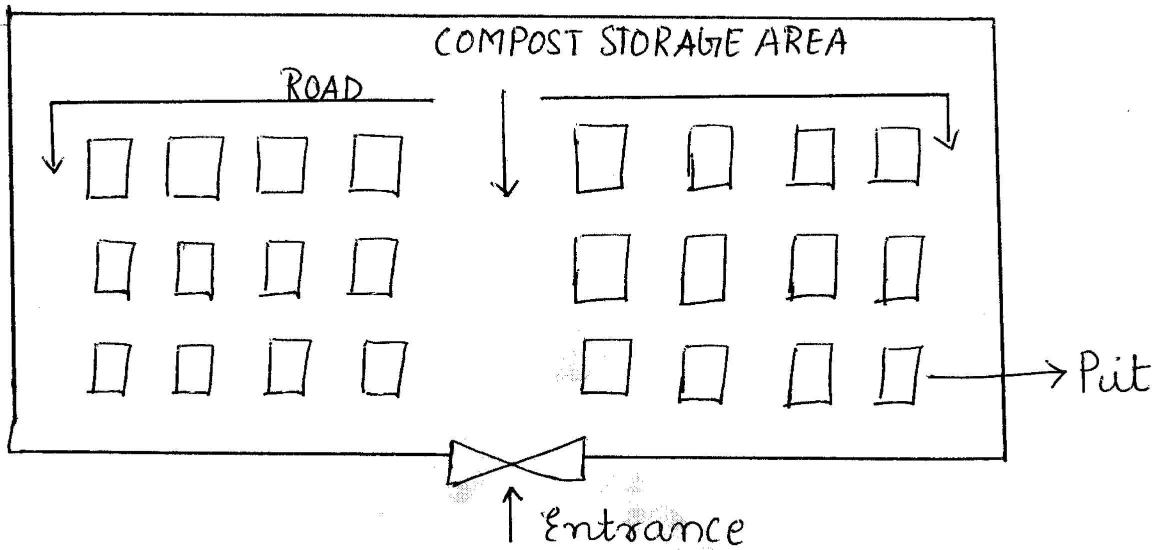
1. The first step involves the enzyme mediated transformation of higher molecular mass compounds into compounds suitable for use as source of energy.
2. The second step involves the bacterial conversion of the compounds resulting from first step into identifiable lower molecular mass compound.
3. The third step involves the bacterial conversion of the intermediate compounds into simpler end product principally methane and carbon dioxide.

In anaerobic decomposition of wastes, no of anaerobic organisms work together to bring about conversion of organic portion of the wastes to a stable end product.

- One group of organisms is responsible for hydrolyzing organic polymer and lipids to basic structural building blocks such as fatty acids, monosaccharide's, amino acids and related compounds.
- Second group of anaerobic bacteria ferments the break down products from the first group to organic acids the most common of which is acetic acid. This group of micro organisms is called acidogens or acid formers.
- Third group of micro organisms converts the hydrogen and acedic acid formed by the acid formers to methane gas and carbon dioxide.
- The bacteria responsible for the conversion are strict anaerobes called methogens or methane formers.

➢ Bangalore Process of Composting — Anaerobic Composting Type

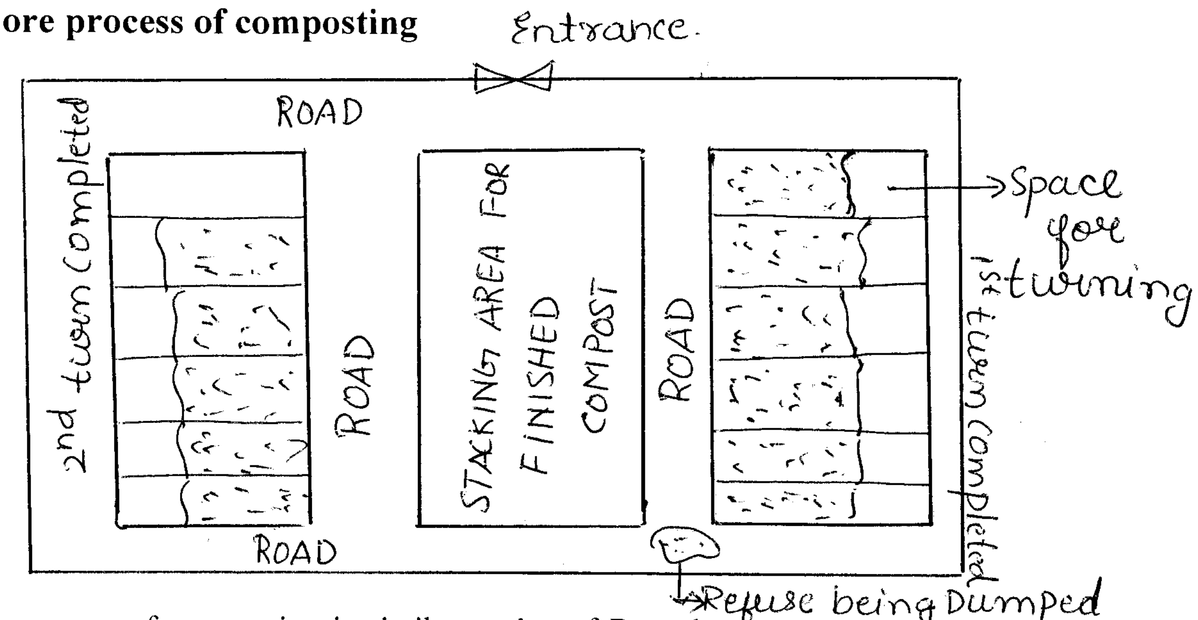
The solid waste is stabilized anaerobically in earthen trenches of 10*1.5m*1.5m deep.



Process

1. A loose layer of solid waste is to be placed and spread at the bottom of the pit.
2. Succeeding layers of waste and night soil/ cow dung is placed. An alternative layer of waste and night soil of 5cm is placed until the layer is about 30cm above the ground surface. The top most layer of the waste should be at least 20cm thick.
3. The composting mass develops a temperature of about of 60°c in a few days.
4. After the material has been decomposed for several days, the volume decreases and the waste settles to one third to two third of the original depth. Again the new layers of night soil and waste can thus be added to the pit until the level is again 30cm above the ground.
5. The pile may be covered with 5cm layer of earth to prevent the escape of ammonia as well as to reduce the escape of odour.
6. The top 10 – 15cm of material in the pit do not decompose properly owing to lower temperature at the surface. This material is again reused for covering the pit
7. Fly control can be improved by covering the pit tightly with a cloth or sealed by a mud plaster.
8. After about 3-4months, the refuse gets finally stabilized and changes into brown colored odourless powdery mass called humus.

➢ Indore process of composting



This process of composting is similar to that of Bangalore process except that the composting mass is returned. It is done to maintain aerobic condition and to keep away odour. It also helps in maintaining high temperature and uniform decomposition.

Process

1. The initial steps in placing the materials in the pit are more or less same as in the Bangalore process except that a small space about 60cm is left vacant at the end of the pit. The vacant space is used to facilitate turning of the compost materials. The thickness of the bottom and intermediate layers is kept slightly lesser to obtain slightly higher moisture content.
2. Since the material is turns, exposure of all the materials to high temperature is assured and high moisture content do not present any problems in maintaining aerobic condition.

After 4 to 7 days of loading the pit, contents must be turns. Turning process performs three functions.

- It completes the mixing of refuse and night soil.
- The materials at the top and sides of pit which are not subjected to high temperature are also subjected to high temperature.
- The materials are aerated which is an essential feature of aerobic stabilization.

Since the volume of the material shrinks during composting additional layers of night soil is added at the time of first turning. This process of turning is continued for about 4 to 5weeks, during which time, the readily biodegradable organics are consumed. The waste compost mass is finally allowed to cure for another 2 to 8 weeks without any turning. The entire composting process, thus, takes about 3-4months time to complete, after which the compost becomes ready for use.

➢ Mechanical and Semi mechanical process of composting

The Composting process involves four processes. Namely

- Receipt of refuse
- Segregation
- Grinding and pulverization
- Digestion

a) **Receipt of Refuse**: The refuse is received at the plant @ 2 to 6 tons per vehicle, and storage capacity at the plant should be about 25 to 50% of the daily arrival of refuse at the plant.

b) **Segregation of Refuse**: Dry refuse is allowed to move along belt conveyor, where ferrous matter is removed by magnetic separator and other non combustible organic matters such as papers, rags, cardboard, non ferrous etc are separated out for recycling and reuse. The separation of such material can be done manually as well as shaker screens.

c) **Grinding or pulverizing of refuse**: The remaining refuse is now pulverized by using different equipments like hammer mill, rasping machine, grinder etc.

d) **Digestion of refuse**: The refuse is finally digested under controlled condition of temperature and moisture content in mechanical digestors.
The digestion is done in closed digestor and opens windrow composting

1. **Closed digestor**: Closed digestors are the most hygienic and require minimum space, though costly and hence largely adopted in developed countries.

- Digestion period in such digestors normally vary between 2 to 5days for refuse containing low cellulose or low c/n ratio; and 7 to 9days for refuse having more quantities of cellulose and higher c/n ratio.
- In Closed digestor plant, the refuse and garbage is processed in four stages.
  1. Is taken to a grinder
  2. Then to a bucket conveyor
  3. For segregation
  4. Finally to a closed digestor containing rotating mechanism for thorough mixing of the refuse for its aerobic digestion under controlled condition of temperature and moisture.
  5. Such closed digestors may prove to be costly and hence uneconomical for composting large quantities of refuse, particularly for developing countries, like India

2. Open Windrow Composting: In this process the refuse is piled up in stacks. These stacks are called as windrows.

- The stacks should have the dimension of 1.5m height and 2.5m width. The moisture content should be 60%.

- The refuse is allowed in windrows and within one month duration the complete digestion is possible, after one month the nitrogen and phosphorous are added to compost to use as fertilizer.
- Up to one month duration turning of refuse is required atleast twice or thrice a day.

➢ Vermi Composting

Vermi composting uses natural composting process of decomposition of biodegradable organic matter by the soil bacteria as in ordinary composting technique, but takes the assistance of cultured earth worms that are produced commercially.

- These earth worms do help in quicker decomposition of the organic matter.
- This method helps in adopting the composting technique in individual bungalows and institution, to dispose of domestic waste and more particularly for disposing of the yard and garden wastes.

The various steps involved in applying the very composting technique are summarized below.

- Dig a small pit about 0.5m square and 1m in deep.
- Line the pit with dried leaves and grass.
- Organize the disposal of organic domestic waste such as vegetable waste into the pit as and when generated.
- Introduce a culture of worms that is produced commercially.
- Cover the pit contents daily, by sprinkling of dried leaves and soil every day.
- Water the pit once or twice a week to keep it moist.
- Turn the contents of the pit every 15days.
- In about 45 days, the waste will be decomposed by the action of the microorganisms.
- The produced humus in the pit is fertile and rich in soil nutrients. It can, hence, be used in the garden.

➢ Factors affecting composting

The most important factors affecting the composting operations are given below.

1. Segregation of refuse
2. Grinding and shredding of refuse
3. C/N ratio
4. Proportion or blending of wastes
5. Moisture content
6. Placement of materials for composting
7. Temperature
8. Aeration
9. Organisms in composting
10. Reaction (pH value)
11. Climatic condition
12. Destruction of pathogenic organisms
13. Fly control

1. **Segregation of refuse**: Segregation is an important factor as they would create difficulties in subsequent process of composting.
   Glass bottles, tin cans, plastic materials can be easily segregated.

2. **Grinding and shredding of refuse:** Grinding and shredding of refuse makes the material more susceptible to bacterial invasion as more area is exposed to bacterial attack.

3. **C/N Ratio (Carbon/ Nitrogen Ratio):** Decomposition of organic matter is affected by the presence of carbon and nitrogen. The c/n ratio represents the initial proportion of two elements.
   - The decomposition of organic matter is brought about by living organisms which use 'c' as a source of energy and 'n' for building cell structure.
   - Since each part of 'n', an initial c/n ratio of 30 seems most favorable for rapid composting.
   - The composting can be decreased by decreasing c/n ratio below 30. This ratio largely depends upon the composition of the solid waste being composted.

4. **Proportion or Blending of Wastes:** C/N ratio and moisture content are the two factors which are to be considered in blending. There is no need for blending when c/n ratio lies between 30 – 40.
   - Materials too dry for good composting and materials too wet to compost without nuisance should be blended in proper proportions
   - Sometimes even earth is added to the organic materials with the idea of increasing the number of microorganisms so as to expedit composting.

5. Moisture content: Aerobic composting can proceed at any moisture content between 30% and 100% provided adequate aeration is maintained. But however a high moisture content must be avoided because water displaces air and availability of oxygen is decreased on the other hand, too low moisture content deprives the organisms of water needed for their metabolism.

- In aerobic composting, the maximum moisture content is not important. If the procedure is to have initial aerobic conditions to produce high temperature lasting a few days for the destruction of pathogenic organisms followed by aerobic composting, the maximum initial moisture content may be as high as 65 – 85% depending on the character of the composting.

6. Placement of Materials for composting: For the aerobic composting, solid wastes are placed in open pile or windrows placed on the ground or on a paved surface or in a shallow pit are the mostly used methods.

- If composting process is to be maintained aerobic throughout, frequent turning becomes essential. On the other hand if composing is to be entirely anaerobic, pits about 1m deep and varying in length and breadth in accordance with the daily quantity of waste.

7. Temperature: In aerobic composting proper temperature is a very important factor. High temperature is essential for the destruction of pathogenic organism and undesirable weed seed.

- Composting also proceeds much more rapidly in the thermophilic temperature range. The optimum temperature ranges 55° - 70°c, around 60°c usually being satisfactory.
- A drop in temperature in the pile of wastes before the material is stabilized indicates that the pile is becoming anaerobic and should be aerated. The variations in moisture content between 30% and 75% have little effect on the maximum temperature.

8. Aeration: Aeration is essential for thermophilic aerobic composting and also for reducing the high initial moisture content. Aeration also avoids anaerobic condition, helps in maintaining high temperature and fly control.

9. Organisms in composting: In aerobic composting a wide variety of micro organism have a variety of specific functions. Compostable waste materials normally contain a large number of many different types of bacteria, fungi and other living organism.

10. Reaction (pH): The initial pH of compostable materials lies usually between 5 and 7. Waste containing ash may be having higher pH value. If the material has undergone putrefication before being received for composting pH will be about 5. Since the optimum pH for most organisms is around 6.5 to 7.5, it would be beneficial if pH could be maintained in that range.

11. Climatic conditions: Climatic condition like temperature, wind and rainfall influence the composting operation.

- Wind lowers the temperature on the windward side of the compost stack.
- Rain presents more of problems when composting done in pits.
- Heavy snowfall greatly hinders continuous composting operation.

12. Destruction of Pathogenic organisms: Aerobic composting of high temperature is effective in destroying pathogenic organisms. Almost all the disease bearing microorganism die away at much lower temperature than the maximum temperature found inside the composting piles. Frequent turning also helps in the elimination of disease producing organisms.

13. Fly control: The composting materials are excellent media for the breeding and development of a large fly population. Grinding, turning and systematic cleanliness are found and is most effective for controlling flies.

➢ **Important design consideration for anaerobic composting**

1. Size of materials – Wastes to be digested should be simplified into size that will not interfere with the efficient working or functioning of mixing operation.
2. Mixing equipment – To achieve optimum effects results and to avoid scum build up, mechanical mixing is recommended.
3. Percentage of solid wastes mixed with sludge – Although amounts of wastes varying from 50 to 90% have been used. 60% appears to be reasonable compromise.
4. Temperature -Between 30 - 38°c for mesophilic organism and 55 - 60°c for thermophilic organism.
5. Destruction of volatile solid waste – Depends upon the nature of characteristics destruction varies from about 60 to 80%, 70% can be used for estimating purpose.
6. Total solid destroyed – Varies from 40 to 60%, depending upon the amount of inert materials present originally.

➢ Important design consideration for aerobic composting

1) Particle size – For optimum results the size should be between 25 to 75mm.

2) Carbon/ nitrogen ratio – Initial carbon and nitrogen ratios between 25 and 50 are optimum for aerobic composting.

3) Blending and seeding – Composting time can be reduced by seeding with partially decomposed solid waste to a extent of about 1 to 5 percent the weight. Sewage sludge can also be added to prepared solid waste.

4) Moisture content – moisture content should be in range between 50 and 60% during the composting process. The optimum moisture content should be about 55%.

5) Mixing and turning – To prevent during, air channeling, material in the process of being compacted should be turns or mixed on regular schedule or as required.

6) Temperature – For best results, temperature should be maintained between 50 - 55°c for first few days and between 55 - 60°c for the remaining of the active composting. If temperature goes beyond 66°c, biological activity is reduced significantly.

7) Air requirement – The theoretical quantity of oxygen required can be estimated and air atleast 50% of the initial oxygen concentration of remaining should reach all parts of the composting material for optimum results.

8) pH Control – To achieve an optimum aerobic decomposition, pH should bremain at 7 to 7.5 range. To minimize the loss of nitrogen in the form of ammonia gas, pH should not rise above 8.5.

9) Land Requirement – The land requirement for a plant with a capacity of 50 tons/day will be 1.5 to 2 acres. The land area required for a larger plant will be less on ton/day basis.

Unit-5

* **Problems :-**

Estimating AIR Requirements

1. Determine the amount of air required to oxidize completely 1tonne of waste having the chemical equation $C_{50}H_{100}O_{40}N$

Solu :

- Oxygen required

$$C_aH_bO_cN_d + \frac{4a+b-2c-3d}{4} O_2 \rightarrow aCO_2 + \frac{b-3d}{2} H_2O + dNH_3$$

$a=50$; $b=100$; $c=40$; $d=1$

$$C_{50}H_{100}O_{40}N_1 + 54.25O_2 \rightarrow 50CO_2 + 48.5H_2O + NH_3$$

(1354) (1736) (2200) (873) (17)

unit wt of carbon = 12

H = 1, O = 16, N = 14

Oxygen required / tonne

$$O_2 = \frac{1736}{1354} \times 1000 = 1.282 \times 10^3 \text{ kg/tenne}$$

$$\boxed{O_2 = 1.282 \times 10^3 \text{ kg/tonne}}$$

II Determine the O_2 Required to stabilize the ammonia

$$NH_3 + 2O_2 \rightarrow H_2O + HNO_3$$

$$(17) \quad (64) \quad (18) \quad (63)$$

$$O_2 = \frac{17}{1354} \times \frac{64}{17} \times 1000 = 47.3\,kg/tonne$$

III Determine the amount of O_2 Required

a) Density of air = 1.2928 kg/m3

air contains 23.15 percent O_2 by weight

$$O_{2(total)} = (1.282 \times 10^3 + 47.3)\,kg/tonn$$

$$= 1329.3\,kg/tonn$$

b) The mass of air

$$AIR_{(mass)} = \frac{1329.3\,kg/tonn}{0.2315}$$

$$= 5742.11\,kg/tonn$$

c) Volume of air

$$V_{air} = \frac{5742.11\,kg/tonn}{1.2928\,kg/m^3}$$

$$V_{air} = 4441.61\,m^3/tonn$$

[redacted]

* Estimating methane production

1. Estimate the theoretical volume of methane gas that would be expected from the anaerobic digestion of a tonne of a waste having the composition $C_{50}H_{100}O_{40}N$

Solution:-

$$C_aH_bO_cN_d + \frac{4a-b-2c+3d}{4}H_2O \rightarrow \frac{4a+b-2c-3d}{8}CH_4 + \frac{4a-b+3c+3d}{8}CO_2 + dNH$$

$a = 50; b = 100, c = 40, d = 1$

$$C_{50}H_{100}O_{40}N + 5.75H_2O \rightarrow 27.15CH_4 + 22.875CO_2 + NH_3$$

(1354) (103.5) (434) (1006.5) (17)

I Determine the mass of methane/tonne

$$\text{Methane} = \frac{434}{1354} \times 1000 = 320.5\text{ kg/tonne}$$

II Using a density value of 0.7167 kg/m3

$$V = \frac{320.5\text{ kg/tonn}}{0.7167\text{ kg/m}^3}$$

V = 44.72 m³/tonne of Waste

Unit – 6

Sanitary Landfill

Landfills have been the most economical and environmentally acceptable method for the disposal of solid waste. Even with the implementation of waste reduction, recycling and transformation technologies, disposal of residual solid waste still remains an important component of an integrated solid waste management. Landfill management incorporates planning, design, operation, closure and post closure control of landfills.

Based on the past experience throughout the world, land disposal in the form of sanitary landfill has proved to be most economical and acceptable method for the disposal of solid waste.

Definitions

1. Landfill – are the physical facilities used for the disposal of residual solid waste in the surface soil of earth.

2. Sanitary Landfill – An operation in which the waste to be disposed off are compacted and covered with the layer of soil at the end of each days operation. When the disposal site has reached its ultimate capacity ie after all disposal operations have been completed, a layer of 2ft or more material is applied.

   Today sanitary landfill refers to an engineered facility for the disposal of soild waste designed and operated to minimize public health and environmental impacts.

3. Cell – It is used to describe volume of materials placed in a landfill during one operating period usually one day. It includes the solid waste deposited and also the daily cover materials surrounding it.

4. Daily cover – Usually consist of 6 – 12 inch of native soil or alternative soil such as compost that are applied to the working faces of the landfill at the end of each operating period. The purposes of daily cover are
   - To control the blowing of waste materials
   - To prevent the rats, flies & other disease vectors from entering the landfill.
   - To control the entry of water into the landfill during operation.

5. Lift – is a complete layer of cells over the active area of the landfill. Typically landfill are comprised of series of lifts.

6. Bench or terrace – is commonly used where the height of the landfill will exceed 50-75ft. Benches are used to maintain the slope stability of the landfill for the placement of surface water, drainage channel and for the location of landfill gas recovery piping.

7. Final cover layer – It is applied to entire landfill surface after all landfilling operation is complete. It usually consist of multiple layer of soil or geomembrane materials designed to enhance surface drainage, intercept percolating water and support surface vegetation.

8. Leachate – The liquid that collects at the bottom of the landfill is known as leachate.
   - In general, leachate is a result of the percolation of precipitation, uncontrolled runoff and irrigation water into the landfill.
   - Leachate can also include water initially contained in the waste as well as infiltrating ground water.
   - Leachate contains a variety of chemical constituents derived from the solubilization of materials deposited in the landfill.

9. Landfill gas - `it is the mixture of gases formed within a landfill. The bulk of landfill gas consist of methane and carbon dioxide. Other components of landfill gas include ~~atmosphere~~, nitrogen, oxygen, ammonia and traces of organic compounds.

10. Landfill liners – are the materials both natural and manufactured that are used to line the bottom area and below grade sites of a landfill. Liner usually consist of layers of compacted clay and geomembrane materials designed to prevent migration of landfill leachate and landfill gas.

❖ Advantages and disadvantages of Sanitary Landfill

Advantages

1. Where land is available, sanitary landfill is usually the most economical method of solid waste disposal.
2. The initial investment is low compared with other disposal methods like incineration or pulverization.
3. Sanitary landfill is a complete or final disposal method as compared to incineration and composting which require additional treatment .
4. Sanitary landfill can receive all types of solid waste eliminating the necessity of separate collection.
5. Sanitary landfill is flexible. Increased quantities of solid wáste can be disposed off with little additional equipment.
6. Sub marginal land can be reclaimed as parking slots, play ground, golf courses etc..

Disadvantages

1. In highly populated areas suitable land may not be available within economical hauling distance.

2. Proper Sanitary landfill standards must be followed daily or the operation may result in an open dump.
3. Sanitary landfill located in residential areas can provoke public opposition.
4. A completed landfill will settle gradually and require periodic maintenance.
5. Special design and construction is required for building constructed on completed landfill because of settlement factor.
6. Methane an explosive gas and other gases produced from the decomposition of waste may become a hazard or nuisance.

❖ **Site Selection**

Factors that must be considered in evaluating potential solid waste disposal sites.

1. Available Land area – In selecting the disposal site, it is important to ensure that sufficient area is available. Although there are no fixed rules concerning the area required, it is desirable to have sufficient area including an adequate buffer zone to operate for at least five years at a given site.
2. Haul Distance – Length of haul significantly affects the overall design in the operation and will have significant impact on operating cost.
3. Soil condition & topography – Because it is necessary to cover the solid waste placed in the landfill each day and to provide final cover after landfilling operation is completed.
    - Data must be obtained on the characteristics of the soil in the area. The cover materials must be available at or near the site.
4. Climatic condition – Local weather condition must also be considered in the evaluation of potential sites. Provision must be made for wet weather condition.
5. Surface water hydrology – The surface water hydrology of the area is important in establishing the existing natural drainage & runoff characteristics that must be considered. Because mitigation measures must be developed to divert surface runoff from the landfill site.
6. Local Environmental conditions – Although it has been possible to build and opposite landfill sites in close proximity to both residential & industrial developments, they must be operated very carefully if they are to be environmentally acceptable with respect to traffic, noise, odor, dust, air borne debris, health hazards etc. To minimize the impact of landfilling operations, landfills are now sited more in remote areas.
7. Ultimate use of completed landfill – one of the advantages of a landfill is that, once it is completed the area of land becomes available for other purposes. Because the ultimate use affects the design & operation of landfill, this issue must be resolved before the landfill & design of landfill is begun.
8. Site Access – as the number of operating landfill continues to decrease, new landfills that are sited are increasing in size because land areas of suitable size are not readily available near existing developed roadways and cities. Construction of

excess roadways and rail lanes has become a fact of life and an important part of landfill sighting.

❖ Methodology

Placement of waste in the sanitary landfill

Once the landfill site has been prepared the next step in the process involves actual placement of waste materials.

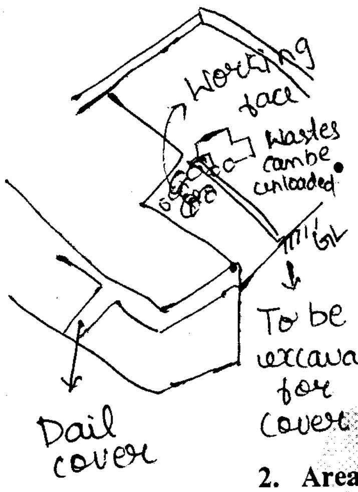
- Solid waste is transported in trucks or tractor to the disposal site and dumped on low lying area i.e trenches.
- The waste is placed incense beginning along the face continuing upwards and outwards of the face.
- The waste deposited by vehicles is spread out in 18 – 24 inch layer and is compacted.
- The waste deposited in each operating period ie in one day forms an individual cell. Typical cell height varies from 8 – 12 feet.
- Length of working face varies from site condition & size of operation. The working face is the area of the landfill where the solid waste is unloaded, placed and compacted during a given operating period.
- All exposed face of the cell is covered with thin layer of soil 6 – 12inch thick at the end of each operating period.
- After one or more lifts have been placed horizontal gas recovery trenches can be excavated in the completed surface. The trenches are filled with gravel and perforated plastic pipes are installed in trenches.
- Gas is extracted through pipes depending on the depth of landfill & additional leachate collection facilities may be placed in lifts.
- A cover layer is applied to the completed landfill section. The final cover is designed to minimize infiltration of leachate and drainage.
- Vertical gas extraction systems may be installed through completed landfill surface and the whole system is tied together and routed to energy recovery facilities.

❖ Sanitary Land filling Methods

The principal methods used for the land filling of solid waste are

1. Trench / excavated method
2. Area / ramp method
3. Canyon / Depression method

1. **Excavated / Trench method** – The excavated cell/ trench method of landfilling is ideally suited through areas where an adequate depth of cover material is available at the site and where water table is not near the ground surface.
    - Typically solid wastes are placed in cells or trench excavated in the soil. The soil excavated from the site is used for daily and final cover. The excavated cell/ trench are usually lined with synthetic membrane liners or low permeability clay or combination of both to limit the movement of landfill gases and leachate. Excavated cells are typically square, up to 1000ft in width and length with side slopes of 1.5:1 to 2:1 in length, 3- 10ft in depth and 15-50ft in width.
    - Landfills are allowed to construct below the high ground water level if special provisions are made to prevent ground water from entering the landfill and to contain or eliminate the movement of leachate or gases from completed cells. Usually the site is dewatered, excavated and lined in compliance with local regulation. The dewatering facilities are operated until the site is filled to avoid the creation of uplift pressures that would cause the liner to heave and rupture.



2. **Area / Ramp method** – is used when the terrain is unsuitable for the excavation of cells or trenches in which to place the solid waste. In high ground water conditions necessitates the use of area method.
    - Landfill site preparation includes the installation of liner and leachate control system.
    - Cover material is hauled in by trucks and earth moving equipments from adjacent land or from burrow pit areas.
    - In location with limited availability of materials that can be used as cover, compost produced from yard waste and municipal solid waste has been used successfully as intermediate cover material.
    - Other techniques that have been used include the use of movable temporary cover materials such as soil and geomembrane.
    - Soil and geomembrane placed temporarily over a completed cell can be removed before the next lift is begun.

Gases

Composition – Landfill gas is composed of number of gases that are present in large amount and no of gases present in small amount. The principal gases are produced by the decomposition of solid wastes. Some of the trace, although present in small quantities may be toxic and could present risk to public health.

Principal Landfill Gas constituents

Gases found in landfill include NH_3, CO_2, CO, H_2S, CH_4, H_2 and O_2. CH_4 & CO_2 are the principal gases produced from anaerobic decomposition of biodegradable organic components in solid wastes. When CH_4 is present in air in concentration between 5 – 15% it is explosive because only limited amount of oxygen is present in landfill when CH_4 concentration reaches critical level. There is little danger that the landfill will explode. However CH_4 mixtures in explosive range can form, if landfill gases migrates offsite and mixes with air. The concentration of these gases that may be expected in the leachate will depend on their concentration in gas phase in contact with leachate.

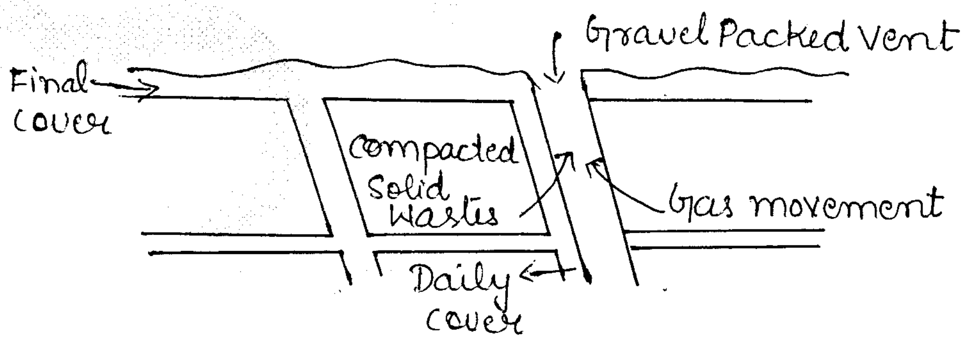
Control of Gas movement

The movement of gases in landfills can be controlled by constructing vents and barriers and by gas recovery system.

- **Control of Gas movement with Vents and barriers**

Vents

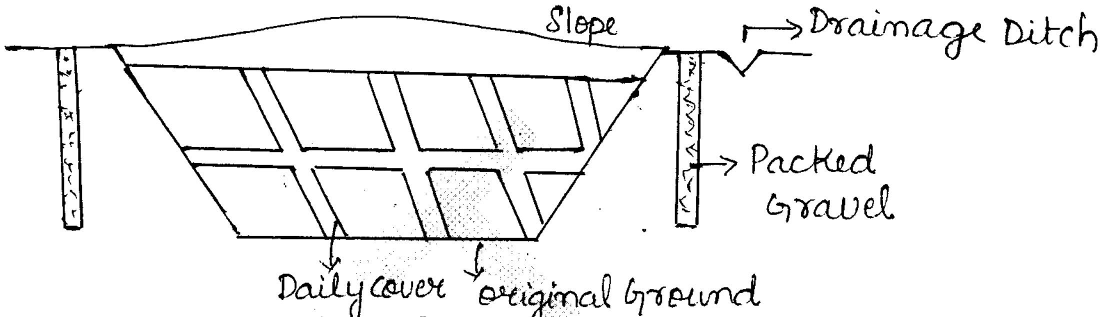
The lateral gas movement of gases produced in a landfill can be controlled by installing vents made of materials that are more permeable than the surrounding soil.



1. Gas vents are constructed of gravel.
2. The spacing of cell vents depends on the width of waste cells but usually varies from 18 – 60m. The thickness of gravel layer should be such that it will remain continuous even though there may be differential settlement.

Barriers or Well Vents – can be used to control the lateral movement of gases. Well vents are often used in conjunction with lateral surface vents buried below grade in a gravel trench to control the downward movement of gas which can be accomplished by installing perforated pipes.

- If the gases cannot be vented laterally, it may be necessary to install gas wells and to vents the pumped gas to the atmosphere.



* Barrier Type

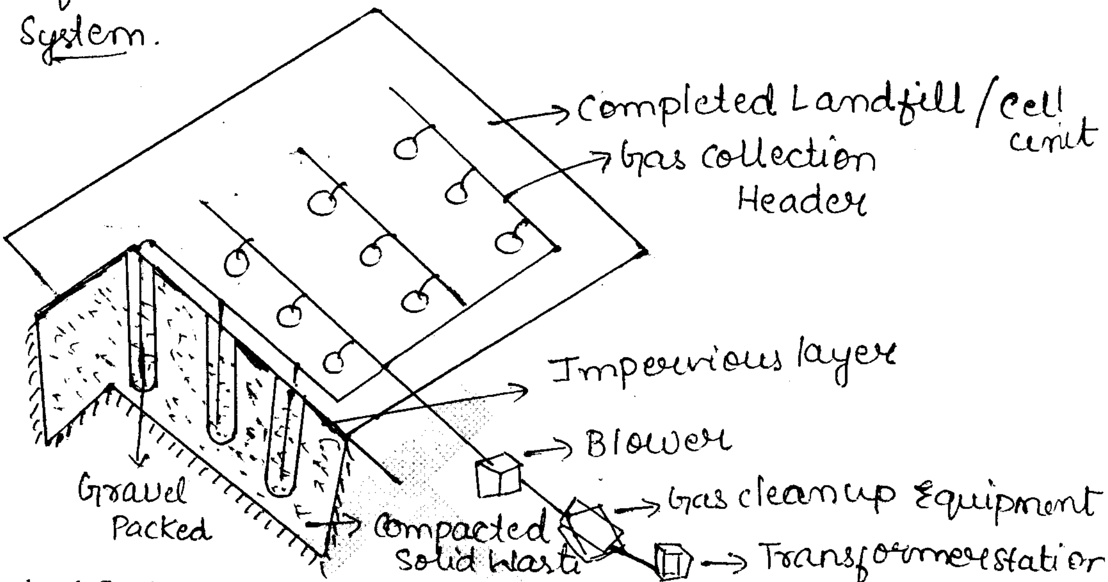
- The movement of landfill gases through adjacent soil formations can be controlled by constructing barriers of materials that are made impermeable than the soil.
- Some of the landfill sealants that are available for the use are bentonite, kaolinite, sodium carbonate, silicate, rubber latex, polymer etc.

Control of gas movement by gas recovery

The movement of gases in landfills can also be controlled by installing gas recovery wells in completed landfills

- Clay and other liners are used where landfill gas is to be recovered.
- In some gas recovery systems, leachate is collected and recycled to the top of the landfill and reinjected through perforated lines located in drainage trenches. Typically, the rate of gas production is greater in leachate recirculation system or where water is added.
- Although gas recovery systems have been installed in some large municipal landfills, the economics of such operations are at present not well defined.
- The cost of gas clean up and processing equipment may limit the recovery of landfill gases especially from small landfills.

* Well System for Gas Recovery System.



Leachate

Leachate may be defined as liquid that has percolated through solid waste and has extracted dissolved and suspended materials and is composed of the liquid that has entered the landfill from external sources such as surface drainage, rainfall, ground water and water from underground springs and liquid produced from decomposition of solid waste.

Leachate Movement – Under normal conditions, leachate is found at the bottom of landfill. From there, its movement is through the underlying strata, although some lateral movement may also occur depending on the characteristics of the surrounding material. The rate of seepage of leachate from the bottom of a landfill can be estimated by darcy's law by assuming that the material below the landfill to the top of the watertable is saturated and that a small layer of leachate exists at the bottom of landfill.

Control of Leachate movement – As leachate percolates through the underlying strata, many of the chemical and biological constituents originally contained in it will be removed by filtering and adsorptive action of the material composing the strata.

- In general, the extent of the action depends on the characteristics' of the soil, especially the clay content. Because of the potential risk involved in allowing leachate to percolate to the ground water, best practice calls for its elimination or containment. Ultimately, it may be necessary to collect and treat the leachate.
- The use of clay has been favored method of reducing or eliminating the percolation of leachate. Membrane liners have also been used, but they are expensive and require care so that they will not be damaged during the filling operation.
- Important in controlling the movement of leachate is the elimination of surface infiltration, which is the major contributor to the total volume of leachate.
- With the use of an impermeable clay layer, appropriate surface slope and adequate drainage surface infiltration can be controlled effectively.

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Unit-6

1. Determine landfill area required for a municipality with a population 50,000, given that
   i) Solid Waste Generation = 350 gm/person/day
   ii) Compacted density of Landfill = 504 kg/m3
   iii) Average depth of compacted S.W = 3

Solution:-

I calculation of total amount of Solid Waste generation in a day.

Total Waste = Population x per capita generation

= 50,000 x 350 = 17.5 x 10³ kg/day

II Calculation of Volume of SW

$$\text{Volume} = \frac{\text{Total amount of SW}}{\text{Compacted density}}$$

$$= \frac{17500 \text{ kg/day}}{504 \text{ kg/m}^3} = 34.72 \text{ m}^3/\text{day}$$

III calculation of landfill area

Average depth = 3m

$$\text{Total landfill area} = \frac{34.72}{3} = 11.57 \text{ m}^2$$

Area = 11.57 m²