Organic waste recycling methods and techniques-composting, vermicomposting, *in situ* composting- System approach.

Compost

A mass of rotted organic matter made from waste is called compost. The compost made from farm waste like sugarcane trash, paddy straw, weeds and other plants and other waste is called farm compost.

The average nutrient content of farm compost is 0.5 % N, 0.15 % P2O5 and 0.5 % K_2O. The nutrient value of farm compost can be increased by application of superphosphate or rock phosphate at 10 to 15 kg/t of raw material at the initial stage of filling the compost pit.

Farm compost is made by placing farm wastes in trenches of suitable size, say, 4.5 m to 5.0 m long, 1.5 m to 2.0 m wide and 1.0 m to 2.0 m deep. Farm waste is placed in the trenches layer by layer. Each layer is well moistened by sprinkling cow-dung slurry or water. Trenches are filled up to a height of 0.5 m above the ground. The compost is ready for application within five to six months.

Compost prepared by traditional method is usually low in nutrients and there is need to improve its quality. Enrichment of compost using low cost N fixing and phosphate solublizing microbes is one of the possible ways of improving nutrient status of the product. It could be achieved by introducing microbial inoculants, which are more efficient than the native strains associated with substrate materials.

Inoculation with Azotobacter/Azospirillum and phosphate solubilising culture in the presence of 1% rock phosphate is a beneficial input to obtain good quality compost rich in N (1.8%). The humus content was also higher in materials treated with microbial inoculants.

The following basic rules are important for the production of good quality compost:

- The purpose of composting is to convert organic matter into growth promoting substances, for sustained soil improvement and crop production.
- The organic matter is partially decomposed and converted by microbes. The conditions should be a favorable for decomposition. Moisture 50% aeration 50% and C:N ratio 30:1
- Soil microorganisms constitute sufficiently to the decomposition of organic matter through their continuous activities. A typical compost earthworm is Eisenia foetida.
- Certain additives accelerate the conversion and improve the final product. The materials such as lime, earth, gypsum, rock phosphate act as effective additives. The

addition of nitrogen (0.1 to 1 %) is important in case of large C:N ratio of the composting material. Addition of lime (0.3 to 0.5 %), if sufficient lime is not present. The preparation of compost takes 2-3 months. The composition of compost varies with in wide limits.

Stages of composting

When organic material is composted in a batch, four stages of the composting process are apparent. Although the same phases occur during continuous composting, they are not as apparent as they are in a batch, and, in fact, they may be occurring concurrently rather than sequentially.

The four phases include:

1) the mesophilic phase;

2) the thermophilic phase;

3) the cooling phase; and

4) the curing phase.

Immature compost can be harmful to plants. Uncured compost can produce phytotoxins (substances toxic to plants), can rob the soil of oxygen and nitrogen, and can contain high levels of organic acids.

Methods of composting

The process of composting was first initiated in England during the period of First World War (1914 -1918). The various systems of composting are 1. ADCO process (Agricultural Development Company) 2. Activated compost process 3. Indore process 4. Bangalore process 5. Coimbatore process 6. Rain -water compost 7. Vermicompost . Some are as follows

1. Indore process:

This process is developed in India by Howard and Ward at the Indian Institute of plant Industry, Indore Materials needed: a) Straw or organic farm wastes as basic raw materials b) Cattle dung as starter (urine, earth and wood ashes)

Procedure: A compost pit of dimensions of 30 x 14 x 3 feet with sloping sides (narrow at bottom and at wide surface) is prepared and the raw material is spread in layers of 3" thickness. A mixture of urine, earth, and wood ashes is sprinkled and this is followed by 2" layer of dung. The pit is filled up this way until the material occupies a height of 3 feet above the ground level . As air can conveniently penetrate only to a depth of 1.5 to 2.0 feet extra

aeration has to be provided, which is done by means of artificial vents (holes) of 4" diameter pipe for every 4 feet length of the pit. The pit is watered twice a day i.e., morning and evening with rose can. The material is turning over 3 times, i.e., First – at the end of the first fort night Second – at the end of the second fort night Third – when the material is two months old in the process of composting.

Observations: I. After 10 days of composting the following things happens A. Synthesis of humus begins i.e., development of fungi and the height of the material is reduced by half B. Check anaerobic decomposition, as indicated by the foul smell and fly breeding C. If there is an anaerobic decomposition ,turn over material for proper aeration D. If insufficient fermentation, hasten by watering the material.

II. At the end of two months A. Fungal activity is over B. Materials become dark C. Now the bacterial aeration takes place D. Stock the material on the ground after 2 months .So 25 % of additional free nitrogen will be fixed from atmosphere. Compost is ready by 3-4 months. One cattle pair produced 50-60 cartloads per year.

2. Bangalore process

This process of composting was developed by Dr.C.N.Acharya in 1949.

1. Basic raw material used: Any organic material 2. Starters or inoculants: FYM or mixture of dung and urine or litter [Undecomposed] 3. Additives:Bone meal or oil cakes, wood ash

Procedure [Pit size: 20 x 4 x 3 feet The basic raw material is spread in a pit of 20 x 4 x 3 feet dimensions to a depth of 6 " layer, moistened with 20-30 gallons of water if the material is dry. Over this FYM or preferably a mixture of dung, urine and litter (undecomposed) from the cattle shed is placed as a layer of 2" thickness. It is again covered on the top with a layer of earth to a thickness of 6". It is beneficial to mix the earth with bone meal or oil cakes, wood ash etc., to improve manurial value of the compost .The piling of layers is continued till the heap raises above the ground level to a height of 2 feet.Then the heap is kept open for one week to facilitate aerobic decomposition. Later the heap is plastered with a layer of moist clay for anaerobic fermentation to occur. Fissures , or cleavages (cracks) that occur in the clay layer , have to be sealed off periodically .The compost will be ready in 4-5 months period starting from the day of preparation .This process is called as aerobic and anaerobic decomposition of compost. In this process the basic raw material is not so well decomposed as in the other methods .But organic matter and N contents are well conserved. The number of turnings are reduced .The out turn of the compost is relatively greater and cheapest process.

3. The coimbatore process:

The basic raw materials: 1.Raw organic matter 2. Starters : Powdered bone meal and cattle dung and water emulsion prepared by mixing Dung in water at 5-10 kg dung in 5-10 litres water. Procedure [Pit: 12 x 6 x 3 feet]: The basic raw material loosely spread [Pit: 12 x 6 x 3 feet] to a depth of 9" and water is sprinkled till the entire material is moist. Then about one kg of powdered bone meal is broadcasted uniformly above the layer and above this an emulsion of 5-10 kg of fresh cattle dung in 5-10 liters of water is applied. Repeat this process until a heap 2 feet above ground level is formed .Then the entire exposed surface area of heap is plastered with mud to facilitate

Semi-aerobic fermentation which would takes place for above 4-6 weeks depending upon the nature of the raw material. After 4-6 weeks, the mud plaster is removed to permit aerobic fermentation. If the heap has sunk unevenly which is a sign of defective fermentation, the material is reheaped after forking and moistened .The decomposition is complete in 3-4 months and is fit for application to the field.

Rain watered compost

In dry areas where it is difficult to obtain water for watering, the composting can be done with the aid of rain fall. The compost heap is built up as usual before the rains set in. The turnings are given during the rainy period at the end of rains the material will be ready for application. About 400 mm rain fall received in 3-4 months is considered sufficient.

Vermicompost

Soil fauna including protozoa to mammals though not considered major is the important source of nutrients. Among the soil fauna earthworms have attracted more attention than others because of their importance in agriculture. Earthworm gut is the site of production of genuine humic acids which are distinct from the polysaccharide-gum humic acids. About half of the gums secreted by earthworm are in form of mucoproteins that help stabilizing pore space distribution. The earthworm soil casts are richer in available plant nutrients (nitrate nitrogen, exchangeable Ca, Mg, K and P) and organic matter. The earthworms through their casts and dead tissues supply about 60-90 kg N to the soil. Earthworm eats on fungal mycelia. Earthworms convert farm waste and organic residues into high quality compost. For this, Eisenia foetida, Perionyx exacavatus, Eudrillus euginiae and Lumbrius rubellus are important. These species can be cultured on organic wastes and dung. The technique of culturing them is called vermiculture and using these for decomposing residue to make compost is called vermicomposting.

About 1000 adult earthworms can convert 5 kg waste into compost per day. The earthworm assimilate 5-10% of the substrate and rest passes through the alimentary canal and is excreted as cast. Earthworm cast contains nutrients, vitamins, hormones and antibiotics.

Vermi-compost is a stable fine granular organic matter, when added to clay soil loosens the soil and provides the passage for the entry of air. he multifarious effects of vermicompost influence the growth and yield of crops.

Definition of vermicomposting: Vermicomposting is a method of making compost, with the use of earthworms, which generally live in soil, eat biomass and excrete it in digested form. This compost is generally called vermicompost or Wormicompost.

Definition of Vermiculture: Vermiculture means scientific method of breeding and raising earthworms in controlled conditions.

Vermitechnology: Vermitechnology is the combination of vermiculture and vermicomposting. Thus, earthworms can be used in the following areas. 1. For development of arable soils, turnover of soil, break down of plant organic matter aeration and drainage 2. For production of useful products like vermifertilizer and worm tissue for animal feed. 3. For maintenance of environmental quality and monitor of the environment for soil fertility, organic and heavy metal non-biodegradable toxic material pollution.

Types of earthworms in vermicomposting Earthworms belong to phyllum Annelida of Animal Kingdom. They are long and cylindrical in shape and size having a large number of grooves. There are about 3000 species of earthworms in the world which are adapted to a range of environment. More than 300 species have been identified in India. Although, hermophrodite, two mature earthworms are required to propagate. At the time of egg laying, the clitellum is transformed into hard, girdle like capsule called cocoon. Shedding of cocoon ranges from 1 to 5, only a few of them survive and hatch. The juveniles and again formation of cocoons takes a period of 50-60 days. Normally, the average life span of earthworms varies with species ranging from 1 to 10 years.

Epigeics (surface feeders) are important in vermicomposting. The epigeics such as Eisenia foetida and Eudrilus eugeniae are exotic worms and Perionyx excavatus is a native one being used for vermicomposting in India. Epianecic are feeders on leaf litter and soil at upper layers of soil. This group such as Lampito mauritii is indegenous and is active in in-situ decomposition of organic wastes and residues in soil. Both epigeics and epianecics groups of earthworms are slender, shorter in length and red to dark brown in colour. They have high reproduction activity and efficient in recycling of organic materials. Increased attention has been paid to Eisenia foetida and Eudrilus eugeniae which have been found to

be potential agent in vermicomposting of wide range of agricultural wastes and can grow at a wide range of temperature varying from 0-40 ◦C. However, the optimum temperature ranges from 20-30 ◦C.

Mechanism of vermicomposting Materials consumed by worms undergo physical breakdown in the gizzard resulting in particles < 2 µ, giving thereby an enhanced surface area for microbial processing. This finally ground material is exposed to various enzymes such as protease, lipase, amylase, cellulase and chitinase secreted into lumen by the gut wall and associated microbes. These enzymes breakdown complex biomolecules into simple compounds. Only 5-10% of the ingested material is abosrbed into the tissues of worms for their growth and rest is excreted as cast. Mucus secretions of gut wall add to the structural stability of vermicompost.

Vermiculture industry or vermicompost preparation: 1. Basic raw material: Any organic material generated in the farm like bhusa, leaf fall etc., Horse dung, due to the risk of Tetanus virus, lethal to human beings is not advisable to be used as feeding material for earthworms. Paddy husk, merigold and pine needles have also advised to be used as feeding materials for earthworms. 2. Starter: Cow dung , Biogas slurry, or urine of cattle 3. Soil animal: Earth worms (Species: Eisenia foetida) 4. Thatched roof/vernished.

Favourable conditions of earth worms in the composting material: A. pH: Range between 6.5 and 7.5 B. Moisture: 60-70% of the moisture below and above range mortality of worms taking place C. Aeration: 50% aeration from the total pore space D. Temperature: Range between 18 ^{0}C to 35 ^{0}C

Procedure It is mostly prepared in either pit or heap method. The dimensions either heap or pit are 10 x 4 x 2 feet. The length and width can be increased or decreased depending on the availability of material but not the depth because the earthworms' activity is confined to 2 feet depth only. First of all select a site which is not under any economic use and is shady and there is no water stagnation. The site should also be nearby to water source. 1st layer: bedding material of 1" thick with soft leaves 2nd layer: 9" thick organic residue layer finely chaffed material 3rd layer: Dung + water equal mixture of 2" layer. Continue the layer up to pile to ground level in the case of pit method and upto 2' in heap or surface bed method. Protect the worms against natural enemies like ants, lizards, snakes, frogs, toads etc., Maintain proper moisture and temperature by turnings and subsequent staking. At the day of 24th, 4000 worms are introduced in to the pit [1m2 =2000 worms] without disturbing the pit by regular watering the entire raw material will be turned into the vermicompost in the form of worm excreta. The turnover of the compost is 75% [the total material accommodated in the pit is 1000 kg; the out turn will be 750 kg]

Harvesting of the vermicompost from the pit Stop watering before one week of harvest. Sometimes the worms spread across the pit come in close and penetrate each other in the form of ball in 2 or 3 locations. Heap the compost by removing the balls and place them in a bucket. However, under most instances, top layer has to be disturbed manually. Earthworms move downward and compost is separated. After collection of compost from top layers, feed material is again replenished and composting process is rescheduled. The material is sieved in 2 mm sieve, the material passed through the sieve is called as vermicompost which is stored in a polythene bags

Precautions 1. Do not cover vermicompost beds/heaps with plastic sheets because it may trap heat and gases. 2. Do not overload the vermicompost heap to avoid high temperature that adversely affect their population. 3. Dry conditions kill the worms and waterlogging drive them away. Watering should be done daily in summer and every third day in rainy and winter season. 4. Addition of higher quantities of acid rich substances such as tomatoes and citrus wastes should be avoided. 5. Make a drainage channel around the heap to avoid stagnation of water particularly in high rainfall areas in rainy season. 6. Organic materials used for composting should be free from non-degradable materials such as stones, glass pieces, plastics, ceramic tubes/bulbs etc.

Natural enemies and their control The important natual enemies of vermiculture are ants, termites, centipedes, rats, pigs, birds etc. Preventive measures include treating of the site with chlorpyriphos 20 EC at 2 ml/l or 4% neem based insecticide before filling the heap.

Transportation of live worms Live earthworms can be packed with moist feed substrate in a container (card board/plastic) with provision of aeration. Feed substrate quantity should be roughly 0.5-1.5 g/individual for 24 hours of transportation journey. Culture should contain cocoon, juveniles and adults because sometimes adults do not acclimatize to new environment and may even die. Under such circumstances cocoons are helpful for population build up of earthworms.

Conversion rates: 1000 earth worms may convert 5 kg waste material per day 1000 worms weighs about a kilogram

Advantages of composting over direct application: 1. There will be no immobilization in compost because of narrow C:N ratio 2. Application is easy, because the compost is humified and have a structure of crumb and granular. 3. It is hygienic, pathogens and weeds seeds are destroyed.

The rate of application is as Field crops 5-6 t/ha; vegetables 10-12 t/ha; flower plants 100-200 g/sq ft; fruit trees 5-10 kg/tree.

Nutrient content &Advantage of vermicompost (Refer lecture 5)

In-situ vermicomposting can be done by direct field application of vermicompost at 5 t/ha followed by application of cow dung (2.5 cm thick layer) and then a layer of available farm waster about 15 cm thick. Irrigation should be done at an interval of 15 days.

System approach in recycling of on farm wastes

Farming system is having different components for different situation. However, some basic components exist in any farming system maintained under varied conditions. They are,

- Crop components and related cropping system in intensive cropped area
- Crop residue management
- Allied enterprises. The enterprises may be animal / Alternate land use system / Sericulture / fish farming
- Recycling of the wastes of allied enterprises.