Composting of solid wastes

Dr.M.Vasanthy
Assistant Professor

Aerobic and anaerobic systems for solid waste treatment

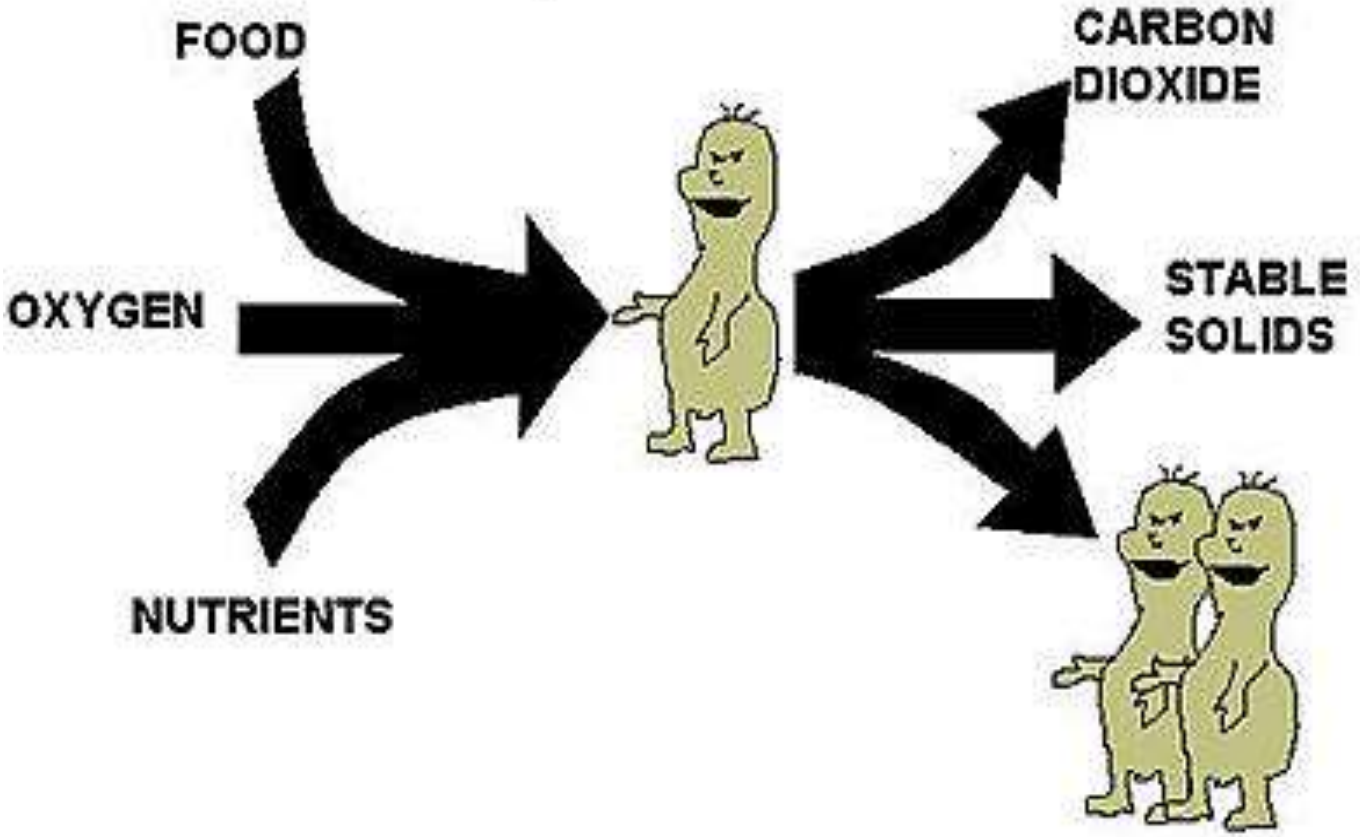
The treatment of the organic solid wastes can be carried out either in the presence or absence of oxygen.

Three common methods of processing include composting, vermicomposting, and biomethanation/anaerobic digestion.

Aerobic Decomposition

- A biological process, in which, organisms use available organic matter to support biological activity.
- The process uses organic matter, nutrients, and dissolved oxygen and produces stable solids, carbon dioxide, and more organisms.
- The microorganisms which can only survive in aerobic conditions are known as aerobic organisms.
- In sewer lines the sewage becomes anoxic if left for a few hours and becomes anaerobic if left for more than 1 1/2 days.

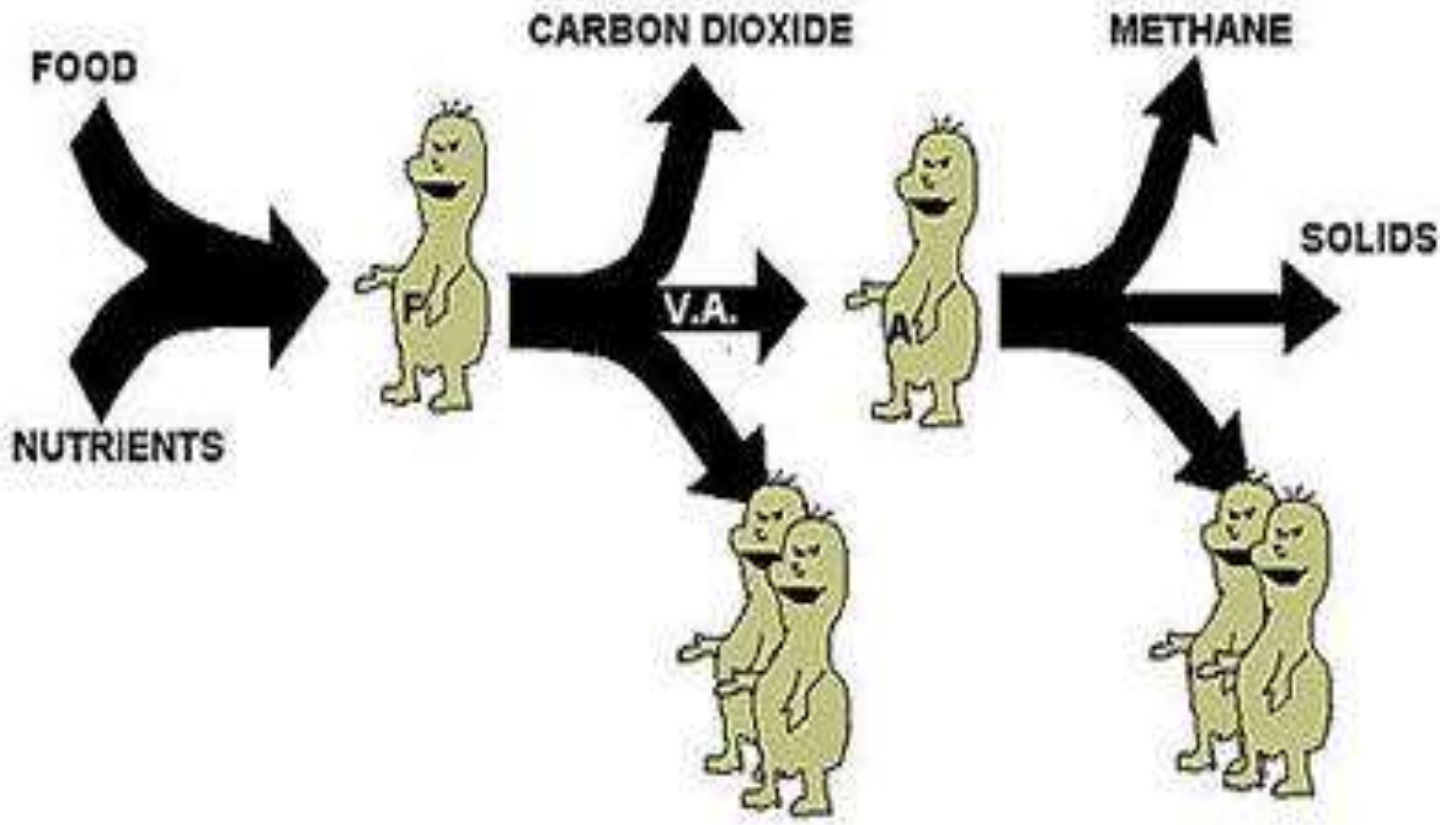
UNDER THE CORRECT ENVIRONMENTAL CONDITIONS



Anaerobic Decomposition

- A biological process, in which, decomposition of organic matter occurs without oxygen is termed as anaerobic decomposition.
- Two processes occur during anaerobic decomposition.
- First, facultative acid forming bacteria use organic matter as a food source and produce volatile (organic) acids, gases such as carbon dioxide and hydrogen sulfide, stable solids and more facultative organisms
- Second, anaerobic methane formers use the volatile acids as a food source and produce methane gas, stable solids and more anaerobic methane formers.
- The methane gas produced by the process is usable as a fuel called the biogas.
- The methane former works slower than the acid former, therefore the pH has to stay constant consistently, slightly basic, to optimize the creation of methane

THE CORRECT ENVIRONMENTAL CONDITIONS MUST BE PRESENT FOR OPTIMUM CONDITIONS



Biogas plants for animal wastes - KVIC (Khadi and Village Industries Commission) biogas plant

The KVIC has been a pioneering agency in the field of biogas in India. The first plant model, Gramalakshmi, was developed in 1950.

This served as a prototype for the KVIC floating dome model that is being disseminated in the country since 1962.

The KVIC biogas plant is a composite unit of a masonry digester and a metallic dome that acts as a gas holder wherein gas is collected and delivered at a constant pressure through a pipeline.

A constant pressure is maintained due to the upward and downward movement of the lid of the digester along the central guide pipe fitted in a frame in the masonry

KVIC biogas plant

Source: ecoursesonline.iasri.res.in

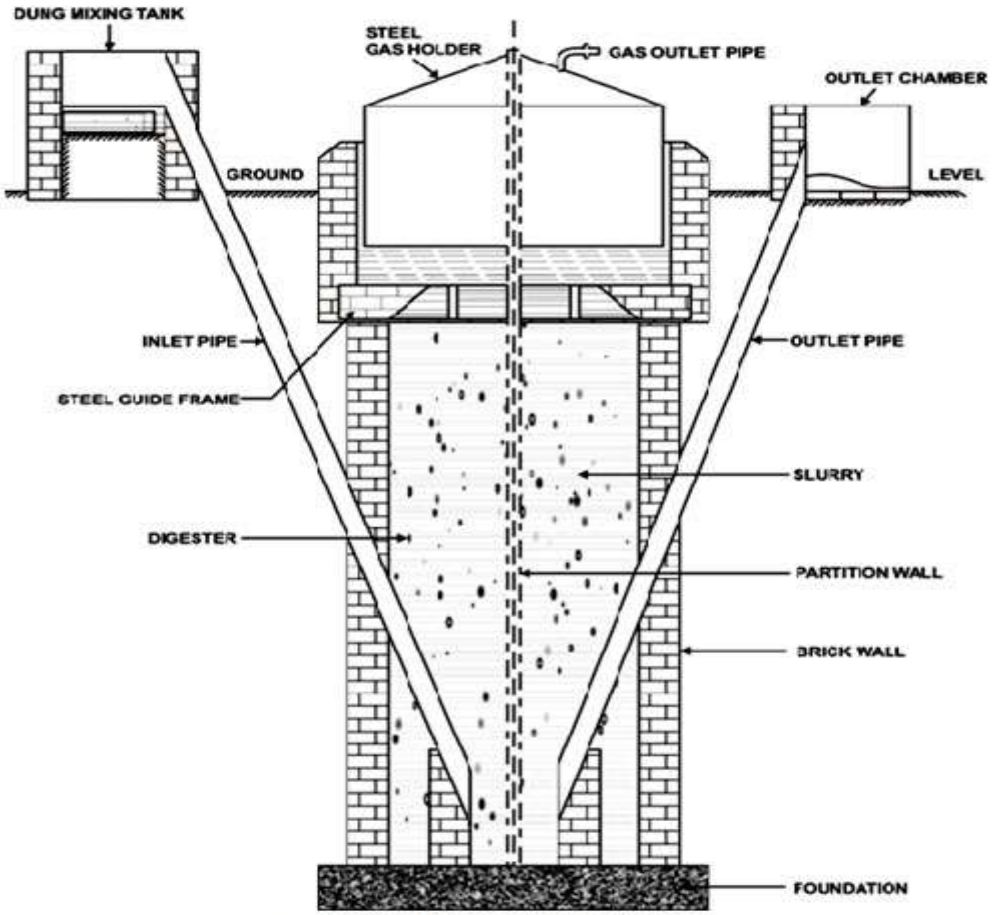


Fig. 6.1 KVIC model biogas plant

Janata biogas plant

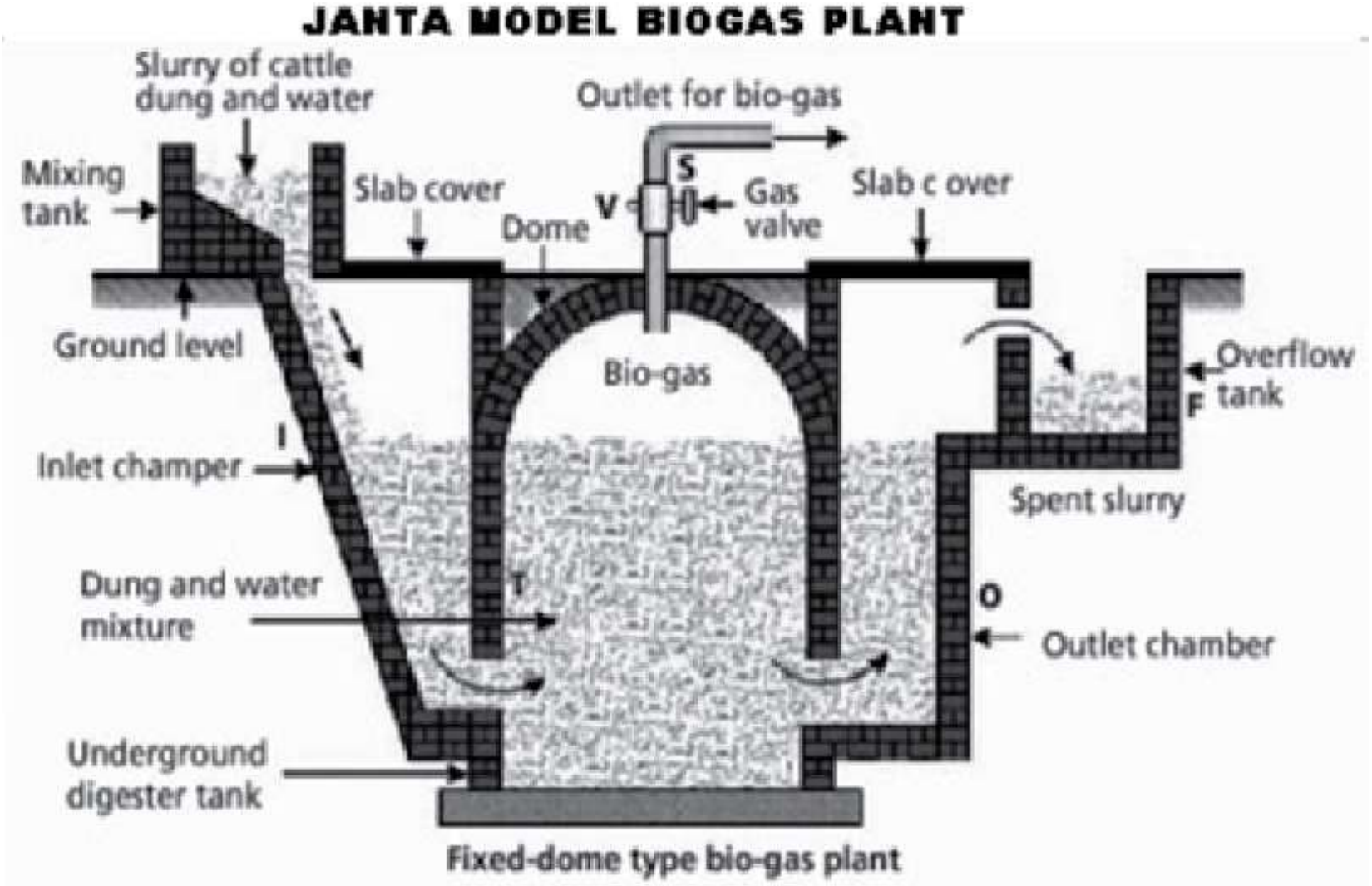
The first fixed dome plant was (originated in China) was introduced in India in the form of Janata biogas plant by Gobar Gas Research Station, Ajitmal (a wing of Planning, Research, and Action Division, Lucknow) in 1978.
In addition to the low installation cost as compared to the KVIC plants, the Janata model plants have the advantages of using locally available building materials and skills in construction.

The design consists of a masonry structure,which integrates the reactor and gas-holding space.

The inlet and outlet tanks are connected to the digester through displacement chambers.

The gas outlet is located on top of the dome and the digested slurry is withdrawn from the opening in the outlet displacement chamber

Source:www.researchgate.net/figure/JANTA-Model-Biogas-Plant



Vermicompost

Earthworm

Earthworms

- The earthworm derives its name from the fact that it burrows and eats its way into the earth. Earthworms have been on the earth over for 20 million years. There are 3627 species of earthworms distributed throughout the world.
- Classification of earthworm

Kingdom Animalia

Phylum Annelida

Class oligochaeta

Order Opisthopora

Family Lumbricidae

Genus A large number of genera have been described in literature

Species A large number of species under each genus have been described in literature

Classification of earthworms

Epigenic species

These species live above the mineral soil surface typically in the litter layer and plant derbis and feed on them. These are phytophagous. Most of the species have insignificant role in humus formation and are not good for use in field conditions for soil reclamination. They have high reproductiove rate and high cacoon production rate. However, their life span is relatively short. They show high metabolidc activity and hencde are particularly useul for vermicomposting

Ex: ***Eisenia foetida, Eisenia andrei, Eudrillus eugenia, perionayx excavatus and Drawida modesta***

Endogenic species

These species inhabit minerial soil beneth the top soil surface generally forming horizontal tunnels to the soil surface. They feed on soil ,ore or less enriched with organic matter. They are probably important in improvemrnt of soil texture and structure (pedogenesis) and are not much benefical in organic matter decompostion and recycling of plant nutrient. Their reproduction rate is moderate and they have shorter life span

Ex**:** ***Octochaetena thurstoni***

Anecic species

These are surface feeding earthworms that construct and live permanent burrows in the mineral soil layer but comes to the surface to feed on organic matter, mostly plant litter, and pull it into their burrows. They are imporatant in burying surface litter. They are great help in incorporation of organic mater ninto the soil, and distribution and cyclimg of planr mutrient and also in improvememt of soil structure and texture. These species have low cacoon production rate and limited reproductive capacity, but their life span is longer

Ex: ***Lampito mauritti, Lumbricus terrestris and Octochartona serrata***

Composting, vermicomposting and vermiculture

- Composting is bioconversion of organic matter by heterotropic microorganisms (bacteria, fungi, actinomycetes and protozoa) in to humus like material called compost.
- The process occurs naturally provided the right organisms, moisture, aerobic conditions, feed material and nutrient available for microbial growth. By controlling these factors the composting process can occur at a much faster rate
- Vermicomposting is the process by which worms are used to convert organic material (usually waste) into humus like material known as vermicompost. The goal is to process the material as quickly and effecient as possible
- Vermiculture is the culture of earthworms. The goal is to continually increase the number of worms in order to obtain a sustainable harvest.

Principle of vermicompost

The earth worms maintain aerobic conditions in the vermicomposting process, ingest solids and convert a portion of it to earthworm biomass and respiration products and egest peat like material termed as worm castings.

Castings are much more fragmented, porous and microbially active than parent material due to humification and increase decompostion. The earthworm derive their nourishment from microorganisms involved in waste decompostion and organic waste to be decomposed.

During this process, important plant nutrient such as nitrogen, potassium, phosphrous, calcium etc present in the waste are converted through microbial action into form that are much more soluble and available to plant than those in parent substrate.

Overall the vermicomposting process is a result of combined action of earthworms and microflora living in earthworm intestine and in the organic waste.

Vermicomposting process

It is an aerobic, biooxidation and stabilization, non thermophilic process of organic waste decomposition that depends upon earthworm to fragment, mix and promote microbial activity. The basic requirements during the process of vermicomposting include suitable

- Bedding
- Food source
- Adequate moisture
- Aeration,
- Suitable temperature
- pH

Bedding

Bedding is any material that provides a relatively stable habitat to worms. For good vermicomposting, this habitate should satisfy the following criteria:

High absorbency: As worms breath through skin, the bedding must be able to absorb and retain adequate water

Good bulking potential: The bulking potential of the material should be such that worms get oxygen properly

Low nitrogen content (high carbon:nitrogen ratio): Although worms consume their bedding as it break down. It is very important that this be a slow process. High protein/nitrogen levels can result in rabid degradation and associated heating may be fatal to worms

Food source

- Regular input of feed material for the earthworms is most essential step in the vermicomposting process.
- Earthworms can use a wide variety of organic materials as food but do exhibit food preferences. In adverse condition, earthworms can extract sufficient nourishment from soil to survive.
- However, earthworms feed mainly on dead and decaying organic waste and on free living soil microflora and fauna.
- Under ideal conditions, worms can consume amount of food higher than their body weights, the general rule of thumb is consumption of food weighing half of their body weight per day.
- Livestock excreta such as goat manure, cattle dung or pig manure are the most commonly used worms feedstock as these materials have higher nitrogen content

Cont..

- **Moisture** : perhaps the most important requirment of earthworms is adequate moisture. They require moisture in the range of 60-70%
- **Aeration:** Factors such as high levels of fatty/oily substance in the feedstock or excessive moisture combained with poor aeration may render anaerobic conditions in vermicomposting system
- **Temperature**: The activity, metabolism, growth, respiration and reproduction of earthworms are greatly influence by temperature. Most earthworms species used in vermicomposting require moderate temperature from 10-35°C
- **pH**: Worms can survive in a pH of 5 to 9 but a range of 7.5 to 8 is consider to be the optimum

Four basic types of vermicomposting systems

- **Windrows**: Windrow system are extensively used both in the open air and under cover, but require either a lot of land or large buildings. Windrow vermicomposting can be carried out in a number of different ways. The two most common types of windrow are **Static pile windrows (batch) , Top-fed windrows (continuous flow)**
- **Wedge system**: this is a modified types of windrow system where one can easily harvest the vermicompost without disturbing the earthworms. In this system organic material are applied in layers against s finished windrow at a 45°angle. The pile can be inside a structure or outdoor if they are covered with a trap or compost cover to prevent the leaching of nutrients
- **Bed and Bin system**: In this system bins are used to breed and harvest the vermicompost and also in some cases beds are made on the ground for the same purpose. This method is labour intensive as vermicompost has to be seperated manually. There are two types **Top-fed beds(continous flow) and Stacked bins (batch or continous flow)**

Windrows

Wedge system

Physico-chemical changes in organic waste during Vermicomposting

- **pH**: During vermicomposting usually pH decreases from alkaline to acidic or neutral pH. The pH shift towards acidic conditions has been attriuted to mineralization of nitrogen and phosphrous into nitrites/nitrates and orthophosthates: bioconversion of the organic material into intermediate species of organic acids
- **Organic carbon**: There is a decrese in the organic carbon content of the feed stock during vermicomposting due to loss of carbon as CO_2
- **Ash content**: There is an increase in the ash content of the feed stock during vermicompsting. Increase in ash content can be attributed to enhance mineralization in the presence of earthworms
- **C:N ration**: The ratio of carbon to nitrogen is important for the proper growth of any plant. The loss of carbon as carbondioxide in the process of respiration and reproduction of mucuc and nitrogenous excrements enhance the level of nitrogen which lower than C:N ratio. The C:N ratio is used as an index for maturity of organic wastes. The decline in C:N ratio <20 indicate an advancee degree of organic matter stabilization and reflect a satisfactory degree of maturity of organic wastes
- **Phosphrous content**: Phousphrous is an essential nutrient which is required for photosynthesis energy transfers within plants and for good floweringand fruit growth. Addition of phosphrous is more importantfor plant maturation than plant growth.

COMPOST

The composting process

- Composting is the biological decomposition of organic matter under controlled conditions brought aout by the growth of microorganisms and invertebrates.
- While decomposition occurs naturally, it can be accelerated and improve by human intervention.
- Composting stabilizes organic matter, yielding an end product that contains humus and has uniform crumbly texture.
- Composting leads to a volume reduction. Much of this reduction results from the loss of carbon di oxide, water and other minor gases to the atmosphere.

Decomposer

- Naturally occurring microorganisms and invertebrates are the primary decomposers that accomplish composting.
- These microorganism include bacteria, mould or fungi, actinomycetes and protozoa
- Tiny invertebrate animals such as mites, millipeds, insects, sowbugs, earthworms and snails are the primary agents of physical decay
- They break up waste debris and transport microorganism from one site to another
- The ease with which organic materials are composted depends on the type of decomposers, the type of organic material being composted and the composting methods used.
- For example, many decomposition organism can utilize the carbon in sugar found in straw, while fewer decomposers can use the carbon in cellilose or lignin fibres found in paper or wood

Aerobic vs Anaerobic microorganism

- Aerobic organism thrive at oxygen levels greater than 5%. They are the preferred microorganisms, since they provide the most rapid and effective composting
- Anaerobic organism thrive when the compost pile is oxygen deficient.
- Decomposition by anaerobic microorganism is referred to as fermentation.
- Anaerobic conditions are undesirable in a compost pile.
- Some of the products of anaerobic decomposition are hydrogen sulfide, cadaverine and putrescine, which cause offensive odours
- In addition anaerobic processes can generate acids and alcohols that are harmful to plants

Aerobic Microorganism and temperature

- Among all microorganisms, aerobic bacteria are the most important indicastors of decomposition and temperature increase within the compost pile.
- Psychrophilic bacteria work in the lowest temperature range and have an optimum temperature lower than 5°C.
- Mesophilic bacteria do best at temperature between 10°nand 45°C. Thermophilic bacteria are heat-loving and thrive above 50°C.
- If the initial pile temperature is less than 21°C psychrophilic bacteria begin decomposition.
- Their activity generates a small amount of heat and causes an increase in pile temperature that changes the environment for dominance by mesophilic bacteria
- In turn the more rapid decomposition by mesophilic bacteria canfurther increase the pile temperature to create an environment where the thermophile can thrive

Factors affecting the composting process

All natural organic material eventually decomposes. Under natural conditions, the decomposition process can extend over a period of months or even years, depending on climatic conditions. However the natural process can be accelerated by controlling the process factors, Each of these factors has the potentials to significantly affect the composting process

Some of the more important factors in the composting operation are

- **Carbon:nitrogen ratio**
- **Surface area and partice size**
- **Aeration**
- **Porosity**
- **Moisture content**
- **Temperature**
- **pH of materials**
- **Nutrients**
- **Toxic substance**

Carbon to nitrogen ratio:

- Carbon(C) and nitrogen (N) compounds are the components most likely to seriously limit the composting process if present in either excessive or insufficient amounts, or when the carbon to nitrogen (C:N ratio is incorrect).
- Microorganism in compost digest (oxidize) carbon as an energy source and ingest nitrogen for protein synthesis
- The proportion of these two elements should app 30 parts carbon to 1 parts nitrogen by weight
- C:N ratio within the range of 25:1 to 40:1 result in an efficient process

Surface area and particle size:

Microbial activity occurs at the interface of particle surface and air.

The surface area of material to be composted can be increased by breaking to be composted can be increased by breaking it into smaller pieces, or by other means.

Increased surface area allows the microorganism to digest more material, multiply faster and generate more heat.

Generally, the smaller the size and the more fragile the particle, the greater the biological activity and rate of composting.

Chopped crop residues, softwood shaving and sawdust, for example, require no further size reduction

Cont..

Aeration: Aeration replace oxygen-deficient air in the centre of the compost pile with fresh air Rapid aerobic decomposition can only occur in the presence of sufficient oxygen

Moisture content: moisture plays an essential role inthe metabolism of microorganism and indirectly in the supply of oxygen. Microorganism can utilize only those organic molecules that are dissolved on water. A moisture content of 40 to 60% provides adequate moisture without limiting aeration

Temperature: Heat generated by microorganism, as they decompose organic material, increase compost pile temperatures. There is a direct relation between temperature and rate of oxygen consumption. The higher the temperature, the greater the oxygen uptake and the faster the rate of decomposition

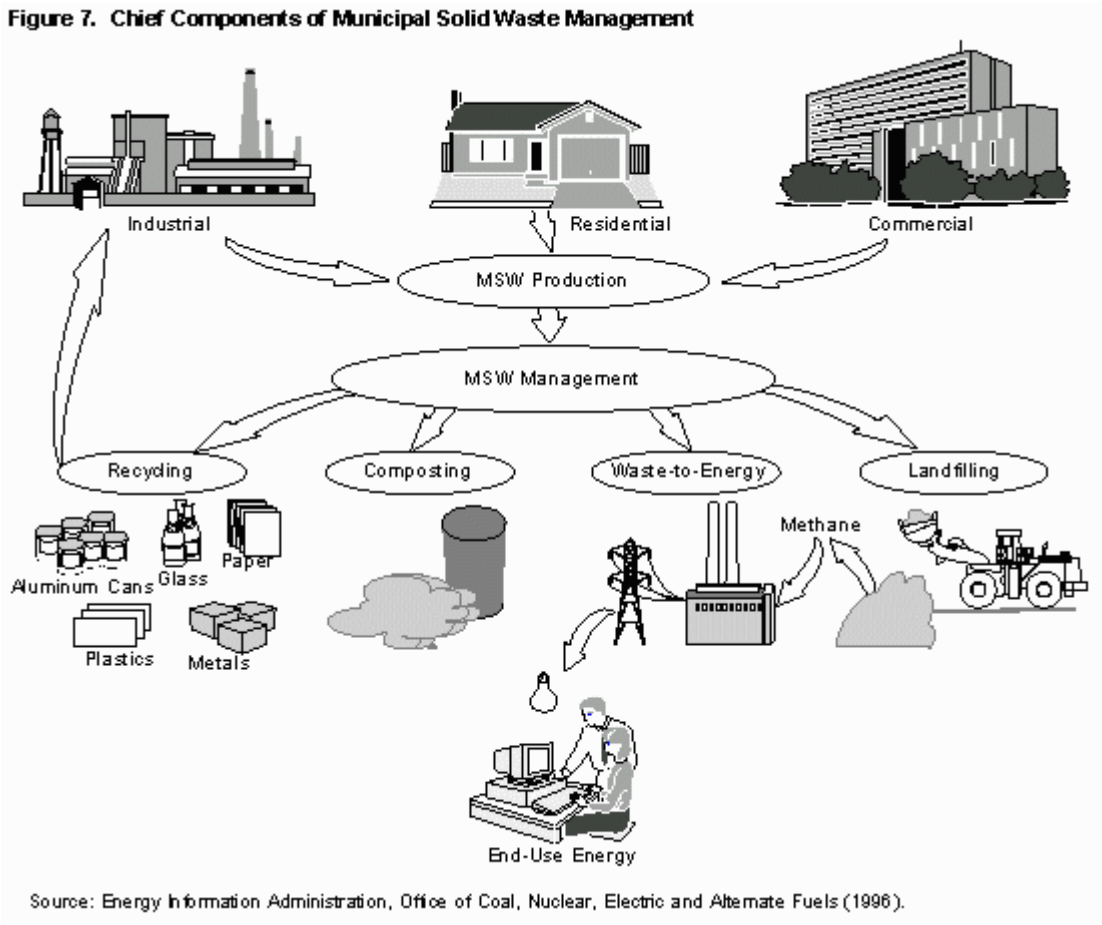
Cont..

- **pH of material**: Composting may proceed effectively over a range of pH without serious limiting the process. The optimum pH for microorganism involved in composting lies between 6.5 and 7.5

- **Nutrients**: Adequate levels of phosphrous and potassium are also important in the composting process and are normaally present in farm organic material such as manure or poultry or pork mortalities

- **Toxic substances**: Some organic materials may contain substances that are toxic to aerobic thermophilic bacteria. Heavy metals such as manganese, copper, Zinc, nickel, chromium and lead may fail into this category. Heavy metals may be immoblilized chemically prior to composting. In some manures, heavy metals are present in appreciable concentration

MSW MANAGEMENT



Thank you