Module 6 Composting

Composting....

Types & method of preparation.

COMPOSTING

- Composting is one element of an integrated solid waste management strategy that can be applied to **mixed municipal solid waste** (MSW) or to separately collected leaves, yard wastes, and food wastes.
- The four basic functions of composting are

(1) *preparation or pre-processing*

(2) *decomposition*,

(3) *post processing*, and

(4) *marketing*.

BENEFITS

- MSW composting results in a volume reduction of up to 50 percent and consumes about 50 percent of the organic mass on a dry weight basis, by releasing mainly CO2 and water.
- Composting breaks down easily degradable plant and animal tissue but does not produce appreciable changes in difficult-to-degrade organics (wood, leather, polymers) or in inorganics (dirt, glass, ceramics, and metals).

The most important pre processing steps are

(1) receiving,

(2) removal of contaminants and recyclable materials,

(3) size reduction, and

(4)possibly some adjustment of the waste properties (e.g., carbon-to-nitrogen ratio).

Three basic systems used for the decomposition steps are

(1) static windrows (piles),

(2) turned windrows, and

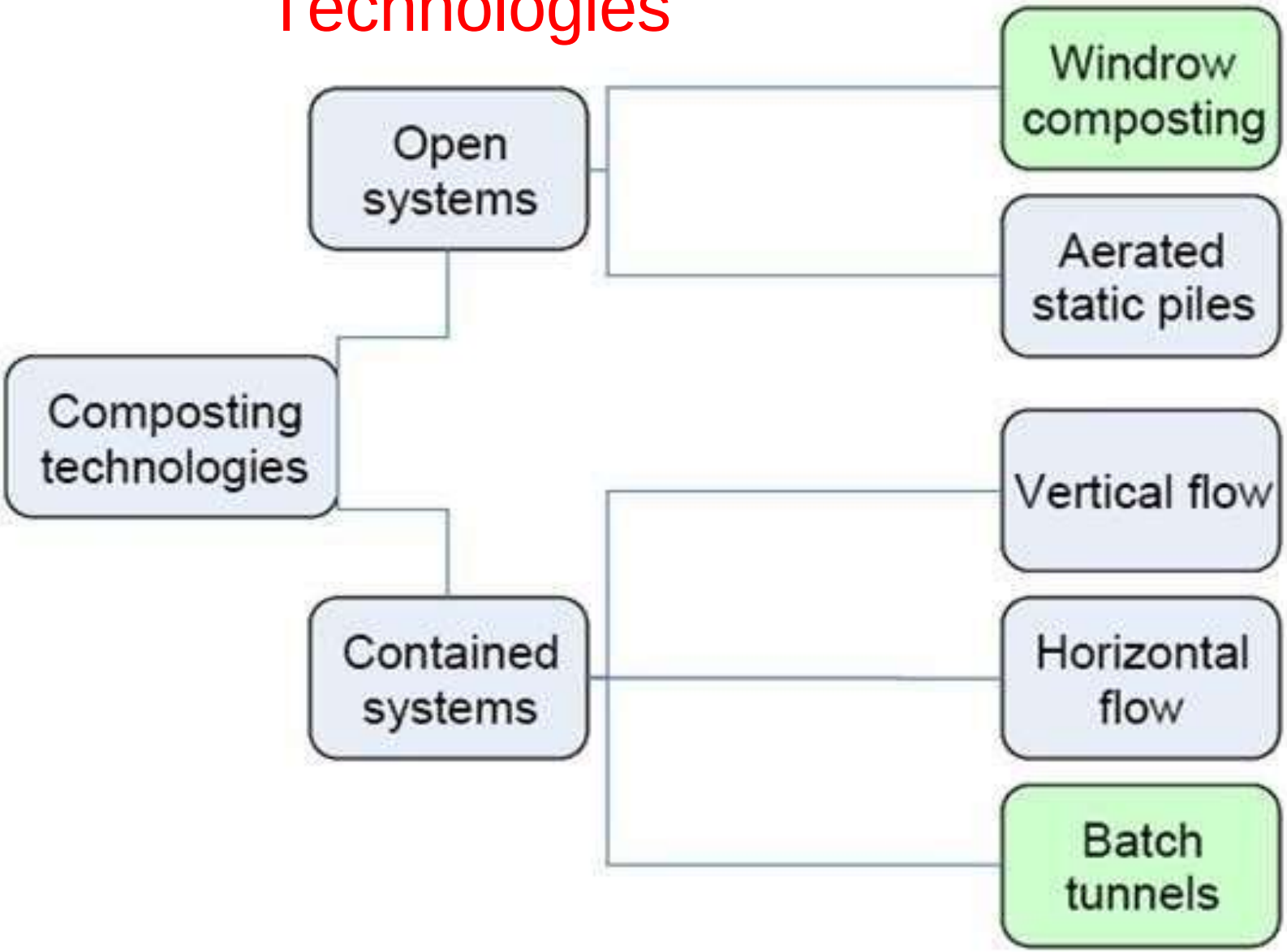
(3) in-vessel composting.

Classification

- The compost process can be classified in terms of distinguishing and in terms of technology.
- Cultural conditions

  aerobic vs. anaerobic
- mesophylic vs. thermophylic.

Types of composting Technologies



Mechanism of Composting

Composting is a biochemical process in which aerobic and anaerobic microorganism decomposes organic matter into valuable manure called as compost.

Release heat

(Thermophilic state, which helps to destroy pathogens)

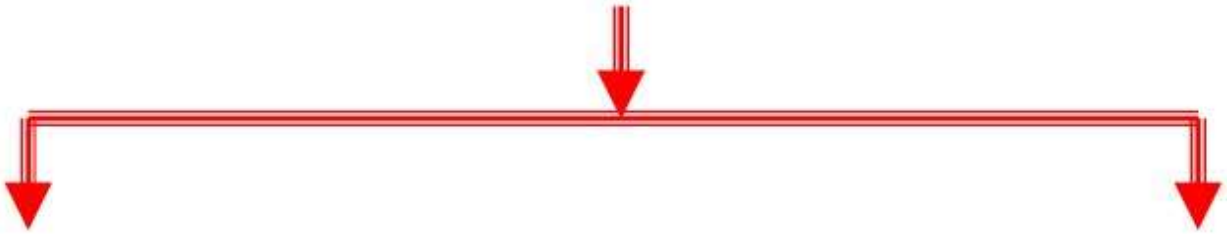
Organic matter → Organic matter → compost

Temp 55-60° c

(Mesophilic state ,Temp. 25-30o c, promote mesophilic microbes for rapid decomposition)

Microorganism Involved in Composting

Two type of microbes which help in composting process are:



Aerobes

Which decompose organic matter in presence of oxygen

Anaerobes

Which decompose organic matter in absence of oxygen

Methods

NADEP Method

Demonstration of this method at large scale was initiated at J. N. Krishi Vidyalaya, Indore.

Bangalore Method

This method was worked out by L. N. Acharya at Indian Institute of Science, Bangalore.

Indore Method

This method was developed by A. Howard and Y. D. Wad at the Institute of Plant industry, Indore, India

Coimbatore method

Classification of Compost Systems.

Compost systems fall into two verybroad groups,

(1) windrow and

(2) in-vessel.

Reflecting their mechanisms of aeration, windrows may be the turned type, forced aeration (static pile) type, or a combinationof turned and forced aeration.

Windraw composting-Aerated

- At its simplest,shredded and/or screened refuse or source-separated organic waste is placed in long parallel piles, called windrows, and the moisture content is maintained near 50%.
- The piles are periodically aerated by fluffing and moving the material around.
- After several weeks, such accelerated aerobic decomposition results in a dark brown earthy- smelling material that has low nutrient value but is an excellent soil conditioner.

The ranges of nitrogen, phosphorus, and potassium in finished compost from MSW

Nutrient	Range, as fraction of total
Nitrogen	0.4 to 1.6
Phosphorus	0.1 to 0.4
Potassium	0.2 to 0.6

Windraw composting-Aerated

- Typically, windrows are constructed of sorted and shredded MSW, mixed with wastewater sludge, and laid in long rows of about 4 to 6 ft (1.2 to 2 m) high. Because the reaction is aerobic, oxygen must be made available to the microorganisms, and this is done either by turning the pile with a specially constructed agitator or by placing the pile on PVC pipes so that air can be pulled through the pile. This is called the *aerated static pile* composting method.

Both of these operations offer the advantage of

- **low capital cost and the simultaneous use of wastewater sludge,**
- **but the operating cost can be high, and odor problems can be serious if the piles are not sufficiently well aerated**

in-vessel composting

- More sophisticated are the *in-vessel* composting plants.
- In one in-vessel process, the shredded and sorted refuse is mixed in an aerobic digester with air being injected through hollow augers.
- The residence time within such a unit is short—often as little as 24 hours but usually more like 5 days—and the rate of decomposition is quite rapid.
- Typically, the composted material is removed from the aerobic digester and allowed to cure in windrows for several weeks prior to sale or disposal.
- A different mechanical technique uses a long rotary drum in which the MSW is slowly turned in a long barrel during a 24-hour detention time.
- Some of these units use refuse in the unshredded and unsorted state with perhaps only a bag opener preceding the composting barrel and screens following digestion.
- As before, the screened fines must then be stored in windrows for several weeks prior to use. The rejects from the screens are sent to a landfill

Indore method

- In the **Indore method** of composting, organic wastes are spread in the cattle shed to serve as bedding.
- Urine soaked material along with dung is removed every day and formed into a layer of about 15 cm thick at suitable sites.
- Urine soaked earth, scraped from cattle sheds is mixed with water and sprinkled over the layer of wastes twice or thrice a day.
- Layering process continued for about a fortnight. A thin layer of well decomposed compost is sprinkled over top and the heap given a turning and reformed.
- Old compost acts as inoculum for decomposing the material.
- The heap is left undisturbed for about a month. Then it is thoroughly moistened and given a turning. The compost is ready for application in another month.

Size of the pit

Breadth - 6-8 feet

Depth - 2-3 feet (not more than 3 feet)

Length - 10 feet or more as per requirement

Raw material

Mix plant residues, weeds, sugarcane leaves, grass, wood ashes, bran etc.

Animal dung

Wood ashes

Water

Urine soaked mud

Filling the composting pits

First of all, spread dry wastes with cattle dung and soil in ratio of 4:2:1 up to 2 inch layer in Composting pit.

Afterwards, sprinkle the water over the materials

Pit is filled with above materials up to 1 foot above the ground level

One more layer of bedding material with wood ash and urinated mud should be added.

Turning

The material is turned three times for proper aeration and moisture.

First turning :

10-15 days after filling the pits.

Second turning :

15 days after first turning.

Third turning :

After 2 month of second turning

Bangalore method

- In the **Bangalore method** of composting, dry waste material of 25 cm thick is spread in a pit and a thick suspension of cow dung in water is sprinkled over for moistening.
- A thin layer of dry waste is laid over the moistened layer.
- The pit is filled alternately with dry layers of material and cow dung suspension till it rises 0.5 m above ground level.
- It is left exposed without covering for 15 days. It is given a turning, plastered with wet mud and left undisturbed for about 5 months or till required.

This method saves labour cost because there is no need of turning and regular sprinkling of water.

Size of the pit

Composting is done in trenches of 30' × 6' × 3' or in pits of 20' × 6' ×3.

Method of Filling the Composting Pits

Spread the moist farm refuse at the bottom of the pit up to one inch.

Then, spread two inch of cattle dung and urinated mud followed by 1 or 2 inch layer of soil

This heap is made up to 1.5-2.0 feet above the ground level following above process.

Finally the heap is covered with 1 inch thick mud.

After 8-9 months all material decomposes and compost becomes ready for the application.

Bangalore method

- This is an anaerobic method conventionally carried out in pits.
- 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.
- 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.
- The final layer of solid waste is at least 25 to 30cm thick. The top of the deposited material is rounded off

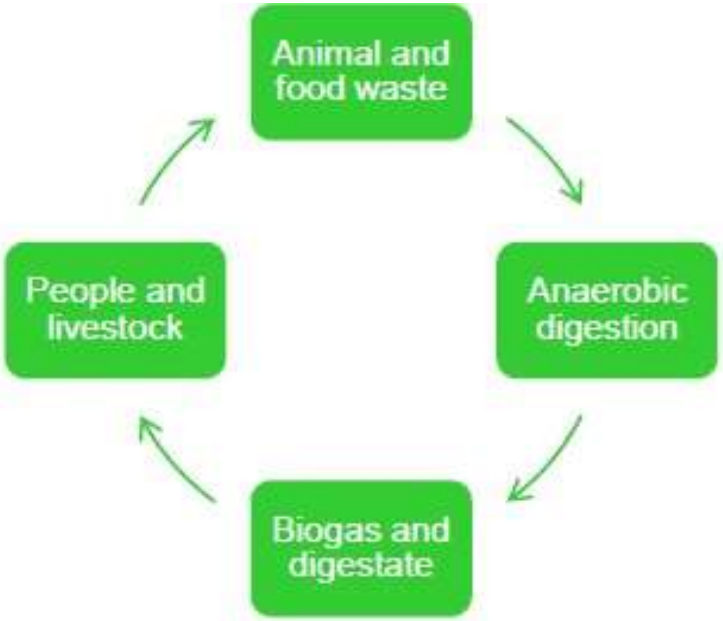
  to avoid rain water entering into the pit.
- After 4 to 6 months of decomposition the material is stabilized and is taken out and used as compost.

Indore method

- The Indore method of composting in pits involves filling of alternate layers of similar thickness as in the Bangalore method.
- 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.
- 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.
- Aerobic composting of solid waste and night soil can be carried out in windrows of more or less the same dimensions as the pits.
- However, aerobic composting in windrows on more commonly used while composting municipal solid waste alone.

Anaerobic Digestion of waste

Anaerobic digestion (AD) is the natural process that breaks down organic matter in the absence of oxygen to release a gas known as biogas, leaving an organic residue called digestate.



Biogas is a mixture of methane, carbon dioxide and water and can be used to produce electricity and heat or used as a natural gas substitute.

Digestate is a nutrient rich by-product of AD and can be used as a fertilizer and soil improver.

Treats food waste sustainably

Can reduce my reliance on landfill

Produces a renewable source of energy

Can help me to reduce greenhouse gas emissions

Can help save money on my energy bills

Stages of AD

Hydrolysis

- Breakdown of complex insoluble organic matter into simple sugars, fatty acids and amino acids

Acidogenesis

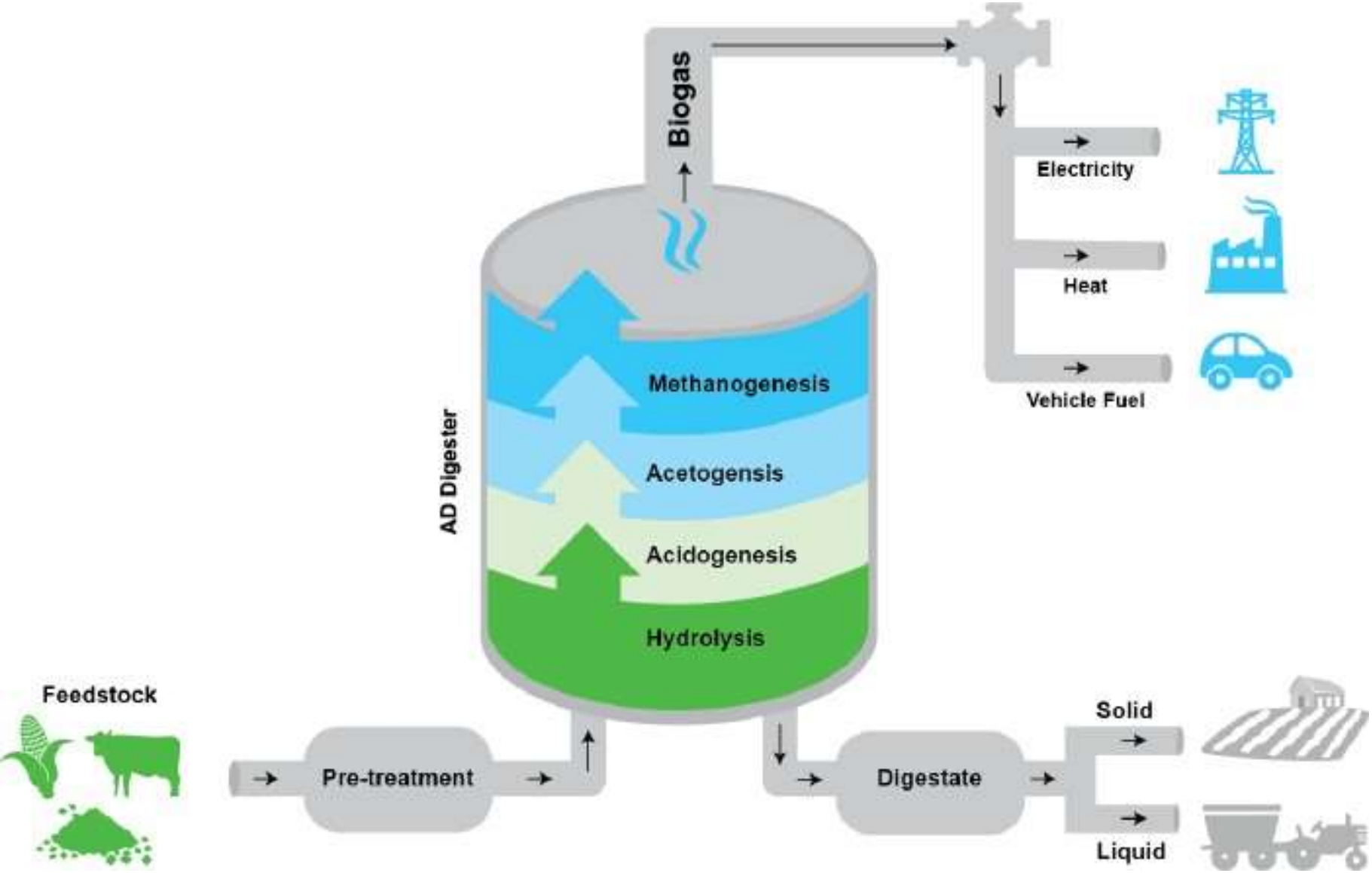
- Further breakdown of simple sugars, fatty acids and amino acids into alcohols & volatile fatty acids (VFAs)

Acetogenesis

- Conversion of VFAs and alcohols into acetic acid, CO_2 and hydrogen

Methano-genesis

- Finally, the acetic acid and hydrogen is converted into methane and carbon dioxide by methanogenic bacteria


Biogas
Electricity
Heat
Vehicle Fuel
AD Digester
Methanogenesis
Acetogensis
Acidogenesis
Hydrolysis
Feedstock
Pre-treatment
Digestate
Solid
Liquid

Feed stock

Feedstocks are normally biodegradable wastes, but energy crops can also be used. Common sources include:

- Municipal, commercial and industrial food wastes
- Agricultural wastes (e.g., slurries, poultry litter and manure)
- Wastewater and sludges from industrial waste treatment
- Food/beverage processing waste
- Energy crops (e.g., maize, grass and silage)

Feed stock composition

Feedstocks vary in composition and should be carefully selected:

- Variable composition
- Bacteria require nutrients

Composition includes:

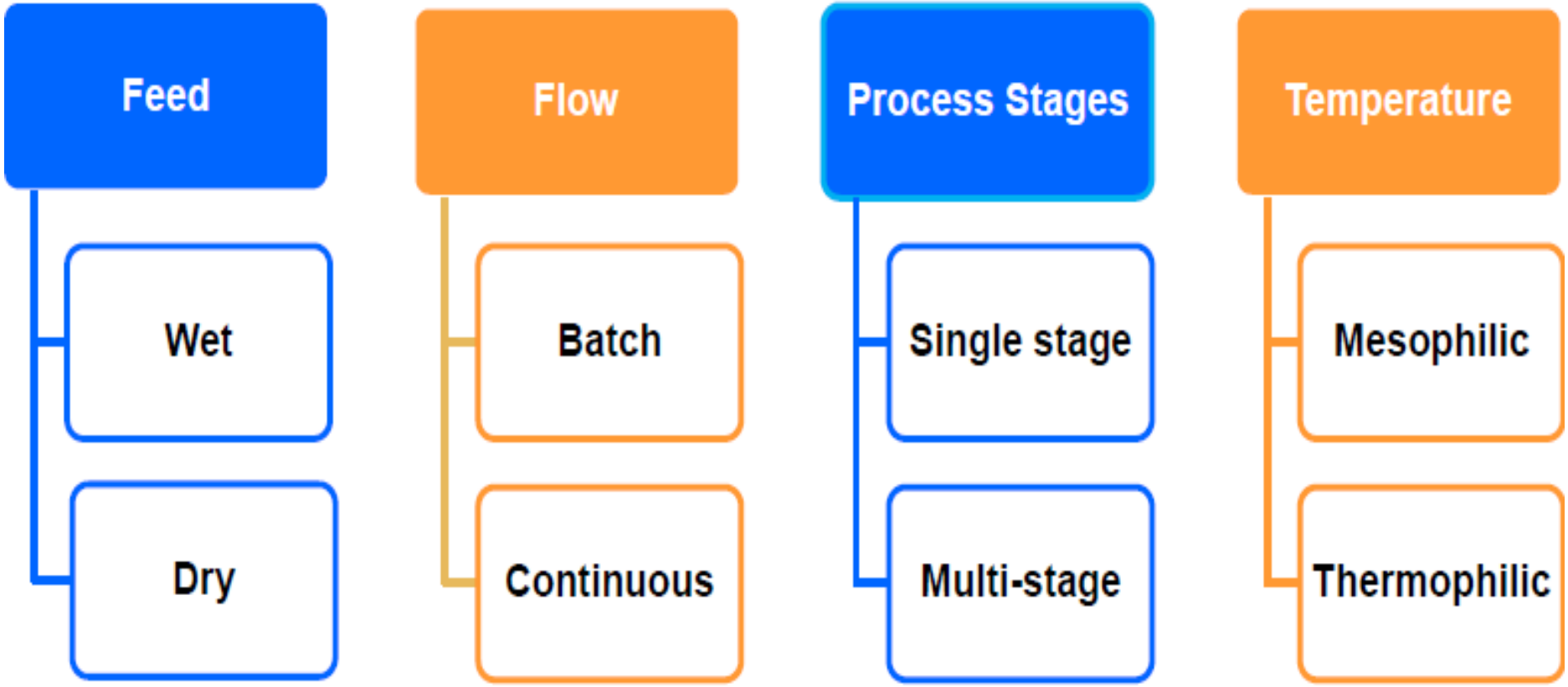
- Dry solids (DS)
- Volatile solids (VS)
- C:N (carbon to nitrogen ratio)

Feed stock Pretreatment

Feedstock	Pre-treatments
Separated food waste	De-packaging may be required depending on contamination levels.
Manures / slurries	Minimal pre-treatment required, usually used with other feedstocks.
Commercial & industrial wastes	De-packaging is required to remove plastics and metals. Often highly contaminated so screening is also required. Effluents require minimal pre-treatment.
Energy crops	Screening to remove stones, cutting or shredded. Silage is usually pre-shredded.

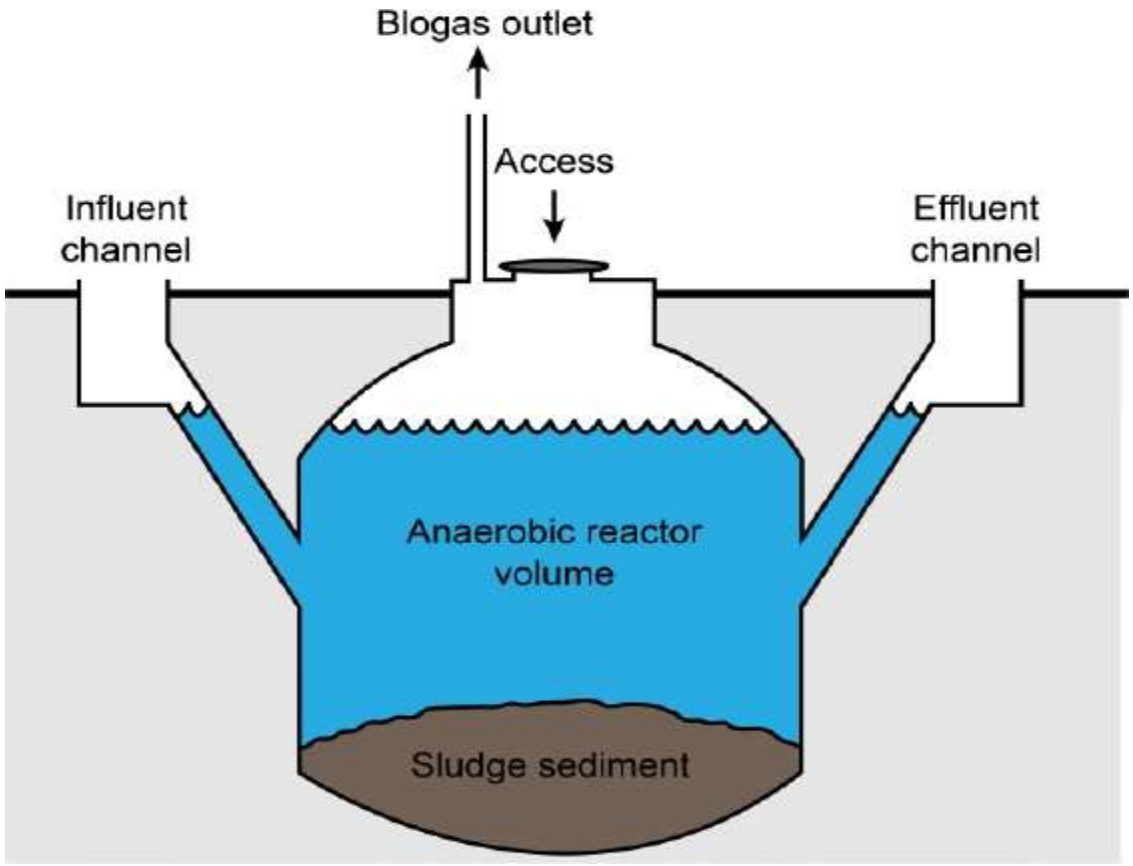
AD Process

AD processes are characterized by the following:



Biogas Digester

Digestion is biological process that occurs in the absence of oxygen and in the presence of anaerobic organisms at temperatures (35-70ºc) and atmospheric pressure. The container in which, this process takes place is known as digester.



Advantages

- The initial investment is low for the construction of biogas plant.
- The technology is very suitable for rural areas.
- Biogas is locally generated and can be easily distributed for domestic use.
- Biogas reduces the rural poor from dependence on traditional fuel sources, which lead to deforestation.
- The use of biogas in village helps in improving the sanitary condition and checks environmental pollution.
- The by-products like nitrogen rich manure can be used with advantage.
- Biogas reduces the drudgery of women and lowers incidence of eye and lung diseases.

Raw materials for biogas generation

Biogas is produced mainly from

- Cow dung
- Sewage
- Crop residues
- Vegetable wastes
- Water hyacinth
- Poultry droppings
- Pig manure

Types of biogas Digesters

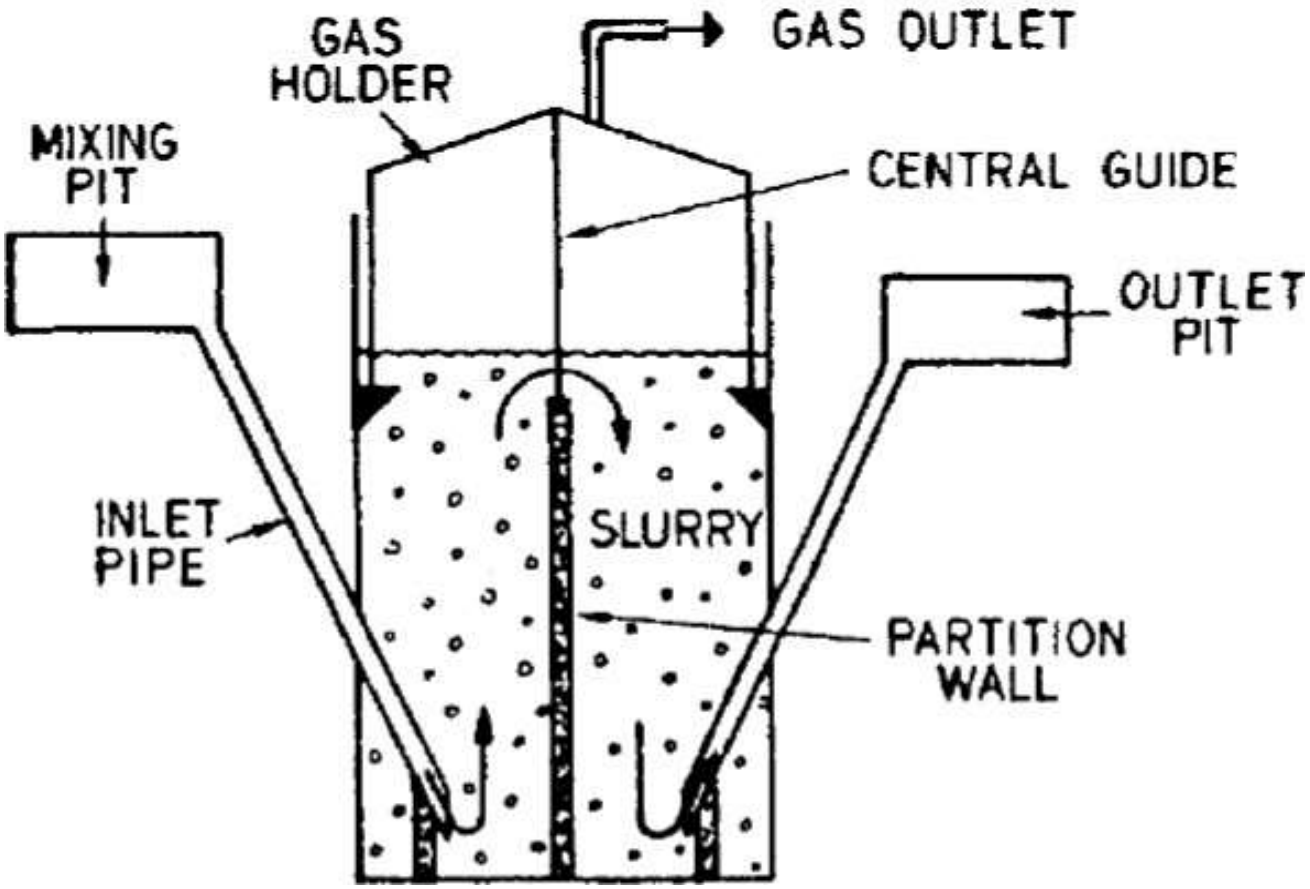
The different types of biogas digesters available are

- batch flow
- Continuous flow
- Continuously expanding
- plug flow and
- contact flow.

The conventional digesters are those used to process fluid row materials with a high content in solids, additionally called rural digesters, the fermentation chamber having a volume below 100 m3.

Conventional digesters are introduced without any sort of mechanism to reduce the maintenance time during which the biomass remains inside are predominant; these systems are fed discontinuously and known as discontinuous-flow i.e. batch digesters, or fed periodically and known as continuous-flow digesters.

Indian digester



Batch biogas designs:-Batch biogas plant designs are filled completely and then emptied completely after a fixed retention time. Each design and each fermentation material is suitable for batch filling. For the gas supply it requires large numbers gasholders and digesters.

Continuous Biogas Designs:-Continuous biogas designs are filled and emptied daily. Each design is suitable for consistent operation; however the feed material must be flow able and uniform. Continuous plants empty consequently through the overflow. Continuous plants are more suitable for rural households.

MODULE 6

COMPOSTING

GENERAL

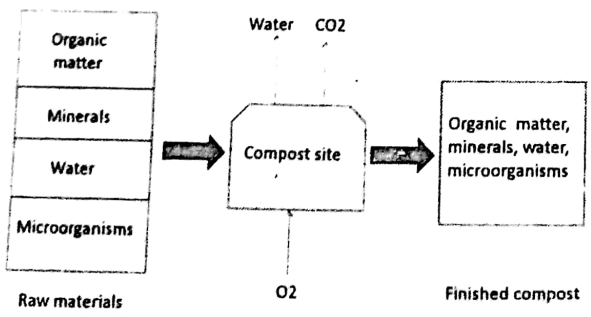
- Composting – disposal method
- Definition – aerobic, thermophilic degradation of solid material by microorganisms
  - Entire process must be aerobic ie, refuse stabilisation must take place in oxygen rich atmosphere
  - No further degradation should take place under anaerobic conditions during storage

- Composting is the transformation of organic material (plant matter) through decomposition into a soil-like material called compost.
- Insects and earthworms microorganisms (bacteria and fungi) help in this transformation.

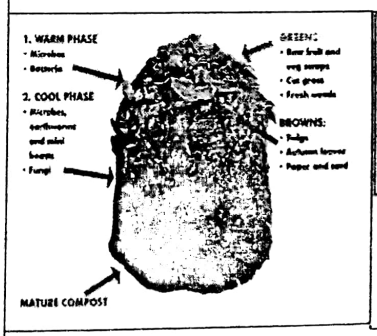
- Overall composting operation

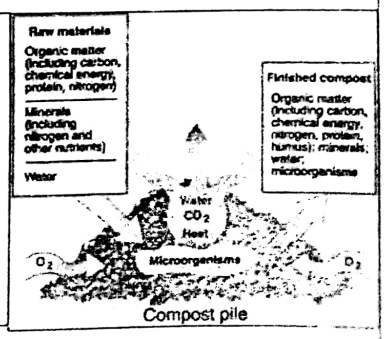
  Organic matter + O_2 → $CO_2 + NH_3 + H_2O$

  + aerobic bacteria + other end products + energy
- End product – compost
- By product - CO_2, water
- Compost is
  - Dark in color
  - Crumbly texture
  - Earthy odour
  - Resembles rich topsoil



Composting process





STAGES

- Five basic stages
  1. Preparation
  2. Digestion
  3. Curing
  4. Screening or finishing
  5. Storage or disposal

1. Preparation

– Involves several steps

- Sorting of recyclable materials
- Removal of non combustibles
- Grinding
- Adding of water sludge

2. Digestion

– Digestion process vary from backyard composting process to highly controlled mechanical digester

– On basis of digestion composting types fall into two categories

- Windrow composting – open atmosphere
- Mechanical composting – enclosed atmosphere

3. Curing

– Also called ageing or maturing phase

– Compost become biologically stable

– Long period curing – pathogen destruction

– Uncured compost – produce phytotoxins – substance toxic to plants

– Takes few days to several months

– Cured compost is then marketed

4. Screening or finishing

– Done to meet market specifications

– Sometimes done before compost curing

– Non compostable fraction retained on coarse screen – send to landfill

– Retained on fine screen send to beginning of composting process for further composting

5. Storage or disposal

– Storage is necessary because its use is seasonal

– Composting plant must have six months storage area

– Many composting operation combine their curing period with storage period

TYPES

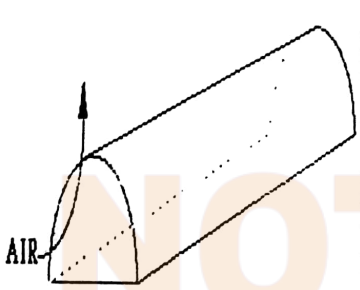
- Composting methods are
  1. Windrow composting
  2. Aerated static pile composting
  3. In-vessel composting system
     - Vertical composting reactor
     - Horizontal composting reactor
     - Rotating drum
  4. Anaerobic composting

1. Windrow composting

- Least expensive
- Most common approach
- Windrows – regularly turned elongated pile with haystack shape in cross section and up to hundred meters or more in length
- Optimum size and shape depends on
  - Particle size
  - Moisture content
  - Pore space
  - Decomposition rate

- Mostly, height - 1.5 to 3 m

  width - 3 to 6 m
- Located on impermeable and firm surface
- Aeration – by turning pile once in week but frequent aeration is required if pile contains more bio-solids
- Turning moves material from pile surface to core so they can undergo composting
- Machines equipped with augers, paddles are used
- Heat will be released as steam to atmosphere

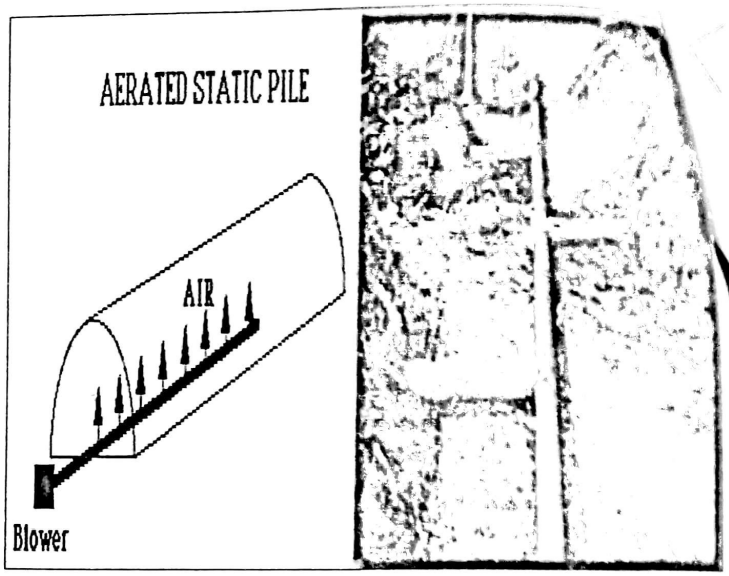


2. Aerated static pile composting

- Mechanically aerated
- Piles are placed over network of pipes connected to blowers
- Blower – supplies air for composting
- Air can be supplied under negative or positive pressure
- Negative pressure – drawing air out of pile
- Positive pressure – forcing air into pile

- Air circulation provides
  - Needed oxygen for composting microbes
  - Prevents excessive heat build up in piles
  - But odour nuisance occurs – controlled by traps or filters
- Inner portion of pile – temperature is adequate to destroy pathogens and weed seeds
- But surface of piles will not reach the desired temperature for destruction of pathogens because piles are not turned
- This problem can be overcome by placing a layer of finished compost of 15 to 30 cms thick
- This layer act as insulating blanket and helps to maintain desired temperature

- Used for
  - Yard trimmings
  - Bio-solids composting
  - Industrial composting
- Can be done under roof or in open
- To make compost – 6 to 12 weeks
- Land requirement - less than windrow composting



3. **In-vessel composting system**
   - Enclose feedstock in chamber or vessel that provide adequate mixing, aeration and moisture
   - Types vary with requirements for pre-processing materials
     - Drums } single or multi-composting units
     - Digester bins } rotates or stationary
     - Tunnels continuous or batch type
   - Require further composting after discharging from vessel
   - Positive pressure – forcing air into pile

- Advantages
  - All environmental conditions can be controlled to allow rapid composting
  - Retention time – one to four weeks
  - minimal odours
  - Little or no leachate
- Commonly used
  i. Vertical composting reactors
  ii. Horizontal composting reactors
  iii. Rotating drum

i. Vertical composting reactors
- Generally over 4m high
- Can be housed in silos or other large structures
- Organic material feed from top
- Moves by gravity
- Aeration – pressure induced – airflow opposite to downward materials flow

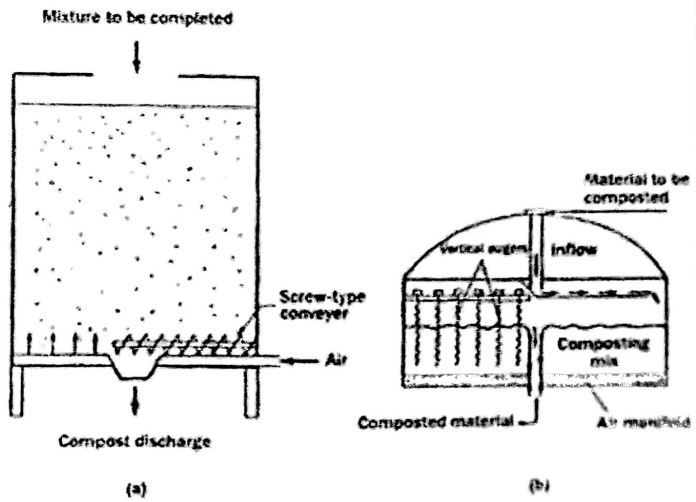
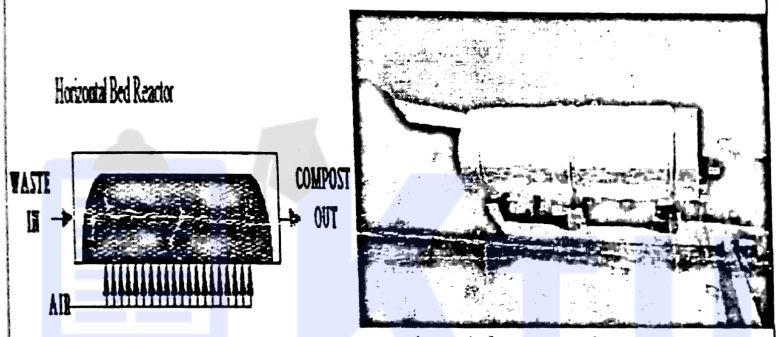


Figure 7.9 Vertical reactors

- Advantages
  - Successfully used in industries with uniform feed stock
- Disadvantages
  - Process control is difficult due to height of reactors
  - Temperature and oxygen cannot be maintained at optimum levels
  - Rarely used in heterogeneous materials like MSW

ii. Horizontal composting reactors

- Can avoid high temperature, oxygen, moisture contents by using short airflow pathway
- Types
  - Static or agitated
  - Pressure or vacuum induced aeration
- Static system – require loading and unloading mechanism
- Agitated system – turning process
- Used in heterogeneous MSW
- Systems with agitation and bed depths less than 2 to 3 m - effective

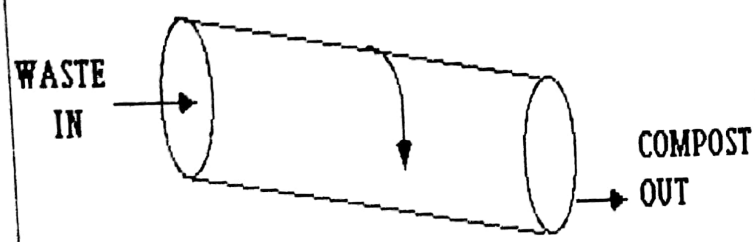


An example of in-vessel composting.

iii. Rotating drum

- Also known as digesters
- Advantage over vertical and horizontal
  - Less cost
  - Less residence time – few hours or days
- Processing is physical than biological
- Normally followed after biological processing

Rotating Drum



4. Anaerobic composting

- Facultative bacteria break down organic materials in absence of oxygen
- Produce methane and CO_2
- Advantage
  - Methane generated – marketed or converted to electricity
- Can be
  - Single stage digesters
  - Two stage digesters

- Single stage digesters
  - entire process in one air tight container
  - Feed stock shredded
  - Water and nutrients added
  - Agitation – continuous stirrers
- Two stage digesters
  - Liquid supernatant is circulated to second stage digester
  - Aeration in this digester can be eliminated

DESIGN CONSIDERATIONS

- For best results in composting
  - Appropriate mixing of sludge
  - Needs optimum mass balance, moisture, temperature, pH, nutrients, air
  - Mass balance diagram can be used for all three composting methods

Item	Comment
Particle size	Size of SW between 25 and 75 mm
Carbon to nitrogen ratio	Between 25 and 50
Seeding	1 – 5 % by weight of decomposed SW
Moisture content	50 - 60%
Mixing/turning	Depend on type of operation
Temperature	First few days – 122° F to 131° F remaining days - 13° F to 140° F
Control of pathogens	Temperature - 140° F to 158° F
Air requirements	Air with at least 50%of oxygen
pH control	7 to 7.5
Degree of decomposition	Measured by COD
Land requirements	Capacity of 50 tons/day – 15 to 20 acres

ADVANTAGES OF COMPOSTING

- Form of source reduction or waste prevention
  - Materials can be completely diverted from disposal facilities
- Reduce waste stream volume
  - Diverting organic materials will frees up landfill space needed for non compostable materials
- Economic advantage
  - For communities where cost of using other options are high

4. Suitable for wide variety of end uses like landscaping, top soil blending and growth media
5. Compost increases water content and retention of sandy soil
6. Compost increases aeration and water infiltration of clay soil
7. Windrow and aerated static pile process require relatively simple mechanical equipment and is simple to operate
8. In vessel process require small area and have ability to control odours

DISADVANTAGES OF COMPOSTING

1. Windrow and aerated static pile process require large area and odour control is a problem
2. Ambient temperature and weather condition influence Windrow and aerated static pile composting
3. In vessel process have limited flexibility to handle changing odour and its maintenance is expensive

INDORE PROCESS

This method involves filling of alternate layers of MSW and night soil, similar thickness. However, to ensure aerobic condition the material is turned at specific intervals for which a 60 cm strip on the longitudinal side of the pit is kept vacant. For starting the turning operation, the first turn is manually given using long handled rakes 4-7 days after filling. Further turning is normally not required and the compost is ready in 2 to 4 weeks.

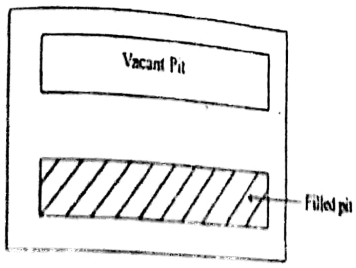
The Indore method involves putting layers of different materials on top of each other to form a heap. First, make a base 1 metre (m) wide and 3m long, with twigs and cane shoots that are loss. Complete this process within one week. After 2 to 3 weeks the heap should be taken apart and rebuilt. This is because the materials do not all decompose evenly. Again, a layer of coarse material should be laid down first. The material which was on the outside of the heap and has not decomposed, should be placed into the middle of the new heap and watered. This should then be covered with the remaining material. The original layered structure is lost. After another three weeks this process may have to be repeated depending on how much the heap has decomposed. Full decomposition should take 3 months. Urine (diluted with 4 parts water) sprinkled over the layers of soil can accelerate the process of decomposition. Urine also adds valuable nutrients to the compost. Ash in small quantities also acts as an accelerator and can be sprinkled over each layer of soil. However, too much urine or ash can be destructive to the microorganisms in the heap.

Advantages:

- The Indore method produces compost in a short space of time and the process can be controlled. Weed seeds and diseases are killed.

Disadvantages:

- The Indore method requires a lot of water and is very labour intensive.
- It works best when you have a lot of material to use all at once.



Indore heap method

BANGALORE PROCESS

This anaerobic method is carried out in pits, where waste was anaerobically stabilized in by alternate layers of MSW and night soil. The pit is completely filled and final soil layer is laid to prevent fly breeding, entry of rain water. The material is allowed to decompose for 4 to 6 months are used as manure.

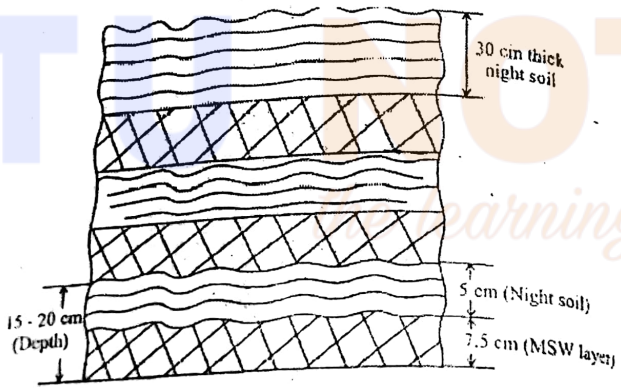
The Bangalore method is a popular method of composting. A few days after completing a heap, it is covered with mud or damp grass so that it is closed off from the outside air. This allows 'anaerobic' micro-organisms (that do not need air) to decompose the heap. The heap should be 1m to 1.5m high, 1m wide and 3m long. The method for building the damp grass

Advantages:

- The Bangalore method uses less water and labour than other methods as turning is not required.

Disadvantages:

- Weed seeds and diseases can survive due to the low temperature.



Bangalore Method

Comparison

Indore method	***Bangalore method***
Both aerobic and anaerobic method	anaerobic method
Endothermic and exothermic process	Endothermic process
Need less space	Need more space
No bad odour	Give bad odour