SOIL SCIENCE Section

Course No. : **SOIL-122**

Course Title : Soil Fertility Management

Credit : 3(2+1)

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Lecture no.- 6 & 7

Manures and Fertilizers

(8 %)

Sub-topics/ Key points

- Introduction and Importance of Manures and Fertilizers;
- Preparation and Properties of Major Manures: FYM, Compost, Vermicompost
- Green Manuring
- Oilcakes.

Manures

- In Agriculture, manure refers to organic matter, primarily animal waste (faeces and urine) with or without plant litter (straw or bedding), used as a natural fertilizer to improve soil fertility and crop yields.
- These are the **materials naturally available in farm or locality and are constituted mainly of remains of plants and animals which are added to a soil as a source of nutrients and for modifying the soil properties.**
- Organic Manures **are plant and animal wastes that are used as sources of plant nutrients.**
- Manures can be grouped into **bulky organic manures** and **concentrated organic manures** based on concentration of the nutrients.

Manures

- They **release nutrients after their decomposition**.
- The manures are **organic in nature**, plant or animal origin and contain organic matter in large proportion and plant nutrients in small quantities and used to improve soil productivity by correcting soil physical, chemical and biological properties.
- Manure is organic matter used as **organic fertilizer** in agriculture.
- Manures contribute to the fertility of the soil by adding organic matter and nutrients, such as nitrogen, that are trapped by bacteria in the soil.
- Higher organisms then feed on the fungi and bacteria in a chain of life that comprises the soil food web.

Major sources of manures -

1. **Cattle shed wastes -** dung, urine and slurry from biogas plants.
2. **Human habitation wastes -** night soil, human urine, town refuse, sewage, sludge and sewage water.
3. **Poultry litter, droppings of sheep and goat.**
4. **Slaughter house wastes -** bone meal, meat meal, blood meal, horn and hoof meal, fish wastes.
5. **Byproducts of agro industries -** oil cakes, bagasse and press mud, fruit and vegetable processing wastes etc.
6. **Crop wastes -** Sugarcane trash, stubbles and other related material
7. **Water hyacinth, weeds.**
8. **Green manure crops** and green leaf manuring material

Importance of Manures -

✓ **Improves soil structure -** Organic manure improves the soil's water-holding capacity and aeration.

✓ **Enhances soil quality -** Organic manure contains nutrients like nitrogen, phosphorus, and potassium, as well as micronutrients like calcium, magnesium, and sulfur.

✓ **Promotes a healthier environment -** Organic manure is free from synthetic chemicals, which can help reduce soil and water pollution.

✓ **Improves soil resistance -** Organic manure increases soil resistance to changes in acidity and salinity.

The main effects/ benefits of organic manures are:

A) Improvement of physical soil properties

- Improvement of soil structure
- Improvement of water holding capacity
- Improvement in soil reaction
- Buffering of soil surface temperature
- Reduction in soil losses due to erosion

B) Improvement in chemical properties

- Supply of essential nutrients in balanced ratio
- Supply of nutrients
- Slow release of nutrients

C) Improvement of biological properties

- Stimulation of soil flora and fauna

Fertilizer

- **Any organic or inorganic material of natural or synthetic origin added to a soil to supply certain element essential for the growth of plants.**
- A fertilizer can be defined as **a mined or manufactured material containing one or more essential plant nutrients in potentially available forms in commercially valuable amounts.**
- **A fertilizer is a substance, either natural or synthetic, applied to soil or plant tissues to provide essential nutrients, thereby promoting plant growth and increasing crop yield.**
- Fertilizers are classified on the basis of major nutrient content.

1. Nitrogenous fertilizers ;
2. Phosphatic fertilizers ;
3. Potassic fertilizers

Advantages of Fertilizers –

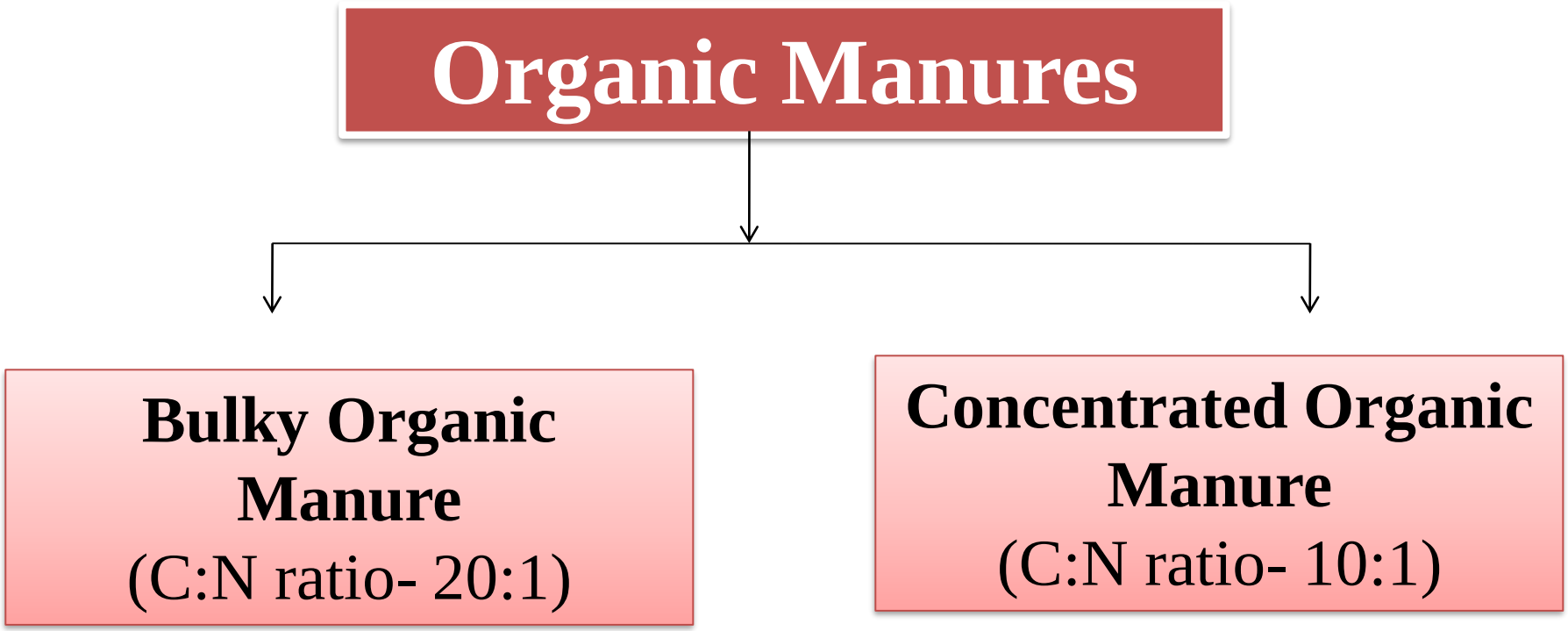
1. They are easy to transport, store and apply.
2. For supplying a specific nutrient we can select a specific fertilizer due to its nutrient specific nature.
3. They are water-soluble and can easily dissolve in the soil. Hence, they are easily absorbed by the plants.
4. They have a rapid effect on the crops.
5. They are predictable and reliable.
6. They increase the crop yield and provide enough food to feed the large population

Disadvantages of Fertilizers –

1. They are expensive.
2. The ingredients in the fertilizers are toxic to the skin and respiratory system.
3. Excessive use of fertilizers damages the plants and reduces soil fertility.
4. Leaching occurs and the fertilizers reach the rivers causing eutrophication.
5. Long term use reduces the microbial activity and disturbs the pH of the soil.

MANURES	FERTILIZERS
Organic in nature	Inorganic in nature
Slow acting	Quick acting
Having low analytical value	Having high analytical value
Having no definite chemical composition	Having definite chemical composition
Obtained from plant , animal and human resources	Mined or manufactured
Improves physical properties of soils	Don’t improve the physical properties of soils
Supply almost all major, minor and micronutrients.	Supply one or very few plant nutrients.
Derived from *French* word ‘**MANOEUVRER**’ to work with soil	Derived from *Latin* word **Fertil** (means Fertile)
Bulky in nature	Non-bulky in nature

MANURES	FERTILIZERS
Contains O.M. and hence improves soil physical properties	Do not contain O.M. and cannot improve soil physical properties
Improves soil fertility as well as productivity	Improves soil fertility
Contains all plant nutrients but small in concentration	Contains one or more plant nutrients but in higher concentration
Required in large quantity bulky and costly	Required in less quantity concentrated and cheaper
Nutrients are slowly available upon decomposition	Nutrients are readily available.
Long lasting effect on soil and crop	Very less residual effect
No salt effect	Salt effect is high
No adverse effect	Adverse effects are observed when not applied in time and in proper proportion.


Organic Manures
Bulky Organic Manure
(C:N ratio- 20:1)
Concentrated Organic Manure
(C:N ratio- 10:1)

A) Bulky Organic Manures

- Organic material of natural origin having greater volume per unit nutrient content.
- Bulky organic manures contain small percentage of nutrients and they are applied in large quantities.
- eg. Farm yard manure (FYM), compost and green manure are the most important and widely used bulky organic manures.

Examples-

1. **FYM:**

Farmyard manure refers to the decomposed mixture of dung and urine of the farm animals along with litter and left over material from roughages or fodder fed to the cattle.

- Well decomposed farmyard manure contains

0.50% N, 0.25% P_2O_5 and 0.50% K_2O.

Factor affecting the composition of FYM:

1. Source of manure
2. Food of Animal
3. Age & condition of animal
4. Function of animal
5. Manure of storage

2. 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 (rural) compost.**

- Rural compost: 0.50% N, 0.15% P_2O_5 and 0.50% K_2O.

- The compost made from town refuses like night soil, street sweepings and dustbin refuse is called **town (urban) compost.**

- Urban compost: 1.40% N, 1.00% P_2O_5 and 1.40% K_2O.

3. Night soil:

Night soil is a human excreta consisting both solid & liquid portion.

- Night soil: 5.50% N, 4.00% P_2O_5 and 2.00% K_2O.

4. Sewage & Sludge:

a. Sewage:

Liquid collected from closed drains usually urine & washings of the night soil and other solid ingredients.

6-10% N, 3-4% P_2O_5 and 3-4% K_2O.

b. Sludge:

Settled sewage solids combined with varying amount of water and dissolved materials removed from sewage by screening, sedimentation, chemical precipitation or bacterial digestion.

1.50-3.50% N, 0.75-4.00% P_2O_5 and 0.30-0.60% K_2O

5. Green Manure:

Green, undecomposed plant material used as manure is called green manure.

- It is obtained in to ways: **growing green manure crops** or **by collecting green leaf (along with twigs) from plants grown** in wastelands, field bunds and forest.
- Green manuring plants usually belonging to leguminous family and incorporating into the soil after sufficient growth.
- The most important green manure crops are sunhemp, dhaincha, and Sesbania rostrata.

6. Vermicompost

7. Sheep and Goat manure

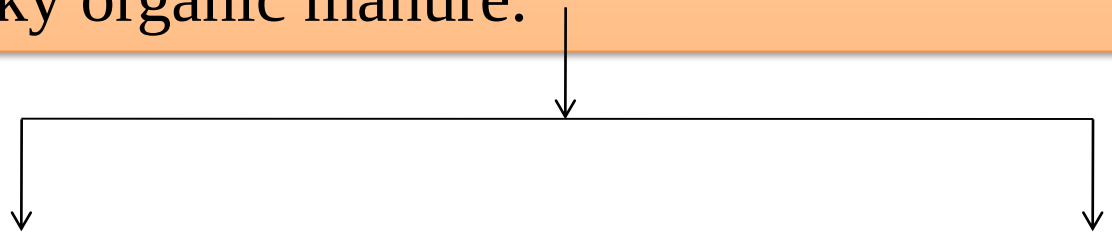
8. Poultry manure

Advantages of Bulky organic manures :

- They supply plant nutrients including micronutrients.
- They improve soil physical properties like structure, water holding capacity etc.,
- They increase the availability of nutrients.
- Carbon dioxide released during decomposition acts as a CO_2 source.
- Plant parasitic nematodes and fungi are controlled to some extent by altering the balance of microorganisms in the soil.

B) Concentrate Organic Manures

- Organic material of natural origin having smaller volume per unit nutrient content.
- Concentrated organic manures have higher nutrient content than bulky organic manure.



Plant origin

Animal origin

a) Plant origin:

It include different oil cakes (After oil is extracted from oilseeds, the remaining solid portion is dried as cake which can, be used as manure).

- The oil cakes are of two types:

i) Edible oil cakes which can be safely fed to livestock;

e.g. Groundnut cake: **7.30% N, 1.50% P_2O_5 and 1.30% K_2O**

Cotton cake : **6.40% N, 2.90% P_2O_5 and 1.60% K_2O**

ii) Non edible oil cakes which are not fit for feeding livestock

e.g. Caster cake : **4.30% N, 1.80% P_2O_5 and 1.30% K_2O**

Neem cake : **5.20% N, 1.00% P_2O_5 and 1.40% K_2O**

- Nutrients present in oil cakes, after mineralization are made available to crops 7 to 10 days after application.

- Oilcakes need to be well powdered before application for even distribution and quicker decomposition.

Oil-cakes	Nutrient content (%)		
	N	P_2O_5	K_2O
Non edible oil-cakes			
Castor cake	4.3	**1.8**	1.3
Cotton seed cake (undecorticated)	3.9	**1.8**	**1.6**
Karanj cake	3.9	0.9	1.2
Mahua cake	2.5	0.8	1.2
Safflower cake (undecorticated)	**4.9**	1.4	1.2
Edible oil-cakes			
Coconut cake	3.0	1.9	1.8
Cotton seed cake (decorticated)	6.4	**2.9**	1.6
Groundnut cake	**7.3**	1.5	1.3
Linseed cake	4.9	1.4	1.3
Niger cake	4.7	1.8	1.3
Rape seed cake	5.2	1.8	1.2
Safflower cake (decorticated)	7.9	2.2	**1.9**
Sesamum cake	6.2	2.0	1.2

b) Animal origin:

- Blood meal when dried and powdered can be used as manure.

-The meat of dead animals is dried and converted into meat meal which is a good source of nitrogen.

Organic manures	Nutrient content (%)		
	N	P_2O_5	K_2O
Blood meal	**10 - 12**	1 - 2	**1.0**
Meat meal	10.5	2.5	0.5
Fish meal	4 - 10	3 - 9	0.3 - 1.5
Horn and Hoof meal	13	-	-
Raw bone meal	3 - 4	20 - 25	-
Steamed bone meal	1 - 2	**25 - 30**	-

Preparation and Properties of Major Manures :

FYM, Composts, Vermicompost. Green manuring, Oilcakes

1. FYM (Farm Yard Manure):-

It is decomposed mixture of solid and liquid excreta of farm animal along with litter, bedding material, left over material from roughages and fodder feed to cattle.

❑ Methods of FYM preparation:-

1.Trench method

2. Gobar gas or slurry method

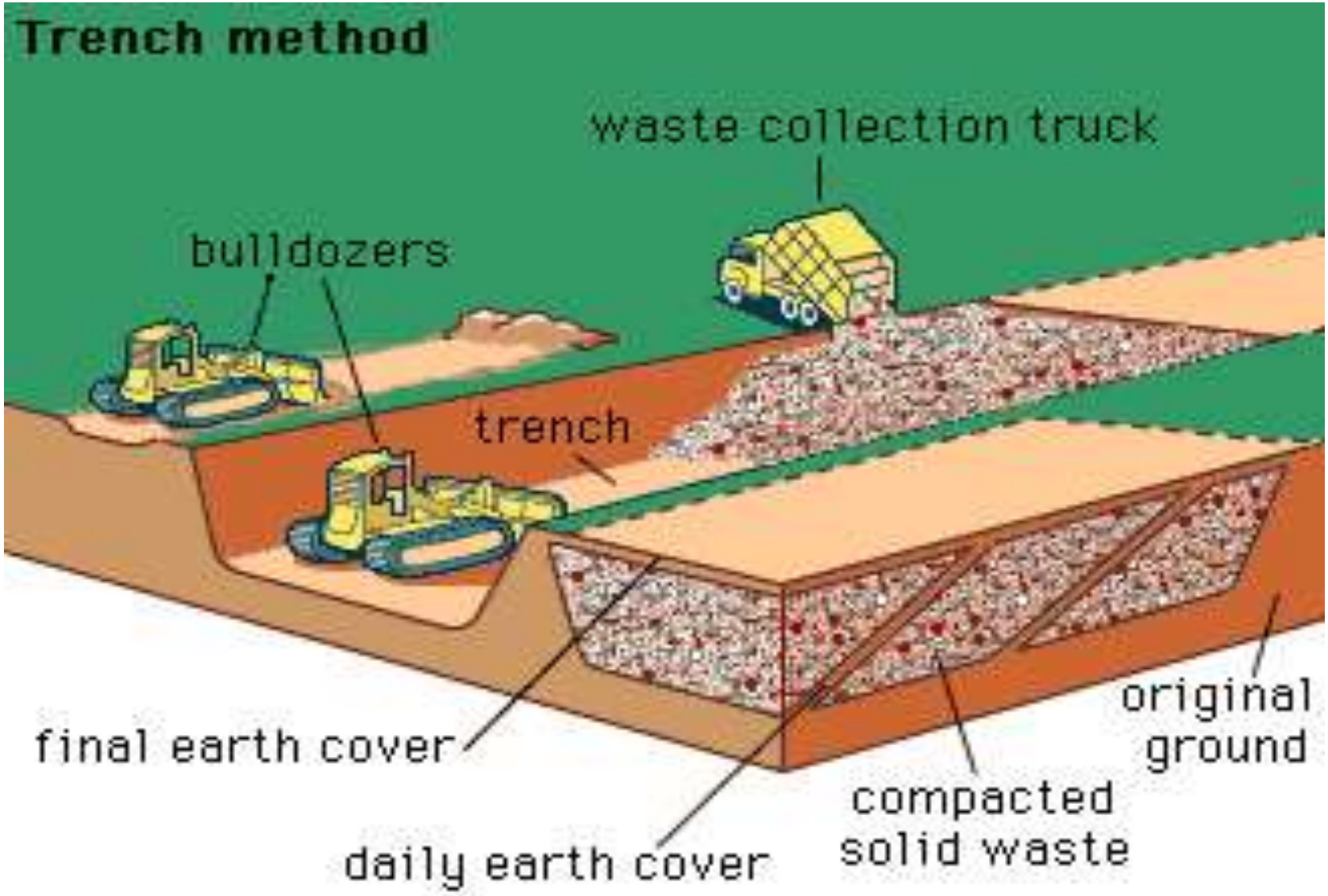
3. Enriched FYM

1. Trench method:-

- Recommended by **C. N. Acharya in 1939.**
- **Anaerobic** method.

Steps:

- Preparation of pit or trench (6.09-7.62 m long, 1.5-1.6 m broad, 0.91-1.06 m deep).
- Mixing of urine soaked litter and dung.
- 0. 91 meter trench from one end should be filled with the daily collection of refuse from the cattle shed.
- Fill up to height of 46 to 61 cm above ground.
- Heap made of dome shaped.
- Plastered with cow dung and earth slurry.
- Next 0.91m length of pit is taken up for filling.
- Keep it for 3 months.
- Prepare 5-6 tons of manure per year/head of cattle.


Trench method
waste collection truck
bulldozers
trench
final earth cover
daily earth cover
compacted
solid waste
original
ground

2. Gobar gas plant or Slurry method:-

The 1st attempt in India was made by **S. V. Desai** at Indian Agricultural Research Institute (IARI), New Delhi.

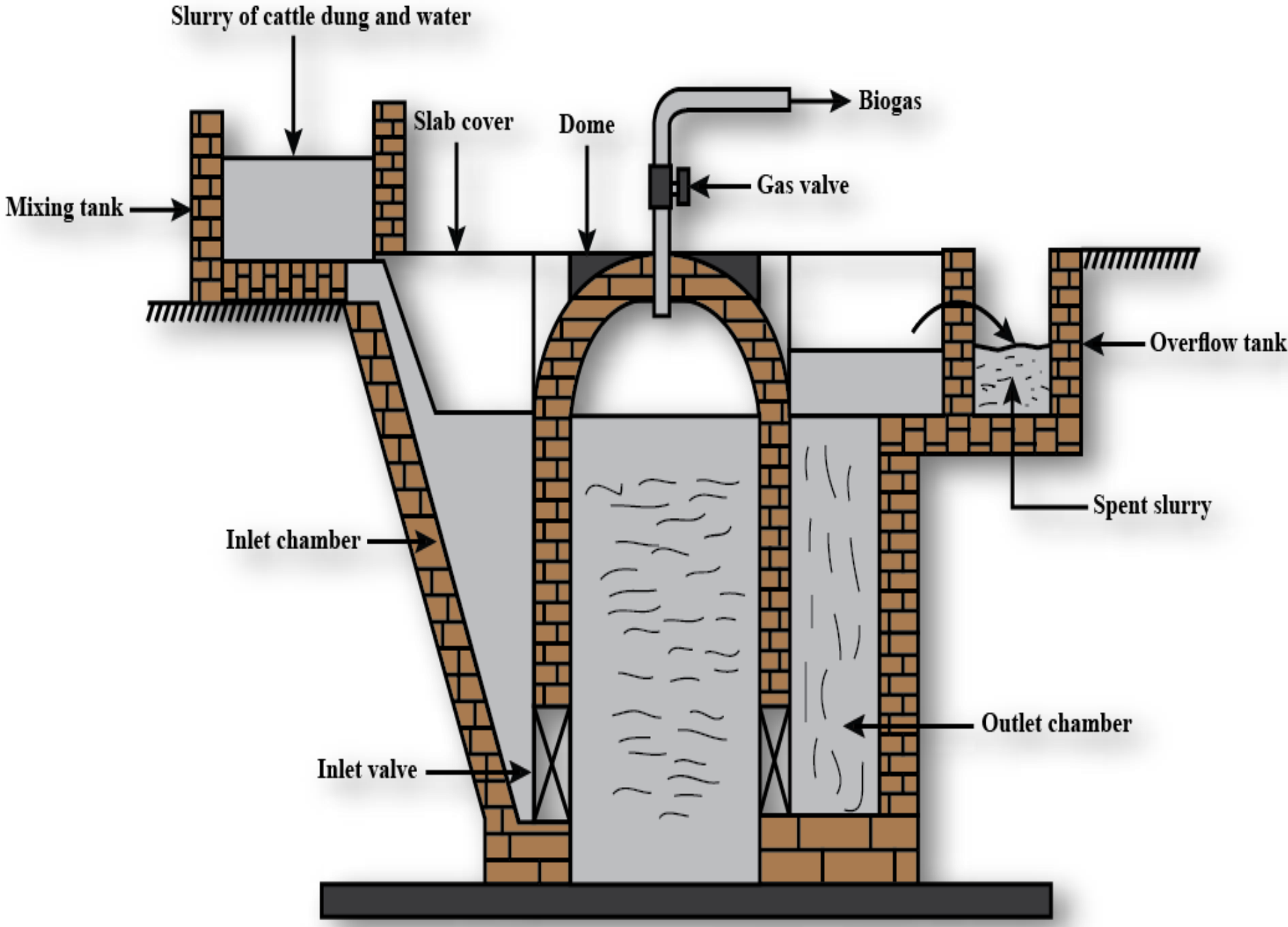
It is used to produce a combustible gas called **methane.**

❖ Properties of methane:

1. It is colourless gas burn with blue flame.
2. Tasteless.
3. No detectable odour.
4. Used as fuel.

Preparation steps:

- It is **Anaerobic** fermentation method.
- It has mainly 2 parts, the **digester** and **gas container**
- Digester is dug and build below ground level having depth 370-610 cm and width 120 to 160 cm diameter.
- It has two slanting cement pipes serve inlet and outlet.
- Fresh dung mixed with water into digester through inlet pipe and decomposing nearly month, it comes out in the form of slurry through outlet pipe & stored in manure pit.
- After drying the slurry can used as manure.
- During decomposition methane is produce is stored in gas container.
- There is supply pipe fitted on top of drum which carries methane gas.



FIXED DOME BIOGAS PLANT

❖ Composition of digested cattle dung slurry

Dry matter	**: 5-8%**
Organic matter	**: 60-70%**
Carbon	**: 35-42%**
Nitrogen	**: 1.8- 2.2%**
C:N ratio	**: 1:17-21**

3. Enriched FYM:-

FYM is enriched by the addition of chemical preservatives, chemicals are added to decrease nitrogen losses.

Ex. Gypsum, superphosphate.

The value of gypsum is preserving nitrogen manure.

$$(NH_4)_2CO_3 + CaSO_4 \longrightarrow CaCO_3 + (NH_4)_2SO_4$$

Superphosphate has been extensively used as manure preservative. Superphosphate contain 50 - 60% gypsum beside monocalcium phosphate.

$$2CaSO_4 + Ca(H_2PO_4)_2 + 2(NH_4)_2CO_3 \longrightarrow Ca_3(PO_4)_2 +$$

Gypsum — Monocalcium Phosphate — Ammonium carbonate — Tricalcium Phosphate

$$2(NH_4)_2SO_4 + 2H_2O + 2CO_2$$

Ammonium Sulphate

Properties of FYM :

- Farmyard manure (FYM), a valuable **organic fertilizer, is rich in nutrients like nitrogen, phosphorus, and potassium, and also contains micronutrients, improving soil structure, water-holding capacity, and aeration.**

Nutrient Content:

Macronutrients: FYM contains essential macronutrients like nitrogen (N), phosphorus (P), and potassium (K).

Micronutrients: It also provides micronutrients such as copper (Cu), manganese (Mn), and zinc (Zn).

Organic Carbon: FYM is a good source of organic carbon, which is vital for soil health and microbial activity.

Decomposition: While FYM contains nutrients, a small portion of nitrogen is directly available to plants, while a larger portion becomes available as it decomposes.

Properties of FYM :

Soil Improvement:

Soil Structure: FYM improves soil structure by increasing aggregation and reducing compaction.

Water-Holding Capacity: It enhances the soil's ability to retain water, which is crucial for plant growth, especially in arid or semi-arid regions.

Aeration: FYM contributes to better aeration, allowing for better root growth and nutrient uptake.

Soil Microbial Activity: FYM stimulates the activity of beneficial soil microorganisms, which play a vital role in nutrient cycling and soil health.

Properties of FYM :

Other Important Properties:

Cost-Effective and Eco-Friendly: FYM is a cost-effective and environmentally friendly alternative to synthetic fertilizers.

Slow-Releasing: FYM is a slow-release fertilizer, meaning it gradually releases nutrients over time, reducing the risk of nutrient loss and pollution.

Physical Properties: FYM's physical properties like moisture content, bulk density, and angle of repose are important for its application and handling.

Microorganisms: FYM contains various microorganisms, including bacteria like Pseudomonas, Bacillus, Azotobacter, Flavobacterium, and Corynebacterium, as well as fungi like Rhizopus, Aspergillus, Penicillium, Trichoderma, and Mucor.

Compost

The bulky organic manure obtained by decomposition of waste organic residues through action of microbes.

❖ Composting:

It is largely a biological process in which aerobic and anaerobic microorganism decompose the organic matter & lower the C:N ratio of the refuse.

Methods of composting:

1. **Indore method or heap method**
2. **Banglore method or pit method**
3. **NADEP method**

1. Indore method / heap method (1931):

Developed by **Albert Howard and Y. D. Wad** at Indore.

- Dimensions: 3 m length x 1.8 to 2.4 m breadth x 1 m height.
- Process : **Aerobic**
- Substrate: Stubble of sugarcane, soybean trash, wheat trash, banana leaves, weeds, material should be chopped.
- Composition :

N : 0.08%,

P_2O_5 : 0-3%,

K_2O : 1.5%

❖ Preparation steps -

- 15 cm layer of mixed substrate is spread on each layer.
- Two inches of dung & urine spread and sprinkle water.
- Top is covered with mud.
- Pit filled with the same sequence up to height of **two or two and half feet above the ground level.**
- Watering at evening and morning.
- **Three times turning.**
- First turning:10 to 14 days old.
- 2nd turning: After 14 days of 1st one.
- Third turning: Two months old.
- Dark material shifted on ground.
- Keep in rectangular heap for month.
- Ready to apply.

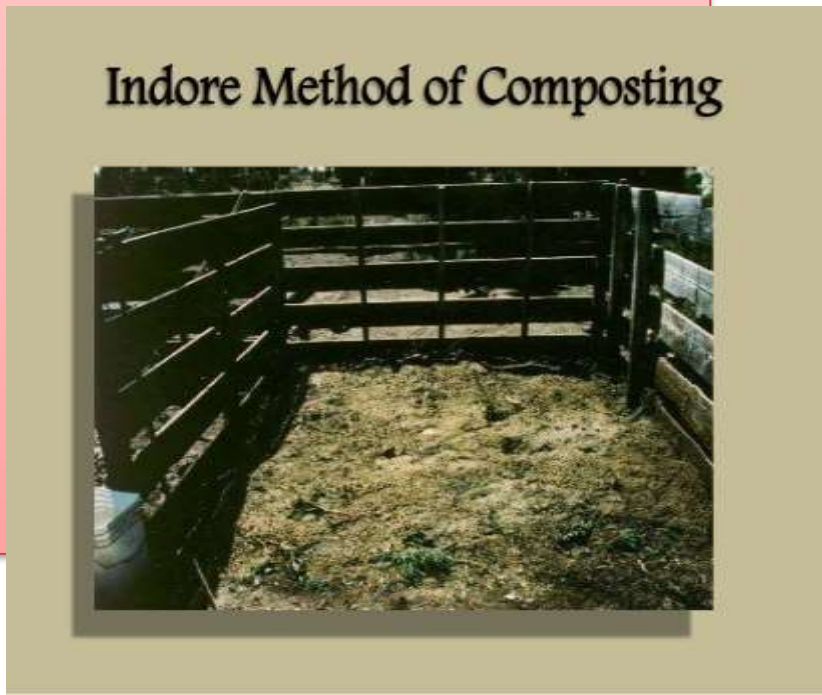


Fig. 2. Indian compost-making in the rainy season when the pile had to be formed on top of the ground rather than in a pit

First and Second Compost Turning - from Agricultural Wastes 1931

2. Banglore method/ Pit method

(Hot fermentation method):

Developed by **Dr. C. N. Acharya** in 1939 At Indian Institute of Science, Bangalore

N :1.40%, P_2O_5 : 1.0%, K_2O : 1.4%

❖ Process: **Complete Anaerobic method**

❖**Preparation steps:**

- Preparation of the pit (915 cm length x 91 cm height x 183 cm breadth).
- Mixing of refuse and cattle shed up to 9 to 10 inches.
- Thin layer of dung, earth, night soil and ash.
- Sprinkle water uniformly.
- Fill the pit about 1 foot above the ground level.
- Heap made in dome shape.
- Plastering it with mud to protect from rain water.
- Ready in six months.

Bangalore Method of Composting

3. NADEP method:

Developed by **Shri. Narayan Deorao Pandhari Pande. (Maharashtra, Pusad)**

❖ **Composition**: **N : 0.5-1.5%**
P_2O_5 : 0.5-0.9%
K_2O : 1.2- 1.4%

❖ **Steps:**

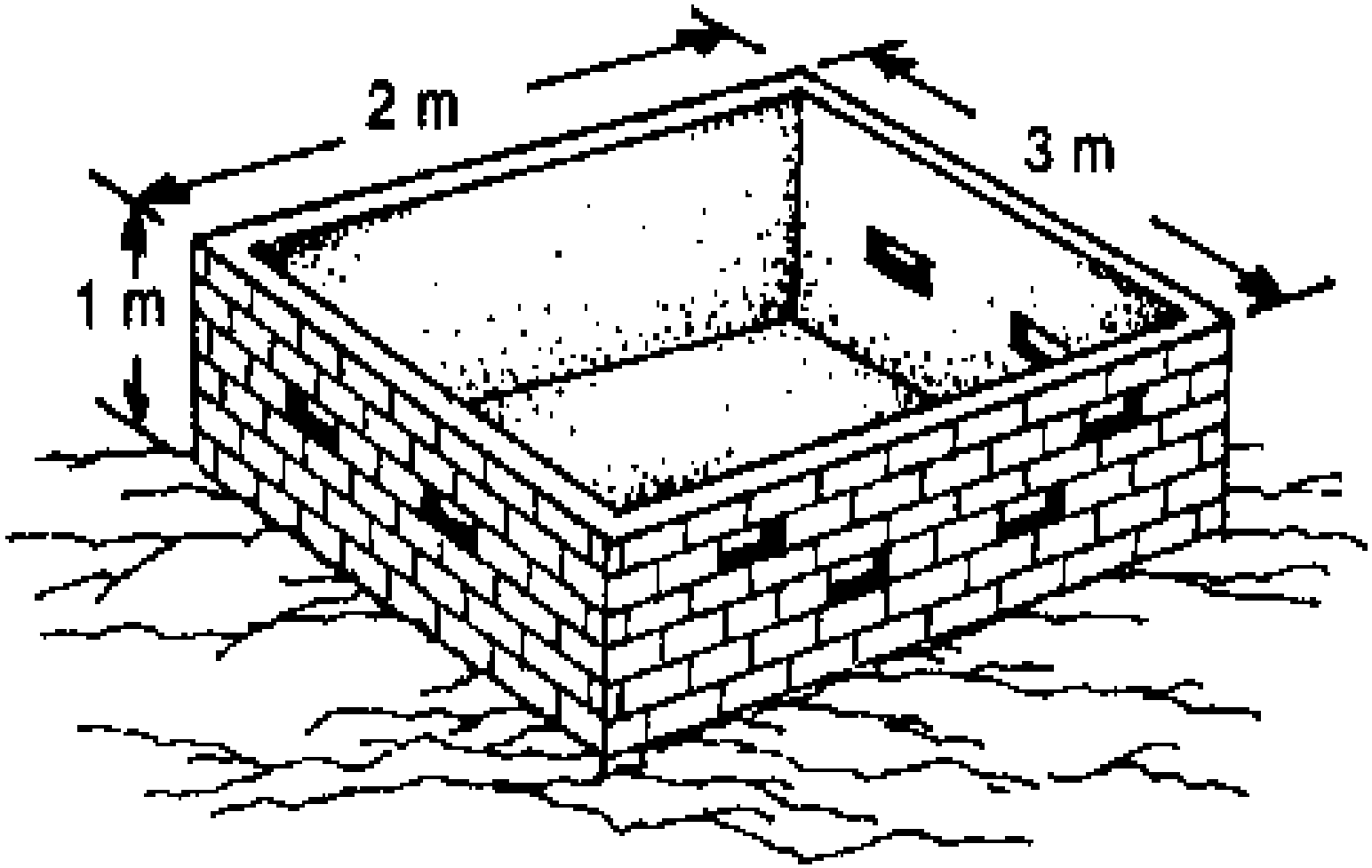
1. Selection of site.
2. Construction of tank (10 × 6 × 3 ft. with thicker wall).
3. Lining with the mud (bricks).
4. Holes of seven inches on four sides.
5. Plastering inner wall of the NADEP.

❖Material required for NADEP:

- Farm residues like weed, grass, leaves, sugarcane cane trash (1400-1500 kg).
- Cattle dung 90-100 kg.
- Dry sieved soil 1750 kg.
- Water 500-2000 lit (According to season)

Method of filling tank:

- Prepare slurry of cow dung.
- Sprinkle water and slurry on walls.
- **First layer:-** plant residue.
- **Second layer:-**cattle dung/gobar gas slurry - 4 to 5 kg in 125 to 150 litre water.
- **Third layer:-**dry sieved soil (50-60 kg).
- Fill tank till **one and half feet above brick level**.
- Made out dome shape at top.
- Cover and seal by 3 inch layers of soil.
- Plastered with dung and soil.
- Within 3 to 4 months it is ready, maintain 15 to 20% moisture.


2 m
3 m
1 m

Decomposition process and nutrient losses during handling and storage.

Decomposition

- **Definition:**

➢ Breakdown of dead plant and animal material and release of inorganic nutrients.

➢ Decomposition is a biological breakdown and biochemical transformation of complex organic molecules of dead material into simpler organic and inorganic molecules (Juma, 1998).

➢ Decomposition is important in releasing nutrients tied up in dead organic matter and return it back to the soil.

Decomposition of organic compounds

1. Sugar, starches & simple Protiens	**Rapid Decomposition**  **Very slow decomposition**
2. Crude protein	
3. Hemicellulose	
4. Cellulose	
5. Fat, Waxes etc.	
6. Lignins	

❖Losses during handling and storage of FYM:

A) Losses during handling:

1. Loss of liquid portion of urine
2. Loss of solid portion or dung

B) Losses during the storage:

1. By leaching
2. By volatilization

Properties of Compost

- Compost, a valuable **soil amendment**, is characterized by its **high organic matter content, improved soil structure, beneficial microbial activity and nutrient-rich composition**, all contributing to healthier plant growth and reduced environmental impact.

- **Physical Characteristics:**

Texture: Finished compost has a crumbly, dark and earthy texture, with small pieces of partially decomposed materials.

Colour: Mature compost is generally dark brown or black, indicating the decomposition of organic matter.

Properties of Compost

➢Physical Characteristics:

Odor: Good quality compost has a pleasant, earthy smell, rather than a foul or ammonia-like odor.

Moisture Content: Compost should be moist but not soggy (very wet and soft and so unpleasant), similar to a wrung-out sponge.

Bulk Density: Compost has a lower bulk density compared to soil, meaning it is lighter and more porous.

Porosity: Compost has high porosity, which allows for good air and water movement through the soil.

Chemical Characteristics:

Nutrient Content: Compost is rich in essential plant nutrients, including Nitrogen (N), Phosphorus (P) and Potassium (K) as well as micronutrients.

Organic Matter: Compost significantly increases the organic matter content of soil, improving its structure and water-holding capacity.

pH: Compost typically has a slightly acidic to neutral pH, which can help to improve nutrient availability.

Carbon-to-Nitrogen (C:N) Ratio: The C:N ratio in compost is important for microbial activity and nutrient availability.

Heavy Metals: Compost should be free from excessive amounts of heavy metals, which can be harmful to plants and the environment.

Biological Characteristics:

Microbial Activity: Compost is teeming with beneficial microorganisms, including bacteria and fungi, that play a crucial role in nutrient cycling and disease suppression.

Pathogen Suppression: Mature compost can help to suppress plant diseases and pests by promoting beneficial microbial populations.

Root Growth: Compost improves soil structure, creating a better environment for root growth and nutrient uptake.

Vermicomposting: Composting with worms, or vermicomposting, can further enhance the quality of compost by speeding up the decomposition process and creating a nutrient-rich "worm castings".

Vermicompost

- **Vermicomposting** is a natural process where earthworms break down organic waste, like food scraps and yard trimmings, into a nutrient-rich soil amendment called vermicompost, which is a valuable fertilizer and soil conditioner.
- **Vermicomposting**, also known as **worm composting**, utilizes earthworms to decompose organic matter, transforming it into a valuable soil amendment.
- **Process:** Earthworms consume organic waste and their digestive process produces "**worm castings**" or **vermicast (Black gold)**, which is a dark, nutrient-rich substance.

- **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.

- **Vermiculture** :

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

- **Vermitechnology**:

  Vermitechnology is the combination of vermiculture and vermicomposting.

Benefits of Vermicomposting -

- **Soil Improvement:** Vermicompost enhances soil structure, aeration and water-holding capacity.
- **Nutrient Source:** It's a rich source of essential plant nutrients, promoting healthy plant growth.
- **Waste Reduction:** Vermicomposting helps reduce food waste and other organic materials that would otherwise end up in landfills.
- **Natural Process:** It's a natural, eco-friendly method of composting that utilizes the natural abilities of earthworms.

Red earthworm is preferred because of its high multiplication rate and thereby converts the organic matter into vermicompost within 45-50 days.

Since it is a surface feeder it converts organic materials into vermicompost from top.

Worms:

- While various earthworm species can be used, red wigglers (*Eisenia fetida*) are particularly well-suited for vermicomposting because of their ability to thrive in bins and consume a wide range of organic materials.
- *Eudrilus eugeniae*

Species of earthworms

Eisenia foetida (Red earthworm), *Eudrilus eugeniae* (night crawler), *Perionyx excavatus* etc.

Important characteristics of red earthworm (Eisenia foetida)

- **Characters** ***Eisenia foetida***
- Body length 3-10cm
- Body weight 0.4-0.6g
- Maturity 50-55days
- Conversion rate 2.0 q/1500worms/2 months
- Cocoon production 1 in every 3 days
- Incubation of co coon 20-23days

Vermicomposting materials

- Decomposable organic wastes such as animal excreta, kitchen waste, farm residues and forest litter are commonly used as composting materials.
- In general, animal dung mostly cow dung and dried chopped crop residues are the key raw materials.
- Mixture of leguminous and non-leguminous crop residues enriches the quality of vermicompost.

Favourable conditions of earthworms in the composting material

- **pH**: Range between 6.5 and 7.5.
- **Moisture**: 60-70% of the moisture below and above range mortality of worms taking place.
- **Aeration**: 50% aeration from the total pore space
- **Temperature**: Range between 18 ^{0}C to 35 ^{0}C

Pit

Shed

Types of vermicomposting

Amount of production and composting structures.

- Small-scale vermicomposting:

personal requirement (5-10 tonnes of vermicompost annually).

- large-scale vermicomposting:

commercial scale (50 – 100 tonnes annually)

Methods of vermicomposting

- *Bed method :*

Composting is done on the pucca / kachcha floor by making bed (6x2x2 feet size) of organic mixture. This method is easy to maintain and to practice

- *Pit method:*

Composting is done in the cemented pits of size 5x5x3 feet. The unit is covered with thatch grass or any other locally available materials. This method is not preferred due to poor aeration, water logging at bottom, and more cost of production.

Bed Vermicomposting

Pit vermicomposting

Steps followed for vermicompost preparation

- Vermicomposting unit should be in a cool, moist and shady site .
- Cow dung and chopped dried leafy materials are mixed in the proportion of 3: 1
- kept for partial decomposition for 15 – 20 days.
- A layer of 15-20cm of chopped dried leaves/grasses should be kept as bedding material at the bottom of the bed.
- Beds of partially decomposed material of size 6x2x2 feet should be made
- Each bed should contain 1.5-2.0q of raw material and the number of beds can be increased as per raw material availability and requirement.

- Red earthworm (1500-2000) should be released on the upper layer of bed.
- Water should be sprinkled with can immediately after the release of worms.
- Beds should be kept moist by sprinkling of water (daily) and b y covering with gunny bags/polythene
- Bed should be turned once after 30 days for maintaining aeration and for proper decomposition.
- Compost gets ready in 45-50 days.
- The finished product is ¾ of the raw materials used.

Harvesting

- When raw material is completely decomposed it appears black and granular.
- Watering should be stopped as compost gets ready.
- The compost should be kept over a heap of partially decomposed cow dung so that earthworms could migrate to cow dung from compost.
- After two days compost can be separated and sieved for use.

Preventive measures

- The floor of the unit should be compact to prevent earthworms' migration into the soil.
- 15-20 days old cow dung should be used to avoid excess heat.
- The organic wastes should be free from plastics, chemicals, pesticides and metals etc.
- Aeration should be maintained for proper growth and multiplication of earthworms.
- Optimum moisture level (30-40 %) should be maintained 18-25℃ temperature should be maintained for proper decomposition.

Trouble shooting

- Death of worms
- They are getting enough food----- food should be burried into the bedding
- Food may be too dry---- moisture
- Food may be too wet--- bedding
- Worms may be too hot--- put bin in shade
- Bad smells
- No enough air circulation
- Dry bedding under and over the worms
- Turning of the food

Nutrient content of vermicompost

- The level of nutrients in compost depends upon the source of the raw material and the species of earthworm. A fine worm cast is rich in N P K besides other nutrients.
- Nutrients in vermicompost are in readily available form and are released within a month of application.

Nutrient Analysis of Vermicompost

Parameters	*Content*
pH	6.8
OC%	11.88
OM%	20.46
C/N ration	11.64
Total Nitrogen (%)	1.02
Available N (%)	0.50
Available P (%)	0.30
Available K (%)	0.24
Ca (%)	0.17
Mg (%)	0.06

Nutrients comparison

nutrient element	vermicompost	garden compost
organic carbon	9.8-13.4	12.2
nitrogen	0.51-1.61	0.8
phosphorus	0.19-1.02	0.35
potassium	0.15-0.73	0.48
calcium	1.18-7.61	2.27
magnesium	0.093-0.568	0.57
sodium	0.058-0.158	0.01
zinc	0.0042-0.110	0.0012
copper	0.0026-0.0048	0.0017
iron	0.2050-1.3313	1.169
mangnese	0.0105-0.2038	0.0414

Advantages of vermicompost

- Vermicompost is rich in all essential plant nutrients.
- Provides excellent effect on overall plant growth, encourages the growth of new shoots / leaves and improves the quality and shelf life of the produce.
- Vermicompost is free flowing, easy to apply, handle and store and does not have bad odour.
- It improves soil structure, texture, aeration, and water holding capacity and prevents soil erosion.
- Vermicompost is rich in beneficial micro flora such as a fixers, P- solubilizers, cellulose decomposing micro-flora etc in addition to improve soil environment.
- Vermicompost contains earthworm cocoons and increases the population and activity of earthworm in the soil.
- It neutralizes the soil protection.
- It prevents nutrient losses and increases the use efficiency of chemical fertilizers.
- Vermicompost is free from pathogens, toxic elements, weed seeds etc.
- Vermicompost minimizes the incidence of pest and diseases.
- It enhances the decomposition of organic matter in soil.
- It contains valuable vitamins, enzymes and hormones like auxins, gibberellins

Natural enemies and their control

- The important natural enemies of vermiculture are **ants, termites, centipedes, rats, pigs, birds** etc.
- Preventive measures include treating of the site with **4% neem based insecticide before filling the heap**

Application rate

- It can be applied in any crop at any stage, but it would be more beneficial if mixed in soil after broadcasting.
- 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.**

- **Vermiwash** is a liquid fertilizer and plant tonic collected from vermicompost, rich in nutrients, hormones, and beneficial microbes, used for foliar sprays and soil application to promote plant growth and health.

- **What it is:** Vermiwash is the liquid that is collected after water passes through compost made by earthworms (vermicompost).

Green manuring

- **Practice of incorporating undecomposed green plant tissues into the soil for the purpose of improving physical structure as well as fertility of the soil.**
- In agriculture, a green manure is a **type of cover crop** grown primarily to add nutrients and organic matter to the soil.
- Typically, a green manure crop is grown for a specific period and then ploughed under and incorporated into the soil.
- Green manures usually perform multiple functions that include soil improvement and soil protection.

GREEN MANURING

It is a practice of ploughing in the green plants tissue grown in the field or adding green plants with tender twigs or leaves from outside and incorporating them into the soil for improving the physical structure as well as fertility of the soil.

Turning off these crops directly in the field by ploughing the field

- Leguminous green manures such as clover and vetch contain nitrogen-fixing symbiotic bacteria in root nodules that fix atmospheric nitrogen in a form that plants can use.
- Green manures increase the percentage of organic matter (biomass) in the soil, thereby improving water retention, aeration and other soil characteristics.
- The root systems of some varieties of green manure grow deep in the soil and bring up nutrient resources unavailable to shallower-rooted crops.

- Common cover crop functions of weed suppression and prevention of soil erosion and compaction are often also taken into account when selecting and using green manures.
- Some green manure crops, when allowed to flower, provide forage (nector and pollen) for pollinating insects.
- Historically, the practice of green manuring can be traced back to the **fallow cycle of crop rotation**, which was used to **allow soils to recover**.

Types of Green Manuring:

Broadly two types of green manuring can be differentiated.

i) **Green manuring Insitu**

ii) **Green leaf manuring**

i) Green manuring Insitu:

- In this system green manure crops are **grown and buried in the same field, either as a pure crop or as intercrop with the main crop.**
- The most common green manure crops grown under this system are **Sunhemp, Dhaincha and Guar**.

Green Manure IN SITU

- Green manuring in situ is growing of plants usually belonging to leguminous family and incorporating them into the soil after sufficient growth that is at the time of flowering or before flowering.
- The plants that are grown for green manure known as green manure crops.
- The most important green manure crops are sun hemp, Dhaincha, *Pillipesara,* Clusterbeans and *Sesbania rostrata.*

Green Manure Crops

Crotalaria juncea

Sesbania rostrata

Cow pea

Cluster bean

Sesbania aculeata

Nutrient content of green manure crops

Plant	Scientific name	Nutrient content (%) on air dry basis		
		N	P2O5	K
Sunhemp	*Crotalaria juncea*	2.30	0.50	1.80
Dhaincha	*Sesbania aculeata*	3.50	0.60	1.20
Sesbania	*Sesbania speciosa*	2.71	0.53	2.21

Biomass production and N accumulation of green manure crops

Crop	Age (Days)	Dry matter (t/ha)	N accumulated
Sesbania aculeata	60	23.2	133
Sunnhemp	60	30.6	134
Cow pea	60	23.2	74
Pillipesara	60	25.0	102
Cluster bean	50	3.2	91
Sesbania rostrata	50	5.0	96

Types of Green Manuring:

ii) Green leaf manuring:

- Green leaf manuring refers to **turning into the soil green leaves and tender green twigs collected from shrubs and trees grown on bunds, waste lands and nearby forest areas**.
- The common shrubs and trees used are **Glyricidia, Sesbania (wild dhaincha), Karanj** etc

GREEN LEAF MANURE

- Application of green leaves and twigs of trees, shrubs and herbs collected from elsewhere is known as green leaf manuring.
- Forest tree leaves are the main sources for green leaf manure.
- Plants growing in wastelands, field bunds etc., are another source of green leaf manure.
- The important plant species useful for green leaf manure are neem, mahua, wild indigo, Glyricidia, Karanji *(Pongamia glabra)* calotropis, avise*(Sesbania grandiflora),* subabul and other shrubs.

Nutrient content of green leaf manure

Plant	Scientific name	Nutrient content (%) on air dry basis		
		N	P2O5	K
Gliricidia	*Gliricidia sepium*	2.76	0.28	4.60
Pongania	*Pongamia glabra*	3.31	0.44	2.39
Neem	*Azadirachta indica*	2.83	0.28	0.35
Gulmohur	*Delonix regia*	2.76	0.46	0.50
Peltophorum	*Peltophorum ferrugenum*	2.63	0.37	0.50
Weeds				
Parthenium	*Parthenium hysterophorus*	2.68	0.68	1.45
Water hyacinth	*Eichhornia crassipes*	3.01	0.90	0.15
Trianthema	*Trianthema portulacastrum*	2.64	0.43	1.30
Ipomoea	*Ipomoea*	2.01	0.33	0.40
Calotrophis	*Calotropis gigantea*	2.06	0.54	0.31
Cassia	*Cassia fistula*	1.60	0.24	1.20

Green Leaf Manure Crops


Cassia fistula


Leucaena leucocephala


Sesbania grandiflora


Calotropis gigantea


Gliricida sepium


Pongamia globra


Delonix regia


Peltophorum ferrrugenum


Azadiracta indica

Advantages of Green Manuring:

1. It adds **organic matter** in to the soil. This stimulates the activity of soil microorganisms.
2. The green manure crops return to the upper top soil, plant nutrients taken up by the crop from deeper layers.
3. It improves the structure of the soil.
4. It facilitates the penetration of rain water thus decreasing run off and erosion.
5. The green manure crops hold plant nutrients that would otherwise be lost by leaching.

IMPORTANCE OF GREEN MANURING

- Green manuring contributes 40 to 80 kg nitrogen per ha.
- Besides supplying nitrogen, it prevents loss of nitrogen by leaching and erosion.
- Vigorous root system of green manure keeps the soil particles bound together.
- Green manure reclaims saline and alkaline soils.
- Some green leaf manure crops serve as fodder.
- The growth of green manure crops is very fast.

Benefits of green manure -

Soil structure: Green manure improves soil structure and moisture retention.

Soil fertility: Green manure increases the availability of nutrients, such as nitrogen, in the soil.

Weed suppression: Green manure acts as ground cover, preventing weeds from growing.

Erosion prevention: Green manure's roots system prevents erosion and the washout of nutrients.

Organic matter: Green manure increases the amount of organic matter in the soil.

Microbial population: Green manure increases the population of microbes in the soil.

Advantages of Green Manuring:

6. When leguminous plants, like sannhemp and dhaincha are used as green manure crops, they add nitrogen to the soil for the succeeding crop.
7. It increases the availability of certain plant nutrients like phosphorus, calcium, potassium, magnesium and iron.
8. Green manuring helps in reclamation of alkaline soils.
9. Root-knot nematodes can be controlled by green manuring.

Disadvantages of Green Manuring:

1. Under rainfed conditions, it is feared that proper decomposition of the green manure crop and satisfactory germination of the succeeding crop may not take place, if sufficient rainfall is not received after burying the green manure crop. This particularly applies to the wheat regions of India.
2. Since green manuring for wheat means loss of *Kharif* crop, the practice of green manuring may not be always economical. This applies to regions where irrigation facilities are available for raising *Kharif* crop along with easy availability of fertilizers.

Disadvantages of Green Manuring:

3. In case the main advantage of green manuring is to be derived from addition of nitrogen, the cost of growing green manure crops may be more than the cost of commercial nitrogenous fertilizers.
4. An increase of diseases, insects and nematodes is possible.
5. A risk is involved in obtaining a satisfactory stand and growth of the green manure crops, if sufficient rainfall is not available.

Green Manure Crops

Leguminous	Non-leguminous
Sannhemp	Bhang
Dhaincha	Jowar
Mung	Maize
Cowpea	Sunflower
Guar	
Senji	
Khesari	

Criteria for selection of green manures include :-

- plants are fleshy and soft
- fast growing;
- fast to decompose;
- leguminous;
- don't attract pests and diseases;
- don't compete with crops;
- provide nutrients needed in the soil

Oil cakes

Oil cakes:

- Oil cake is the residue left after the oil is extracted from oil bearing seeds.
- It contains varying quantities of oil depending upon the process of manufacture employed in treating the oil seed as shown below:
- **Process of manufacture Oil (per cent)**

Country ghani 10-15, Hydraulic press 8-10, Expeller 5-8, Solvent 1-2

- **Oil cakes are of two types:**

1) Edible Oil cake **2) Non Edible Oil cake**

- Edible oil cakes are valued more as cattle feed and seldom used as manure, except when it becomes mouldy or rancid and unfit for feeding to cattle.
- Non edible oil cakes are used as manure.

Oil-cakes	Nutrient content (%)		
	N	P_2O_5	K_2O
Non edible oil-cakes			
Castor cake	4.3	**1.8**	1.3
Cotton seed cake (undecorticated)	3.9	**1.8**	**1.6**
Karanj cake	3.9	0.9	1.2
Mahua cake	2.5	0.8	1.2
Safflower cake (undecorticated)	**4.9**	1.4	1.2
Edible oil-cakes			
Coconut cake	3.0	1.9	1.8
Cotton seed cake (decorticated)	6.4	**2.9**	1.6
Groundnut cake	**7.3**	1.5	1.3
Linseed cake	4.9	1.4	1.3
Niger cake	4.7	1.8	1.3
Rape seed cake	5.2	1.8	1.2
Safflower cake (decorticated)	7.9	2.2	**1.9**
Sesamum cake	6.2	2.0	1.2

Characteristics:

1. Quick acting organic manures as C:N ratio is usually narrow (5-15).
2. Oil prevents rapid conversion of N.
3. Nearly 50-80% of its N is made available in 2-3 months and rate of availability varies with the type of cake and nature of soil.
4. **Castor cake** contain **Ricin,** **Mahuva cake** contains **Saponin** and **Neem** cake contains **Nimbidin** which are responsible for slow nitrification of their N due to effects of alkaloids on soil microorganisms.
5. Castor cake has also good vermicidal effect against white ants.
6. Groundnut cake has the highest nitrification rate.
7. Mahua cake is very poor in N and takes a long time to nitrify. When used as manure it has got to be applied to the soil two to three months before sowing/planting of crop

Precautions in using oil cakes:

1. It should be powdered before use.
2. Apply during last ploughing in short duration crop.
3. It is best used as a topdressing after the plants have established themselves.
4. Use only when there is sufficient moisture in the soil.
5. If Mahua cake is to be used, apply before 2-3 months before planting or decompose in a pit and then apply or treat with ammonium sulphate.