SYLLABUS

Paper Code - MBOTEC -1 : Applied Microbiology and plant pathology
Unit - III
Treatment of solid waste : Composting & land filling

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INTRODUCTION

Waste is defined as an unusable or unwanted substance or material. It can be in solid, liquid or gaseous form.
Solid waste refers here to all non-liquid wastes.

According to European Legislation, the advanced approach to waste management based on principle "waste hierarchy". Here, the order of the priorities of solid waste management is introduce.

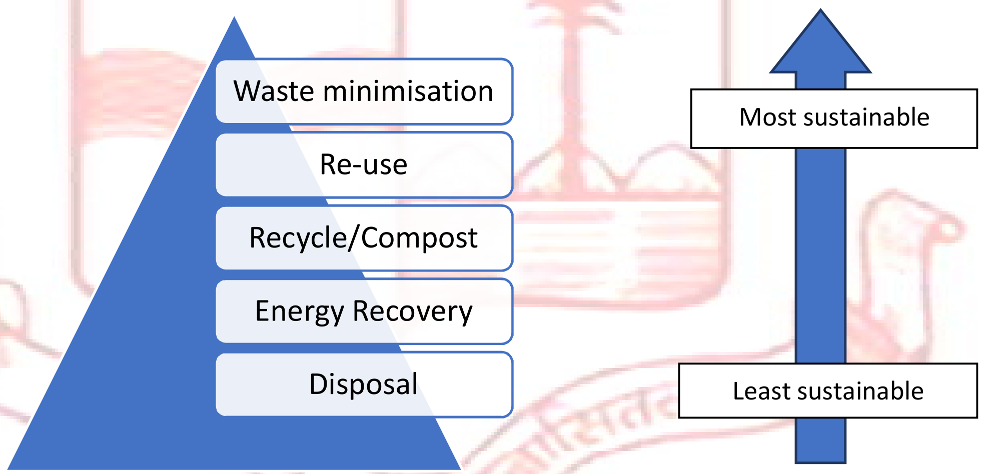

Fig.1 : *Hierarchy of the priorities in the waste management sector*

Solid waste can create significant health problems and a very unpleasant living environment if not disposed of safely and appropriately. If not correctly disposed of, waste may provide breeding sites for insect-vectors, pests, snakes and vermin (rats) that increase the likelihood of disease transmission. It may also pollute water sources and the environment.

1 Associated risks

1.1 Disease transmission

Decomposing organic waste attracts animals, vermin and flies. Flies may play a major role in the transmission of faecal-oral diseases. Rodents may increase the transmission of diseases such as leptospirosis and salmonella, and attract snakes to waste heaps.

Solid waste may also provide breeding sites for mosquitoes. Mosquitoes of the *Aedes* genus lay eggs in water stored in discarded items such as tins and drums; these are responsible for the spread of dengue and yellow fevers. Such conditions may also attract mosquitoes of the *Anopheles* genus, which transmit malaria. Mosquitoes of the *Culex* genus breed in stagnant water with high organic content and transmit microfilariases.

1.2 Pollution

Poor management of the collection and disposal of solid waste may lead to leachate pollution of surface water or groundwater. This may cause significant problems if the waste contains toxic substances, or if nearby water sources are used for water supplies.

Where large quantities of dry waste are stored in hot climates this may create a fire hazard. Related hazards include smoke pollution and fire threat to buildings and people.

2. Initial steps

In order to establish effective solid waste management in the affected area the following process should be used:

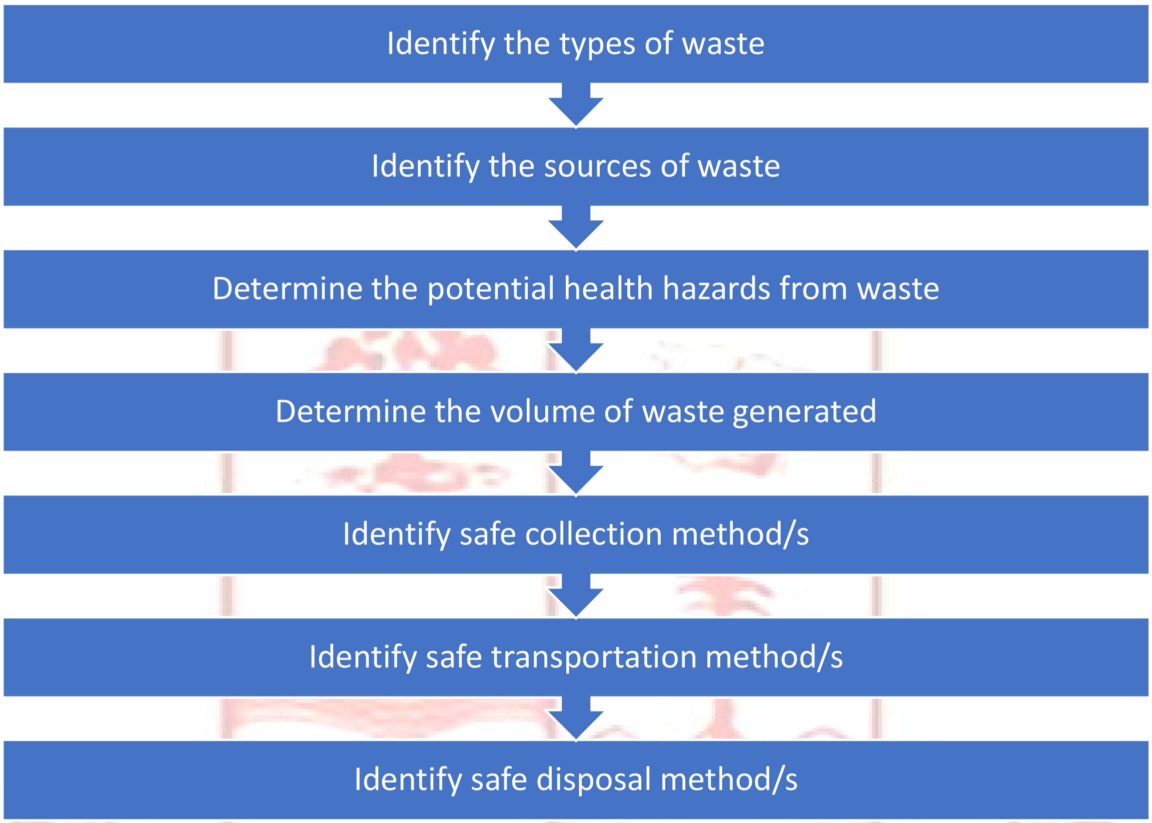

Fig. 2:- Initial steps in solid waste management

3. Sources and types of solid waste

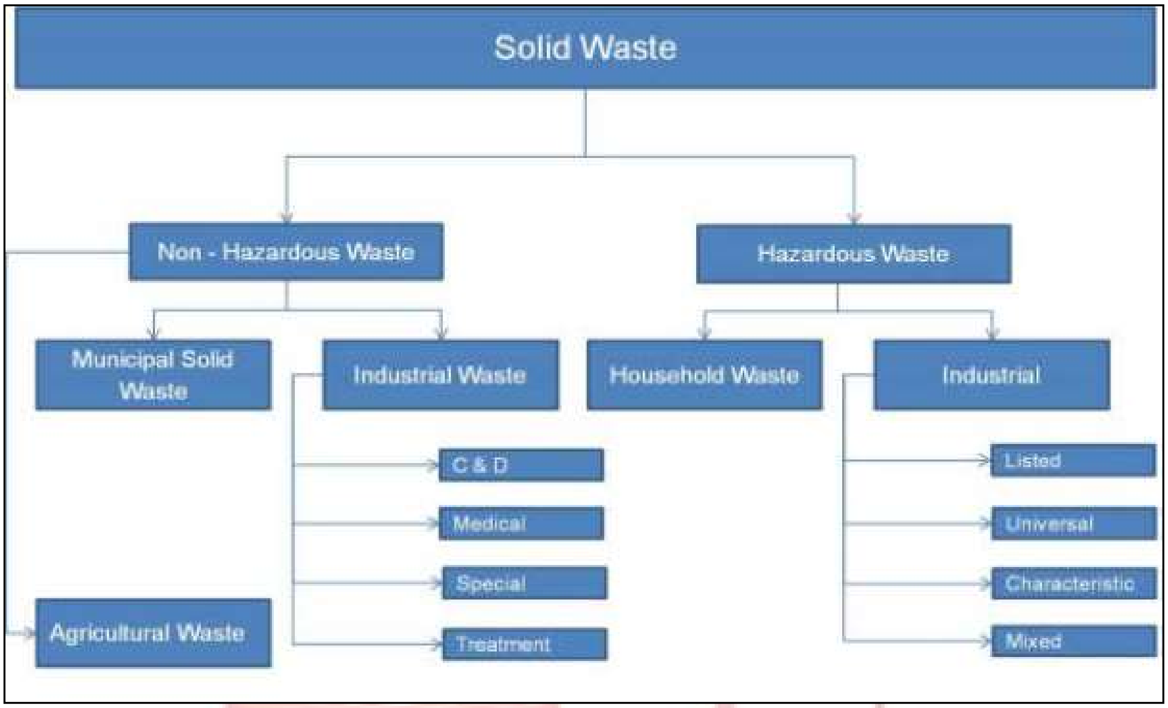

Fig. 3:- Source of solid waste

Types of waste	Time it takes to degenerate
Organic waste such as vegetables and fruit	A week or two
Paper	10-30 days
Cotton cloth	2-5 months
Wood	10-15 years
Woollen items	1 year
Tin, aluminium and other metal items such as cans	100-500 years
Plastic bags	Million years
Glass bottles	Undetermined

***Table 1** : The type of solid waste and the approximate time it takes to degenerate.*

4. Key components of solid waste management

Solid waste management can be divided into five key components:

- Generation
- Storage

- Collection
- Transportation
- Disposal

4.1 Generation

Generation of solid waste is the stage at which materials become valueless to the owner and since they have no use for them and require them no longer, they wish to get rid of them. Items which may be valueless to one individual may not necessarily be valueless to another. For example, waste items such as tins and cans may be highly sought after by young children.

4.2 Storage

Storage is a system for keeping materials after they have been discarded and prior to collection and final disposal. Where on-site disposal systems are implemented, such as where people discard items directly into family pits, storage may not be necessary. In emergency situations, especially in the early stages, it is likely that the affected population will discard domestic waste in poorly defined heaps close to dwelling areas. If this is the case, improved disposal or storage facilities should be provided fairly quickly and these should be located where people are able to use them easily. Improved storage facilities include:

- Small containers: household containers, plastic bins, etc.
- Large containers: communal bins, oil drums, etc.
- Shallow pits
- Communal depots: walled or fenced-in areas

In determining the size, quantity and distribution of storage facilities the number of users, type of waste and maximum walking distance must be considered. The frequency of emptying must also be determined, and it should be ensured that all facilities are reasonably safe from theft or vandalism.

4.3 Collection

Collection simply refers to how waste is collected for transportation to the final disposal site. Any collection system should be carefully planned to ensure that storage facilities do not become overloaded. Collection intervals and volumes of collected waste must be estimated carefully.

4.4 Transportation This is the stage when solid waste is transported to the final disposal site. There are various modes of transport which may be adopted and the chosen method depends upon local availability and the volume of waste to be transported. Types of transportation can be divided into three categories:

- Human-powered: open hand-cart, hand-cart with bins, wheelbarrow, tricycle
- Animal-powered: donkey-drawn cart
- Motorised: tractor and trailer, standard truck, tipper-truck

4.5 Disposal

The final stage of solid waste management is safe disposal where associated risks are minimised. There are four main methods for the disposal of solid waste:

- Land application: burial or landfilling
- Composting
- Burning or incineration
- Recycling (resource recovery)

The most common of these is undoubtedly land application, although all four are commonly applied in emergency situations.

5. On-site disposal options

The technology choices outlined below are general guidelines for disposal and storage of waste on-site, these may be adapted for the particular site and situation in question.

5.1 Communal pit disposal

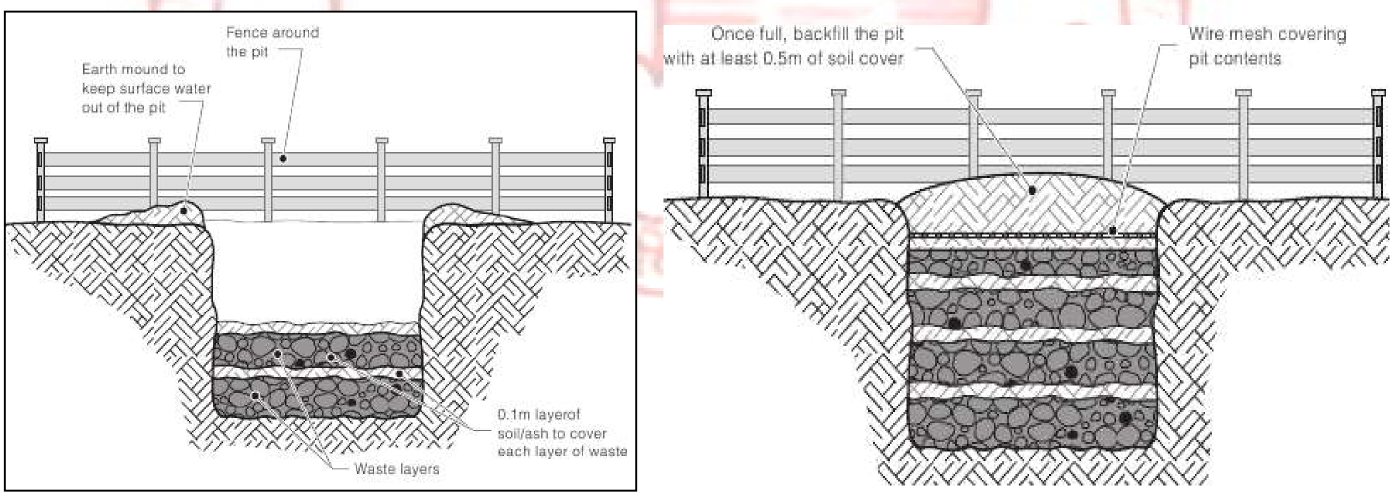

Fig. 4. :- Communal pit disposal

Perhaps the simplest solid waste management system is where consumers dispose of waste directly into a communal pit. The size of this pit will depend on the number of people it serves. The long-term recommended objective is six cubic metres per fifty people. The pit should be fenced off to prevent small children falling in and should generally not be more than 100m from the dwellings to be served. Ideally, waste should be covered at least weekly with a thin layer of soil to minimise flies and other pests.

Advantages: It is rapid to implement; and requires little operation and maintenance.

Disadvantage: The distance to communal pit may cause indiscriminate disposal; and waste workers required to manage pits.

5.2 Family pit disposal

Family pits may provide a better long-term option where there is adequate space. These should be fairly shallow (up to 1m deep) and families should be encouraged to regularly cover waste with soil from sweeping or ash from fires used for cooking. This method is best suited where families have large plots and where organic food wastes are the main component of domestic refuse.

Advantages: Families are responsible for managing their own waste; no external waste workers are required; and community mobilisation can be incorporated into hygiene promotion programme.

Disadvantage: Involves considerable community mobilisation for construction, operation and maintenance of pits; and considerable space is needed.

5.3 Communal bins

Communal bins or containers are designed to collect waste where it will not be dispersed by wind or animals, and where it can easily be removed for transportation and disposal. Plastic containers are generally inappropriate since these may be blown over by the wind, can easily be removed and may be desirable for alternative uses. A popular solution is to provide oil

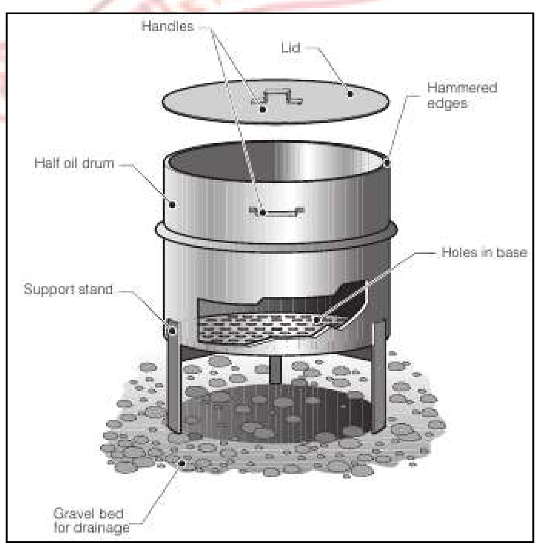

Figure 5

drums cut in half. The bases of these should be perforated to allow liquid to pass out and to prevent their use for other purposes. A lid and handles can be provided if necessary.

In general, a single 100-litre bin should be provided for every fifty people in domestic areas, every one hundred people at feeding centres and every ten market stalls. In general, bins should be emptied daily.

Advantages: Bins are potentially a highly hygienic and sanitary management method; and final disposal of waste well away from dwelling areas.

Disadvantage: Significant collection, transportation and human resources are required; system takes time to implement; and efficient management is essential.

5.4 Family bins

Family bins are rarely used in emergency situations since they require an intensive collection and transportation system and the number of containers or bins required is likely to be huge. In the later stages of an emergency, however, community members can be encouraged to make their own refuse baskets or pots and to take responsibility to empty these at communal pits or depots.

Advantages: Families are responsible for maintaining collection containers; and potentially a highly sanitary management method.

Disadvantage: In general, the number of bins required is too large; significant collection, transportation and human resources are required; takes time to implement; and efficient management essential.

5.5 Communal disposal without bins

For some public institutions, such as markets or distribution centres, solid waste management systems without bins can be implemented, whereby users dispose of waste directly onto the ground. This can only work if cleaners are employed to regularly sweep around market stalls, gather waste together and transport it to a designated off-site disposal site. This is likely to be appropriate for vegetable waste but slaughterhouse waste should be disposed of in liquid-tight containers and buried separately.

Advantages: System rapid to implement; there is minimal reliance on actions of users; and it may be in line with traditional/usual practice.

Disadvantage: Requires efficient and effective management; and full-time waste workers must be employed.

6. Off-site disposal options

The technology choices outlined below are general options for the final disposal of waste offsite.

6.1 *Incineration*

The incineration is process of combustion of solid waste chemical elements (carbon, hydrogen, sulphur) in an oxygen-rich environment, at temperature higher than 850°C and producing combustion gases, especially CO, CO_2, NOx, H_2O, SO_2, ash, and heat. The inorganic content of the waste is converted to ash.

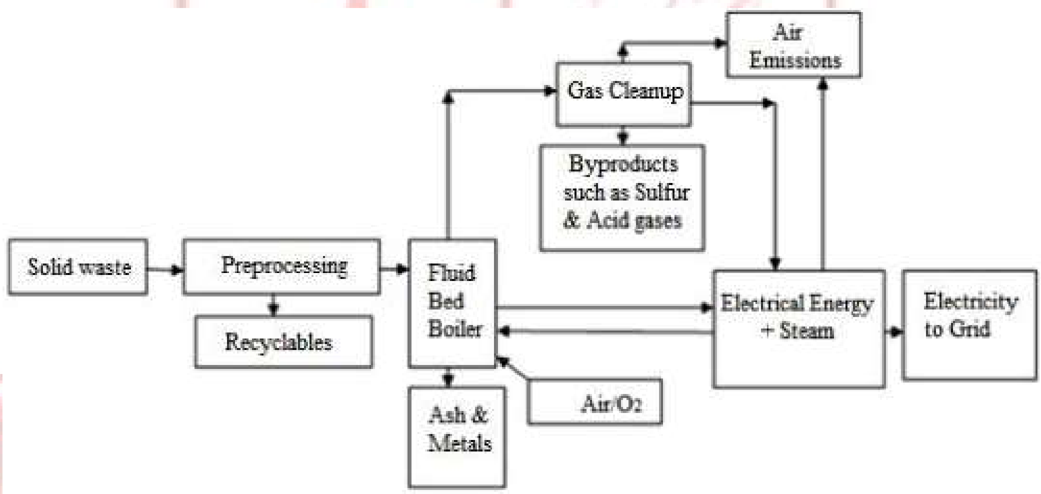

Fig. 6. :- Process of incineration

High-pressure steam produced in the fluid bed boiler is sent to the power plant for energy generation. Hot exhaust gases from the fluid bed boiler are sent for gas cleanup and heat recovery sent to the power plant for generation of energy.

The main elementary reactions of solid wastes in the combustion process at the incinerator are the follow ones :

$C + O_2 \rightarrow CO_2$ $2H_2 + O2 \rightarrow 2H_2O$ $S + O_2 \rightarrow SO_2$

In the case of lack of oxygen, the reactions are characterized as incomplete combustion ones, where the produced CO_2 reacts with C that has not been consumed yet and is converted to CO at higher temperatures.

$$C + CO_2 \rightarrow 2CO$$

The object of this thermal treatment method is the reduction of the volume of the treated waste with simultaneous utilization of the contained energy. The recovered energy could be used for: heating, steam production, electric energy production. The net energy that can be produced per ton of solid waste is about 0.7 MW/h of electricity and 2 MW/h of district heating.

Incineration is a process that can be used to treat different types of waste including municipal solid waste and industrial solid waste. The method could be applied for the treatment of mixed solid waste as well as for the treatment of pre-selected waste.

6.2 Landfilling

This approach is used to treat solid wastes, like garbage, and the solids remaining after waste treatment. The wastes are used for landfill in which a natural or man-made pit or hollow is filled with the waste, covered with soil and often landscaped.

The site of landfill is carefully selected to avoid subsequent problems; it is highly desirable that landfills are located in an unused area or a derelict land. The waste is collected and may be pre-treated in some way before being placed in the pit.

The pre-treatment may be:

(i) Sorting of the wastes,
(ii) Mechanical pulverization or even
(iii) Incineration.

The landfill practice may be divided into two classes on the basis of the type of pit used:

(i) Cell emplacement and
(ii) Trench method or 'cut and fill' method.

(i) Cell Emplacement Method:

In this method 2.5 m deep cells of suitable size are excavated at the site of landfill, their size depending on the amount of garbage to be dumped each day. Everyday the waste dumped in the cell is compacted and covered with about 20 cm deep layer of soil. The cells may be designed to be single or multi-layered. A single layered cell is filled to the top by the solid waste of a single day and covered with soil. In contrast, multi-layered cells accommodate the waste of two or more days; each day, the waste is compacted and covered with 30-40 cm soil, and when the cell is full it is covered with 60-90 cm soil layer.

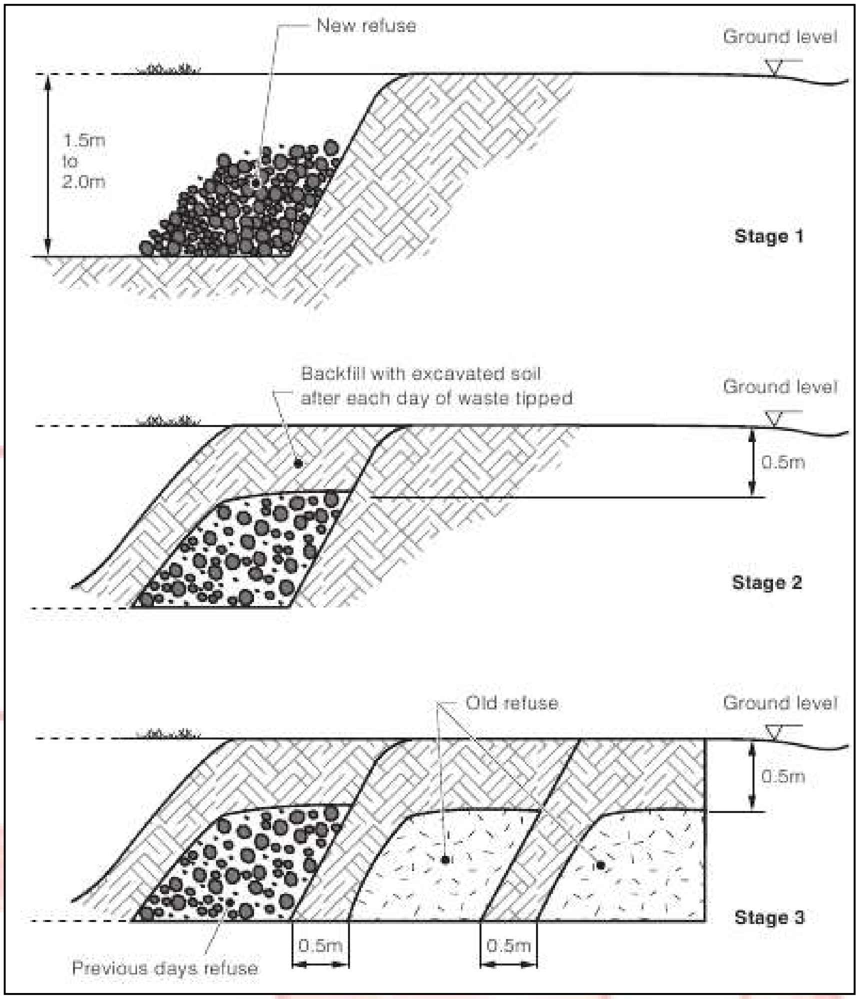

Fig.7

(ii) Trench Method:

In this method, long trenches are dug, filled with waste and covered with soil. In both cell emplacement and trench methods the soil for covering the waste is dug from the site of the next trench/cell.

However, since about only 20% of the cell/trench volume is occupied by soil, 80% of the soil excavated from the second and subsequent cells/trenches will have to be moved away, unless the level of landfill site is to be raised above the ground level.

Uses of Landfill Sites:

Landfill sites can be useful in the following two ways:

(i) As a source of biogas,

(ii) For reclamation of derelict sites to develop landscaped gardens etc.

i. Landfill sites generate considerable amounts of methane, which leaks from the soil cover. This presents a fire hazard and gives foul odour, but it can be collected and used as biogas.
ii. The landfill site may be landscaped and planted with vegetation. But problems may arise due to toxic substances present in the waste or produced due to degradation of the wastes, and many plant species may not survive. One way to surmount this difficulty may be to seal the surface of landfill and put another layer of topsoil. But in such cases, the methane must be lapped and collected to be burnt away from the site or used as biogas.

Hazards of Landfill:

The disposal of wastes in landfills presents several hazards including:

(i) Fires in the waste materials,
(ii) Increase in the population of disease vectors like flies,
(iii) Offensive odors,
(iv) Methane leakage, and
(v) Leaching of toxic and corrosive materials into surface and underground waters.

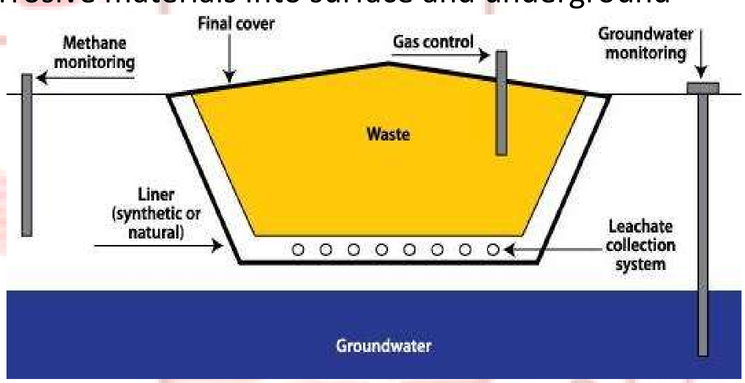

Figure 8

The water (leachate) from landfills may contain 6000-7000 mg/l total solids, COD value of 1000-2000 and 800 mg/l sodium, while the outflow from landfills may have 1000-2000 mg/l total solids, COD value of 70-80 and 300 mg/l sodium. The risks of Fires, offensive odours and increased vector populations may be circumvented by covering the waste with soil on daily basis.

The risk due to methane can be removed by burning or tapping. Similarly, the damage to the environment from landfill leachate may be avoided by lining the pit with an impermeable material like clay, soil-cement mixtures, concrete, polymeric materials and asphalts. But long- term containment with some of the linings, e.g., clay, is questionable. Therefore, specific pre-treatments of the wastes to reduce toxicity is preferable.

6.3 Composting

Principles of composting

Composting is defined as biological decomposition of solid complex organic materials into simpler humus material called as compost. In this method the solid organic fractions are degraded by the action of microorganisms like bacteria, fungi and actinomycetes under aerobic condition. The final produced compost is highly nutritious eco-friendly product used in cultivation of plants. In these method huge quantities of organic waste is converted into compost within short time. During composting process, the pathogenic microorganism and undesirable weed seeds are destroyed. Also beneficial microorganisms have vital role in composting process and it consume oxygen during degradation of organic matter and generate heat, carbon dioxide and water vapour are released into the air. It is important to manage the suitable conditions like oxygen and aeration, nutrients like nitrogen, carbon and moisture.

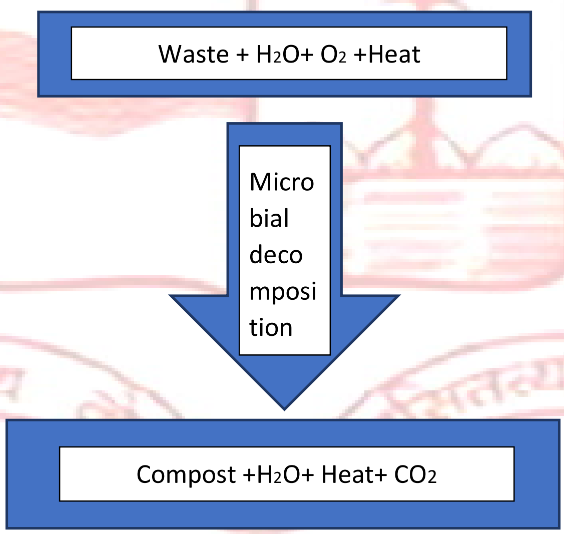

Fig.9 P*rocess of composting*

There are wide ranges of organic waste like animal wastes, food garbage, municipal wastes and suitable industrial wastes. The compost helps in enhancing the growth and production of agricultural crops. Increase the physico-chemical and biological properties of the soil as well as protect the plants from stresses such as drought, diseases and toxicity. Compost also helps the crop in improved uptake of plant nutrients and act as an active nutrient cycling capacity because of vigorous microbial activity.

Aerobic and anaerobic decomposition

Based on the nature of decomposition, it is classified into aerobic and anaerobic degradation. Aerobic decomposition occurs in presence of oxygen to break down the organic matter. In this aerobic process carbon dioxide (CO2), ammonia, water, heat and humus as a stable organic end product are produced. During the process, the heat generated accelerates the breakdown of proteins, fats and complex carbohydrates such as cellulose and hemi-cellulose.

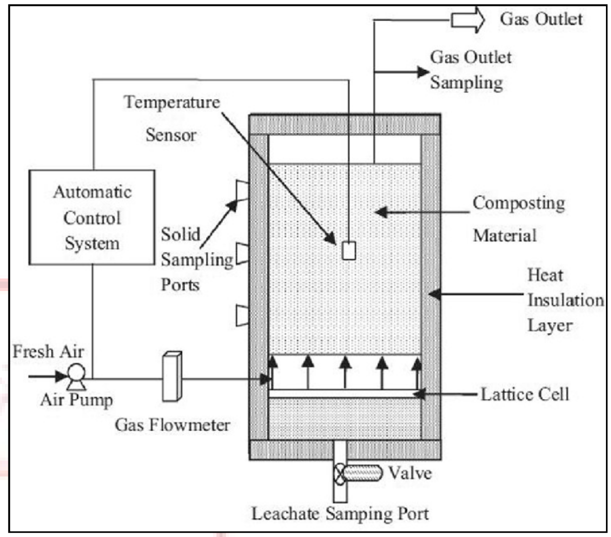

Fig. 10. :- aerobic decomposition

Anaerobic decomposition takes place in absent or limited oxygen condition. In this process anaerobic micro-organisms dominate and develop intermediate compounds including methane, organic acids. Generally anaerobic decomposition is long time process. Effective compost generally produced in aerobic composting method.

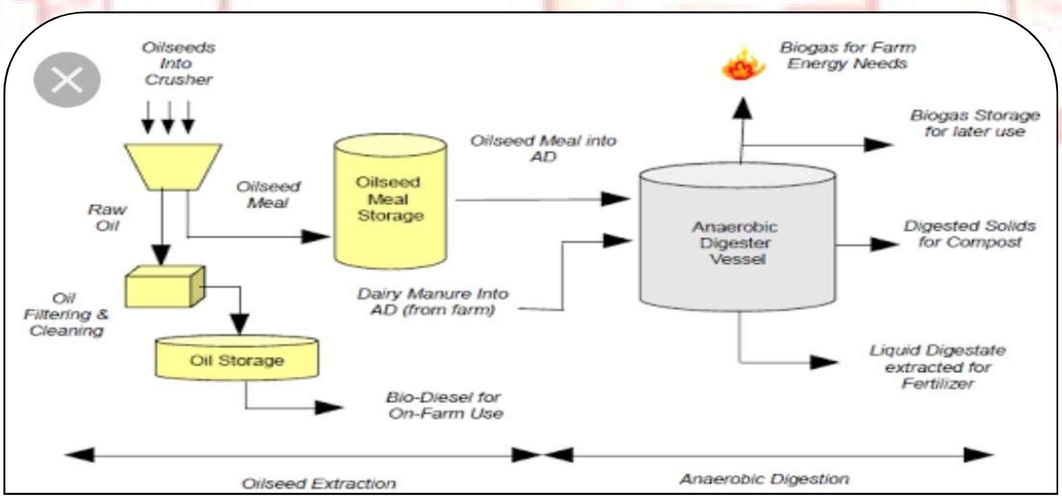

Fig. 11. :- Anaerobic decomposition flowchart

Various factors controlling composting process

Different environmental conditions and nutrient balance affects the bio-composting process. The controlling factor includes oxygen flow, moisture, carbon content, nitrogen content and other factors like bulk density and pH.

i. **Oxygen Flow or Aeration** :Aeration is very important factor to accelerate the degradation of organic materials under presence of oxygen. During the initial day of the composting process large amount of oxygen is required. Lesser oxygen reduces the degradation rate and process becomes anaerobic. Average of 5% oxygen is required to manage biocomposting process well. Aerating the pile allows decomposition to occur at a faster rate than anaerobic conditions. Aeration also helps in removing heat, water vapour and other gases trapped within the composting materials. Bulking agents like wood chips and shredded newspaper help in aerate the pile.

ii. **Moisture Content** :Microorganisms required specific moisture content to survive in compost pile. Watering and moisture support the movement of nutrient within pile and make nutrient available to microbes. Along with organic material containing moisture, intentional also helps in moisture maintenance. Ideally 40 %to 60% moisture is required to achieve efficient activity. More than 60% moisture, displace the air pore space of composting materials and make anaerobic conditions.

iii. **Particle Size** :Addition of various bulking agents like grinding, chipping, and shredding materials increases the surface area in which microorganisms efficiently feed the materials. Smaller particles also produce a more uniform compost mixture and increase pile insulation to help maintain optimum temperatures. Too smaller particle also negatively affect the composting process due to blocking of air flowing pores.

iv. **Temperature**: Microorganisms like bacteria, fungi and actinomycetes required optimum concentration of temperature to enhance the composting process and also helps in destroying pathogens and weed seeds. Different temperature range like Mesophilic temperature range of 80^{o} -120^{o}F and thermophilic temperature range of 105^{o} -150^{o} F enhance the composting process. Higher temperature helps in killing pathogenic microorganisms. Temperature in compost pile can be maintained by turning and aeration of a compost pile.

v. **Feedstock and Nutrient Balance (C: N ratio) :** As a microbial based process, biocomposting process required various primary nutrients like Carbon (C), nitrogen (N), phosphorus (P) and potassium (K). Microorganism required more carbon than the nitrogen content. Hence, it is important to maintain the balance between carbon and nitrogen ratio in composting process. To attain the required C:N concentration in composting materials the raw organic waste usually blended with wood chips, and branches. Generally controlled decomposition of organic materials required a balance of "brown" organic materials and "Green" organic material. The green organic materials include grass clippings, food scraps, and manure, which contain large amounts of nitrogen. "Brown" organic materials include dry leaves, wood chips, and branches, which contain high content of carbon whereas lesser content of nitrogen. Maintaining the nutrient balance in raw composting materials helps in producing high value compost and it is used for effective primary nutrient for the plant growth.

The C: N combination is very important and useful to formulate the composting material composition. It is also important to assess the carbon degradation rate in compost material. Ideally the raw organic material blended with green and brown material to provide C: N ratio of 25:1 to 30:1is effective in composting. Even initial ratios of 20:1 up to 40:1 provide good composting process. The C: N ratio is a useful guide to formulate. For example the straw decomposes easily and releases the carbon whereas woody materials are bound with lignin compounds and highly resistance to biological degradation.

Parameters	Conditions
Moisture	45-60^{o}C
Temperature	40-60^{o}C
C:N ratio	30:1
Oxygen	>10%
Bulk density	1000 lbs/yd
pH	6.5-8

Table 2: Optimum conditions for composting

The total composting period is depends on above listed parameters. Sufficient moisture content, C: N ratio and aeration ensure the shortest composting period. Properly managed composting process can able to generate high quality standard within four months.

Different raw materials and Co-composting process:

More than one type of organic waste raw materials used in co-composting process. In this method the initial trial experiment helps in standardizing the compostable mixtures. Based on the physical and chemical characteristics of the waste material, the composting material combination is used to get desired C: N ratio.

Microorganisms and Composting

Three important phases involved in decomposition process and various diverse microflora such as bacteria, fungi, actinomycetes of mesophilic group (*Streptomyces rectus*) and Actinomycetes of thermophilic group (*Actinobifida chromogena (Thermomonospora fusca) Microbispora (Thermopolyspora) bispora, Therinomnonospora curvata, Thermoactinomyces sp.*) are effectively involved in composting process. The Mesophilic organisms involved in initial degradation process of sugar and proteins and ultimately carbon-dioxide and temperature increases. In second phase the thermophilic community replaces mesophilic strains from 45 °C to approximately 70 °C due to increase in compost pile temperature. Again in third phase mesophiles dominates the thermophiles due to decrease in temperature. Further existence of actinomycetes and fungi in compost pile enhance the degradation of lignin, cellulose, starches, and proteins.

Composting methods

There are different composting methods employed to generate high quality biocompost. Based on the quantity of raw materials and availability of space, composting is carried out in aerated (turned) windrow composting, aerated static pile composting and in-vessel composting.

Aerated (Turned) Windrow Composting

This method is commonly applied for large volume such as that waste generated from entire communities or large quantity form any industrial process. In this method, organic waste is placed in long rows of piles called "windrows" and aerating them periodically by either manual or mechanical turning.

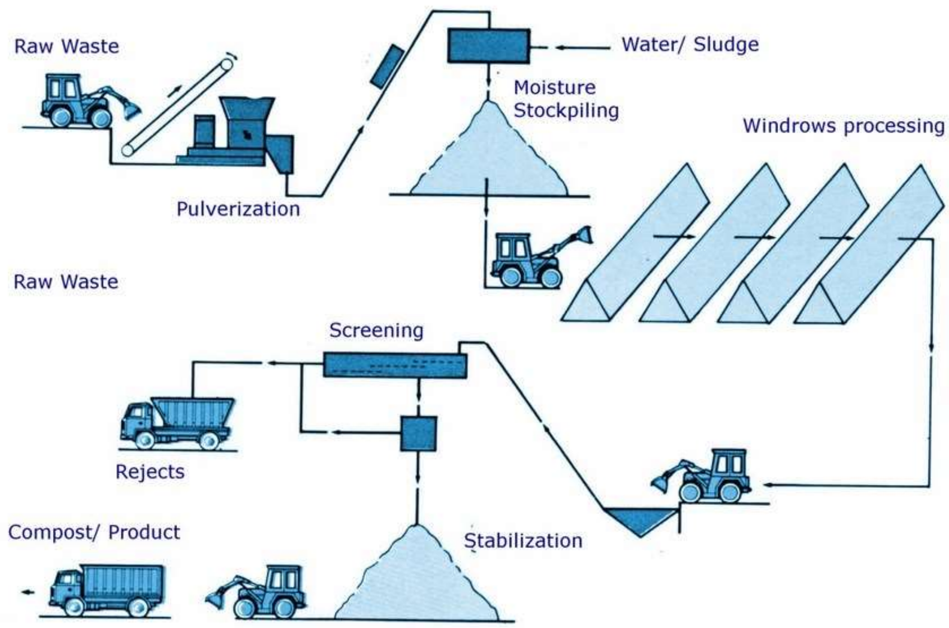

Fig. 12. :- aerated(turned) windrow composting

In this method the raw organic materials placed with ideal pile height is between four and eight feet with a width of 14 to 16 feet. The pile size is maintained sufficiently to generate heat and maintain the temperature and eventually it also allow oxygen flow inside the pile. A large volume of diverse wastes such as yard trimmings, grease, liquids, and animal byproducts (such as fish and poultry wastes) is used to make compost. Large volumes of diverse wastes such as yard trimmings, grease, liquids, and animal byproducts (such as fish and poultry wastes) can be composted through this method.

Fig. 13. :- result of aerated compost

Aerated Static Pile Compost

In this method organic composting materials are placed in rows of piles and aerated from bottom of pile. Most suitable method for composting relatively homogeneous mix of organic waste and efficient for handling large quantity of solid waste such as yard trimmings and compostable municipal solid waste. Aerated static pile system relatively required less time period of three to six months. This method however, does not work effectively for composting of animal byproducts or grease from food processing industries.

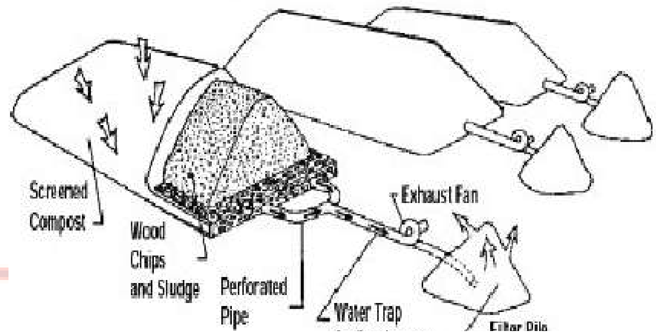

Fig. 14. :- aerated static pile compost

In order to facilitate the aeration inside the compost pile, bulking agents like wood chips, shredded newspaper) are added so that air can pass from the bottom to the top of the pile.

Alternatively the pile also placed above the pipe network containing holes that helps in circulating the air from bottom of the compost pile with help of air blowers.

Fig 15. Aerated static pile compost

Vermi-composting and verimiculture

Vermicomposting is a decomposition process in which earthworms and microorganisms jointly involved in decomposition of organic raw materials to biocompost. In this process earthworm play a crucial role in fragmentation and conditioning the substrates and efficiently increase the biological activities. Earthworms act as a mechanical blenders and it helps in change the physico-chemical status of organic materials, gradually decreases the C:N ratio, increase the surface area by which surface area exposed to microorganisms and enhance the microbial activities as well as decomposition. An earthworm directly or indirectly helps in organic matter decomposition, stabilization, and nutrient turn-over.

Vermicompost are highly nutritive and also called as “nutritive bio-fertilizer” generally has 4-5 folds more powerful than conventional composts and superior to chemical fertilizers for better crop growth and safe food production. Economically & environmentally preferred technology over the conventional microbial degradation and composting technology.

Mechanisms of Earthworm action during biocomposting

Earthworms influence the bio compost formation by grinding action and enzyme action. In grinding action, organic materials passage through the earthworm gut and form bacteria rich excrements. Earthworms involve in decomposition, stabilization and nutrient rich organic matters. The earthworms cast after organic matter degradation termed as “biofertilizer” or “microbial inoculant” which consist of live or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolytic microorganisms. The end product also “disinfected” and “detoxified”. Advantage of vermicomposting is that, easy earthworm cultivation and maintenance. Generally, one million worms doubling every two months can become 64 million worms at the end of the year and each adult worm (particularly Eisenia fetida) consume organics waste equivalent to its own body weight every day.

Enzymatic action

Earthworm intestine and gizzard act as a “bioreactor”. Earthworms secrete various enzymes like proteases, lipases, amylases, cellulases and chitinases. These enzymes help in biochemical conversion of cellulosic and the proteinaceous materials present in the organic wastes. It also digests the food material and removes the pathogenic microorganisms and also deposit them mixed with minerals and beneficial microbes as “vermicasts” in the soil.

Vermiculturing

Vermiculture is an artificial cultivation of earthworms. These earthworms are cultivated in simple method either in pits, crates, tanks, concrete rings or any containers. Earthworms are generally cultivated and used in vermicomposting. A mixture of cow dung and dried leaves in 1:1 proportion used to cultivate the earthworm. Around 50 earthworms are introduced in 10 kg of waste materials of dried leaves or husk and maintained under shade with adequate moisture. In this process, earthworms multiply 300 times within one to two months. These earthworms can be used to prepare vermicompost.

There are more than two thousand species of earthworms are identified in globally, in which around five hundred species has been identified in India. Earthworms diversity varies with different location and types of soil. Local earthworms species are best choice to use in composting process due its easy cultivation and adapted to local environmental conditions. Earthworms commonly used in India are *Perionyx excavatus* and *Lampito mauritii*. Other species of earthworms used in vermicomposting are *Eudrilus eugeiae, Eisenia fetida, Megascolx megascolex, Pheretima elongate, Perionyx elongate* and *Perionyx ceylanenssis*.

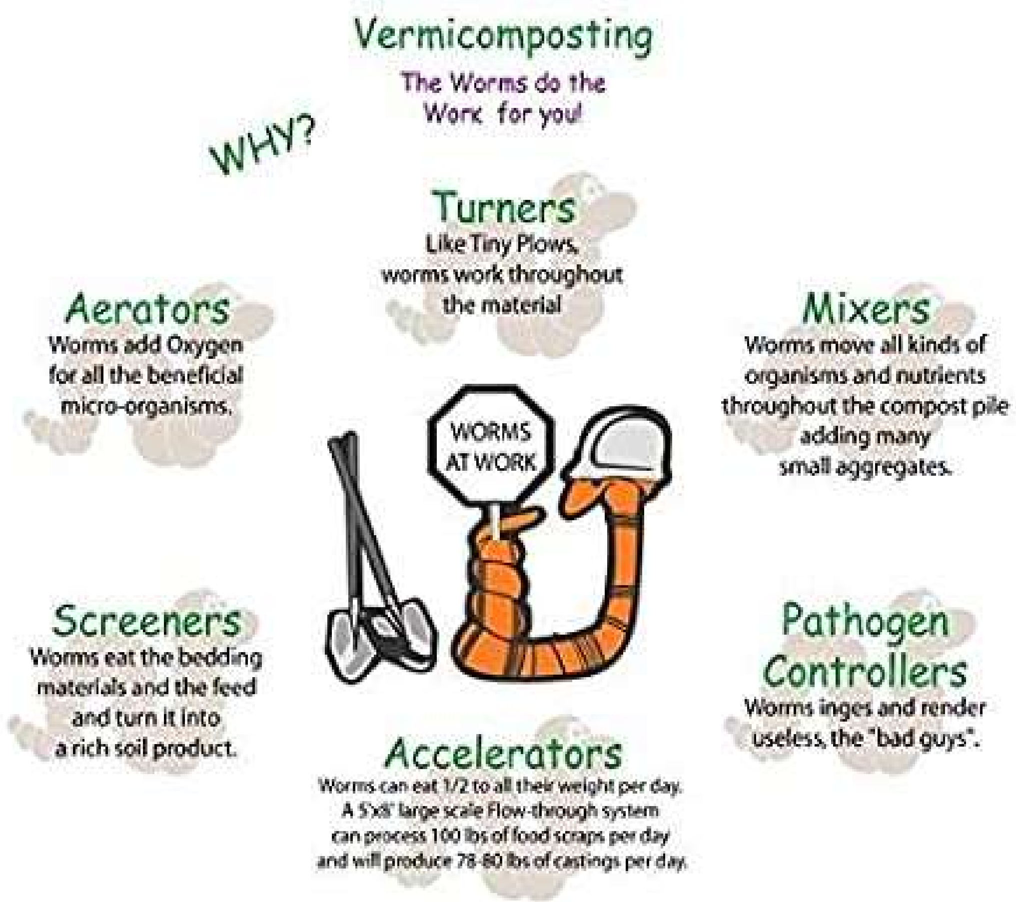

Figure 16: Advantages of vermicomposting

Vermicomposting process

Vermi-composting pits are prepared in any convenient dimension in garden or field or in concrete tank. Very common pit size is 2m x 1m x 0.75m constructed in brick with proper water outlet. Tank can be used in cement or clay of 750 mm diameter and 300 to 450 mm height can also be used. Vermibed is prepared with bottom loamy soil and above this 50 to 200 mm thick a thin layer of bricks and coarse sand. Earthworms are introduced into loamy soil, in which worms inhabit. Cattle dung placed above vermibed and maintained with proper moisture. Above the vermibed, a layer of dry leaves or chopped straw layered around 50 mm and maintained for 30 days. After 30 days wet predigested organic waste spread over it with thickness of 50 mm. Involves applying thin layers of sanitised and partially matured compost, to the surface of beds containing high densities of earthworms. Addition of pre-digested waste can be repeated twice a week. New layers of waste are applied to beds on a regular basis and the earthworms move upwards into the fresh waste to feed and to process the material. Earthworm numbers increase as more waste is applied until a limiting density is reached. The organic waste is added up to vermicompost tank get full. The earthworms are then harvested or the beds are divided. The compost organic materials are watered and mixed periodically and ensure the worms are in live condition. Generally turning can be done every week without affecting worms. After 2-3 months of continuous process the matured quality compost can be separated and sieved to remove the earthworms for further use.

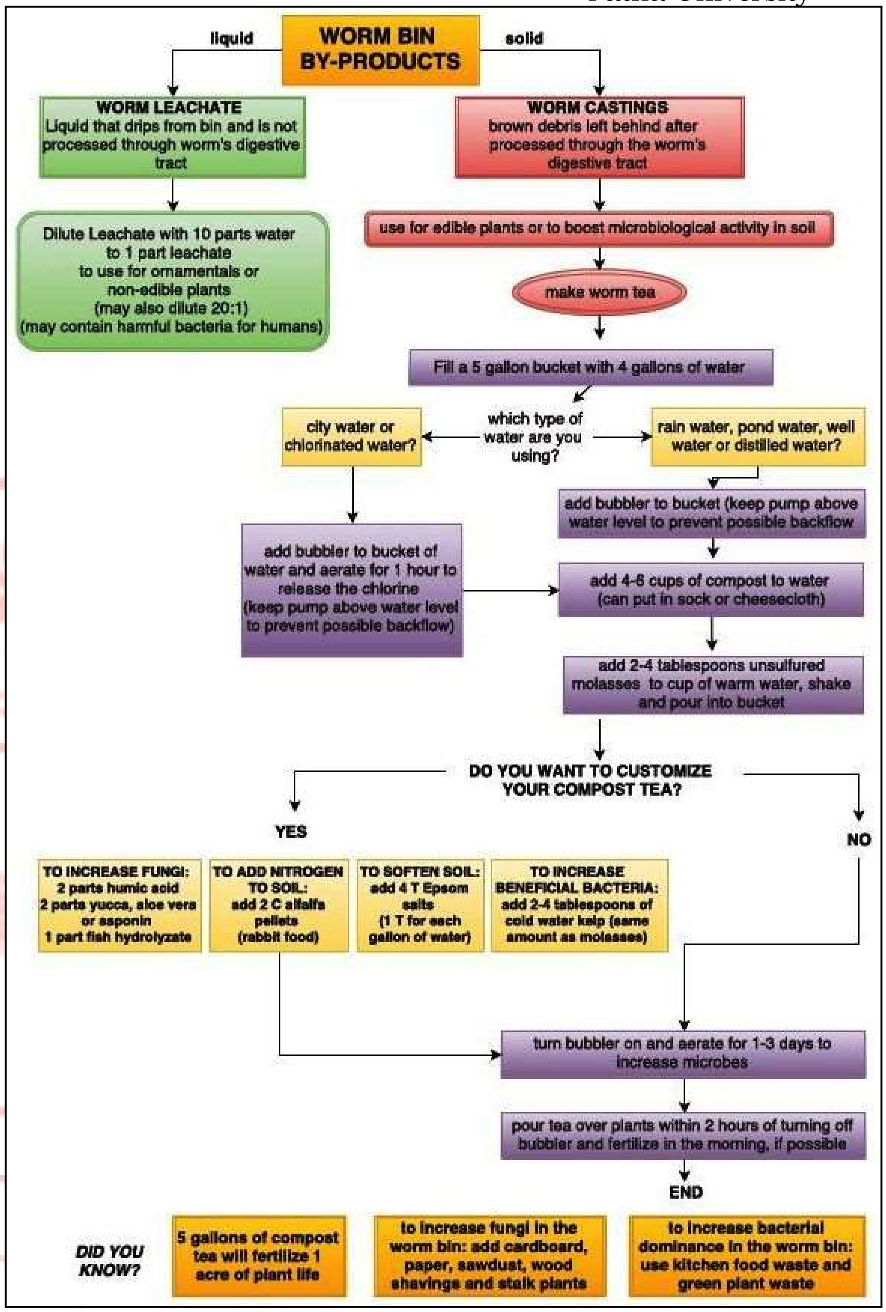

Figure17: overview of vermicomposting process

Four tank and two tank method

This method used to produce continuous vermicompost production in rural sectors where limited bulk availability of organic waste materials. In this method daily produced dung, cattle sheds, weeds, leaf litter and other farm waste used to produce manure under shade of trees. In this method, 22.5 cm brick walls with equal part with suitable vents for the aeration a well as for the earthworms from one tank to another tank.

Figure 18

Figure 19

In two tank method, initially first tank filled with waste over a period of two months and covered with polyethylene sheet followed by second tank start feeding raw materials. After 20-30 days the locally collected 150 to 200 earthworms are released into the biomass. After 45 to 60 days the vermicompost is collected from first tank. In the mean time the second tank gets filled and starts decomposing. The worms from the first vermicompost tank get migrate into second tank through vents and biocompost is produced.

6.4 *Gasification*

Gasification is defined as a thermal reaction with insufficient oxygen present for reaction of all hydrocarbons (compounds of carbon, hydrogen and oxygen molecules) to CO2 and H2O. This is a partial oxidation process which produces a composite gas comprised primarily of hydrogen (H2) and carbon monoxide (CO). The oxidant may be air, pure oxygen and/or steam. The gasification conditions are between 700-1600°C. Steam is injected into gasification reactor to promote CO and H2.

The main reactions taking place during gasification are:

Oxidation: $C + O_2 \rightarrow CO_2$ (exothermic)

Water evaporation reaction: $C + H_2O \rightarrow CO + H_2$ (endothermic)

$CO + H_2O \rightarrow CO_2 + H_2$ (exothermic)

$C + CO_2 \rightarrow 2CO$

CH4 formation reaction: $C + 2H_2 \rightarrow CH_4$ (exothermic)

Thus, CO, H2 and CH4 are the basic components of the gasification process producing the gaseous mixture. The resulting gas mixture is called syngas. Heating values of syngas are generally around 4-10 MJ/m3.

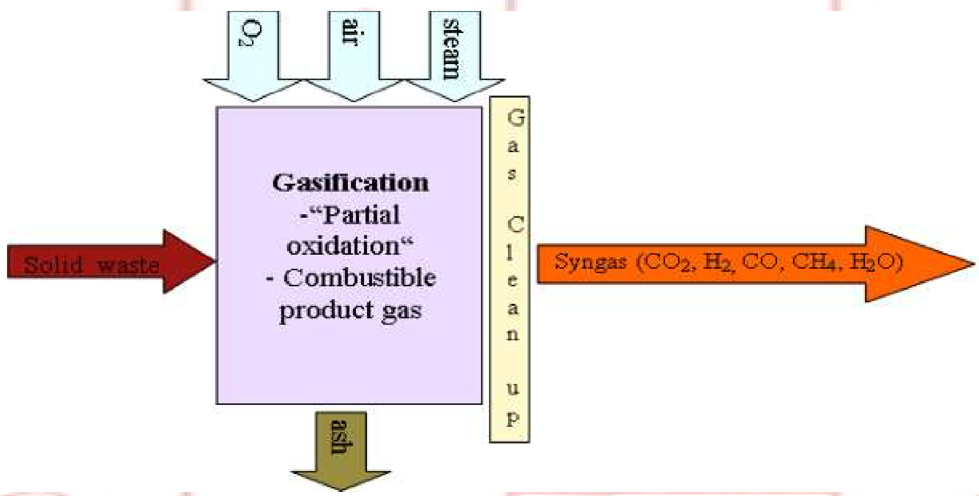

Fig. 20. :- process of gasification

The raw syngas exits the reactor and is cleaned up of carryover particulate matter from the reactor, sulfur, chlorides/acid gases. Syngas is sent to the power generation plant to produce energy, such steam and electricity for use in the process and energy. The export energy is converted to electricity and sold to the grid

6.5 Pyrolysis

Pyrolysis is the thermal degradation of carbon-based materials through the use of an indirect, external source of heat, typically at temperatures of 450 to 750°C, in the absence or almost complete absence of free oxygen to produce a carbonaceous char, oils and combustible gases. This drives off the volatile portions of the organic materials, resulting in a syngas composed primarily of H_2, CO, CO_2, CH_4 and complex hydrocarbons.

The reactions taking place initially are decomposition ones, where organic components of low volatility are converted into other more volatile ones .

$$CxHy \rightarrow CcHd + CmHn$$

Moreover, at the early stages of pyrolysis process, reactions occurring include condensation, hydrogen removal and ring formation reactions that lead to the formation of solid residue from organic substances of low volatility:

$$CxHy \rightarrow CpHq + H_2 + \text{coke}$$

In the case of existence of oxygen, CO and CO_2 are produced or the interaction with water is possible. The produced coke can be vaporized into O_2 and CO_2.

The products obtained from the pyrolysis process are solid residues and synthetic gas "syngas". The majority of the organic substances in waste are subjected to pyrolysis by 75 – 90 % into volatile substances and by 10–25% to solid residue (coke). The syngas cleanup step is designed to remove carry-over particulate matter from the reactor, sulfur, chlorides/acid gases (such as hydrochloric acid), and trace metals such as mercury.

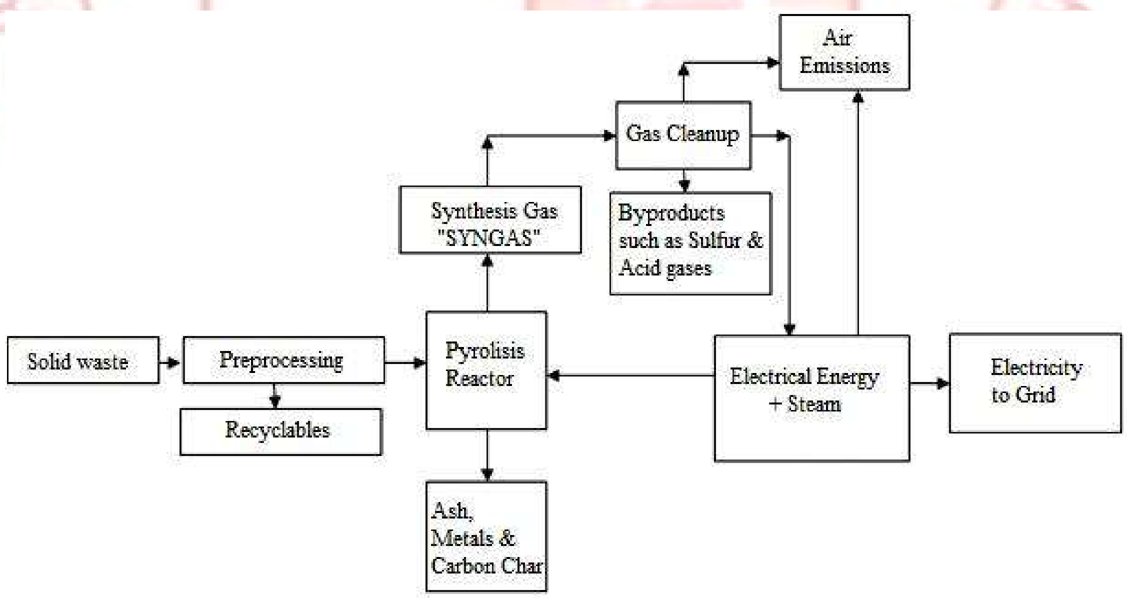

Fig. 21. :- Process of pyrolysis

Syngas is used in the power generation plant to produce energy, such as steam and electricity, for use in the process and export energy. The export energy is typically converted into electricity and supplied/sold to the grid. Synthetic gas typically has energy value between 10 and 20 MJ/Nm3 . If it is necessary, the cooling part synthetic gas can be collected as condensate to be used as a liquid fuel.

The bottoms from the reactor are ash, carbon char, and metals. The carbon char and metals have use as recyclables in industry. However, the ash from the pyrolysis process is usually disposed of in a landfill .

6.6 Recycling

Complex recycling systems are unlikely to be appropriate but the recycling of some waste items may be possible on occasions. Plastic bags, containers, tins and glass will often be automatically recycled since they are likely to be scarce commodities in many situations. In most developing country contexts there exists a strong tradition of recycling leading to lower volumes of waste than in many more developed societies.

Advantages: Recycling is environmentally friendly.

Disadvantage: There is limited potential in most emergency situations; and it is expensive to set up.

7. Protective measures

In order to minimise disease transmission there are several protective measures that can be undertaken. These concern equipment for staff and the siting and management of disposal sites.

If the volumes of waste generated are large, or space within the site is severely limited, it may be necessary to dispose of waste off-site. Where off-site disposal is to be used the following measures should be taken in selecting and developing an appropriate site:

- Locate sites at least 500m (ideally 1 kilometre) downwind of nearest settlement.
- Locate sites downhill from groundwater sources.
- Locate sites at least 50m from surface water sources.
- Provide a drainage ditch downhill of landfill site on sloping land.
- Fence and secure access to site.

Careful assessment should be made to determine who owns the proposed site and to ensure that apparently unused areas are not in fact someone’s farm or back yard.

8. Intervention levels

Table 7.1. Recommended interventions for different scenarios

Scenarios and recommended interventions	*The affected population go through a transit camp immediately after a disaster*	*The affected population remain in a temporary location for up to six months*	*The affected population stay in the affected area immediately after a disaster*	*The affected population move to a new area and are likely to remain for more than a year*
Immediate action	■ Clearing of scattered waste ■ Burning and burial of waste on site ■ Temporary communal pits ■ Temporary communal bins and off-site disposal ■ Repairing or upgrading of existing facilities			
Short-term measure	■ Communal pits ■ Family pits ■ Communal bins and off-site disposal			
Long-term measure			■ Communal pits ■ Family pits ■ Communal bins and off-site disposal ■ Repairing or upgrading of existing facilities ■ Recycling	

table indicates general intervention strategies for the storage and disposal of solid waste in different emergency scenarios.

9.References

- http://wedc.lboro.ac.uk/publications/pdfs/es/EC07CD.pdf
- http://eprints.ugd.edu.mk>SOLID WASTE TREATMENT TECHNOLOGIES
- http://epgp.inflibnet.ac.in