- 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**.
**Manure**
1. Contains O.M. and hence improves soil physical properties
2. Improves soil *fertility* as well as *productivity*
3. Contains all plant nutrients but *small* in concentration
4. Required in large quantity bulky and costly
5. Nutrients are *slowly* available upon decomposition
6. Long lasting effect on soil and crop
7. No *salt* effect
8. No adverse effect

**Fertilizer**
1. *Do not contain* O.M. and can not improve soil physical properties
2. Improves soil *fertility*
3. Contains one or more plant nutrients but in *higher* concentration
4. Required in less quantity concentrated and cheaper
5. Nutrients are *readily* available.
6. Very *less residual effect*
7. *Salt effect* is high
8. Adverse effects are observed when not applied in *time and in proper proportion.*
Bulky Organic Manures:

Bulky organic manures include farm yard manure (FYM) or farm manure, farm compost, town compost, night soil, sludge, green manures and other bulky sources of organic matter.

All these manures are bulky in nature and supply

(i) plant nutrients in small quantities and
(ii) organic matter in large quantities.

Of the various bulky organic manures, farm yard manure, compost and green manure are by far most important and most widely used.
Effect of bulky organic manures on soil:

- Direct effect on **plant growth**
- Increase organic matter content and improve physical properties of soil.
- Increase humus content of soil and consequently WHC of sandy soil is increased and the drainage of clayey soil is improved.
- Provide **food for soil microorganisms**.
- This increases **activity of microbes** which in turn helps in converting unavailable plant nutrients into **available forms**.
Organic Manures

Bulky organic Manures
- Mainly derived from animal, plant and other organic wastes and green plant tissues
  - Well decomposed Animal plant and other organic residues
    - Farm yard manure (FYM), composts from farm and town refuses etc.
  - Green plant tissues (unde decomposed)
    - Green manures (e.g. dhaincha, glyricidia, other leguminous crops, etc.)

Concentrated organic Manures
- Oil cakes meal
- Meat meal
- Others etc.
  - Non-edible to cattle (e.g. mahua, neem oil cakes, etc.)
  - Edible to cattle (e.g. mustard oil cake, groundnut, oil cake etc.)
Farm Yard Manure (FYM):

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

FYM contains 0.5% N, 0.2% P₂O₅ and 0.5% K₂O.

FYM is one of the most important agricultural by products. nearly 50 per cent of the cattle dung production in India today is utilized as fuel and is thus lost to agriculture.

Average percentage of N, P₂O₅ and K₂O in the fresh excreta of farm animals:

<table>
<thead>
<tr>
<th>Excreta of</th>
<th>N (%)</th>
<th>P₂O₅ (%)</th>
<th>K₂O (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows and bullocks</td>
<td>Dung</td>
<td>0.40</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>Urine</td>
<td>1.00</td>
<td>Traces</td>
</tr>
<tr>
<td>Sheep and goat</td>
<td>Dung</td>
<td>0.75</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Urine</td>
<td>1.35</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>Dung</td>
<td>0.26</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Urine</td>
<td>0.62</td>
<td>Traces</td>
</tr>
<tr>
<td>Poultry</td>
<td>-</td>
<td>1.46</td>
<td>1.17</td>
</tr>
</tbody>
</table>

Poultry manure is the richest of all
Urine of all animals contains more percentage of N and K₂O compared to the dung portion.
Factors Affecting Nutritional Build up of FYM:

The following factors affect the composition of FYM:

1. **Age of animal:** Growing animals and cows producing milk retain in their system nitrogen and phosphorus required for productive purposes like making growth and producing milk and the excreta do not contain all the ingredients of plant food given in the feed. Old animals on the downgrade waste their body tissues and excrete more than what they do ingest.

2. **Feed:** When the feed is rich in plant food ingredients, the excreta produced is correspondingly enriched.

3. **Nature of Litter Used:** Cereal straw and leguminous plant refuse used as litter enriched the manure with nitrogen.

4. **Ageing of Manure:** The manure gets richer and less bulky with ageing.

5. **Manner of Making and Storage:** In making and storage losses are in various ways. (see ‘Losses in FYM).
Losses during handling and storage of FYM:

(I) Losses during handling:

- FYM consists of two original components the solid or dung and liquid or urine.
- Both the components contain N, P$_2$O$_5$ and K$_2$O the distribution of these nutrients in the dung and urine is shown in figure below:
- Approximately half of N and K$_2$O is in the dung and the other half in urine.
- By contrast, nearly all of the P$_2$O$_5$ (96%) is in the solid portion.
- To conserve N, P$_2$O$_5$ and K$_2$O, it is most essential that both the parts of cattle manure are properly handled and stored.
i) Loss of liquid portion or urine

- Under Indian conditions the floor of the cattle shed is usually un-cemented or Kachha.
- As such the urine passed by animals during night gets soaked into the Kachha floor.
- When the animals, particularly bullocks, are kept in the fields during the summer season, urine gets soaked into soil.
- But during remaining period cattle are kept in a covered shed and therefore the Kachha floor soaks the urine every day.
- Large quantities of nitrogen are thus lost through the formation of gaseous NH₃. The following reactions take place:

\[
\begin{align*}
\text{Urea in urine} & \quad \rightarrow \quad (\text{NH}_4)_2\text{CO}_3 \\
\text{Ammonium carbonate} & \\
(\text{NH}_4)_2\text{CO}_3 + 2\text{H}_2\text{O} & \quad \rightarrow \quad 2\text{NH}_4\text{OH} + \text{H}_2\text{CO}_3 \\
\text{NH}_4\text{OH} & \quad \rightarrow \quad \text{NH}_3 + \text{H}_2\text{O} \\
\text{Gaseous Ammonia} &
\end{align*}
\]
ii) Loss of solid portion or dung
   - It is often said that \(\frac{2}{3}\) of the manure is either utilized for making cakes or is lost during grazing, the remaining manure is applied to the soil after collecting in heaps.

   - Firstly, the most serious loss of dung is through cakes for burning or for use as fuel
   - Secondly, when milch animals go out for grazing, no efforts are made to collect the dung dropped by them, nor is this practicable, unless all milch animals are allowed to graze only in enclosed small size pastures.
(II) Loss during storage:

- Mostly, cattle dung and waste from fodder are collected daily in the morning by the cultivators and put in manure heaps in an open space outside the village.
- The manure remains exposed to the sun and rain. During such type of storage, nutrients are lost in the following ways:

i) By leaching:

- Losses by leaching will vary with the intensity of rainfall and the slope of land on which manure is heaped.
- About half of portion of N and P$_2$O$_5$ of FYM and nearly 90% of K are water soluble.
- These water soluble nutrients are liable to get washed off by rain water.
ii) By Volatilization:
- During storage considerable amount of NH₃ is produced in the manure heap from the decomposition of urea and other nitrogenous compounds of the urine and the much slower decomposition of the nitrogenous organic compounds of the dung.
- As the rotting proceeds, more and more quantity of ammonia is formed.
- This NH₃ combines with carbonic acid to form ammonium carbonate and bicarbonate.
- These ammonium compounds are unstable and gaseous NH₃ may be liberated as indicated below:

1. Urea and other nitrogenous compounds in urine and dung $\xrightarrow{\text{microbial decomposition}}$ NH₃
2. $2\text{NH}_3 + \text{H}_2\text{CO}_3 \rightarrow (\text{NH}_4)_2 \text{CO}_3$
3. $(\text{NH}_4)_2 \text{CO}_3 + 2\text{H}_2\text{O} \rightarrow 2\text{NH}_4 \text{OH} + \text{H}_2\text{CO}_3$
4. $\text{NH}_4\text{OH} \rightarrow \text{NH}_3 + \text{H}_2\text{O}$

Loss of NH₃ increases with
- the increase in the concentration of ammonium carbonate
- increase in the temperature and air movement
Improved Methods of Handling FYM:

It is practically impossible to check completely the losses of plant nutrients and organic matter during handing and storage of FYM. However, improved methods could be adopted to reduce such losses considerably.

Among these methods are described here under:

- Trench method of preparing FYM
- Use of gobar gas-compost plant
- Proper field management of FYM
- Use of chemical preservatives
ii) Use of gobar gas compost plant: 
Methane gas is generated due to anaerobic fermentation of the most common organic materials such as cattle dung, grass, vegetable waste and human excreta. Gobar gas and manure both are useful on farms as well as in homes. A few advantages of this method are give below:

1. The methane gas generated can be used for heating, lighting and motive power.
2. The methane gas can be used for running oil engines and generators
3. The manure which comes out from the plant after decomposition is quite rich in nutrients. $N - 1.5\%, \text{ } P_2O_5 - 0.5\%, \text{ } K_2O - 2.0\%$
4. Gobar gas manure is extremely cheap and is made by locally available materials.
5.
Superiority of gobar gas compost plant over traditional method:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars</th>
<th>Traditional method</th>
<th>Gobar gas plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Loss of</td>
<td>500 Kg</td>
<td>270 Kg</td>
</tr>
<tr>
<td>2.</td>
<td>Loss of N</td>
<td>1.25 Kg</td>
<td>Nil</td>
</tr>
<tr>
<td>3.</td>
<td>Final manure</td>
<td>500 Kg</td>
<td>730 Kg</td>
</tr>
<tr>
<td>4.</td>
<td>% N</td>
<td>0.5%</td>
<td>1.5%</td>
</tr>
<tr>
<td>5.</td>
<td>Additional advantage</td>
<td>-</td>
<td>2000 C.ft. gas for cooking</td>
</tr>
</tbody>
</table>
iii) Proper field management of FYM:

- Under field conditions, most of the cultivators unload FYM in **small piles** in the field before spreading.
- The manure is **left in piles for a month** or more before it is spread.
- Plant nutrients are **lost through heating and drying**.
- To derive maximum benefit from FYM, it is most essential that it should not be **kept in small piles in the field** before spreading, but it should be **spread evenly and mixed with the soil immediately**.
iv) Use of Chemical Preservatives:

- Chemical preservatives are added to the FYM to decrease N losses.
- To be most effective, the preservatives are applied in the cattle yard to permit direct contact with the liquid portion of excreta or urine.
- This has to be done because the loss of N from urine starts immediately.
- The commonly used chemical preservatives are:
  1) Gypsum and 2) Super phosphate.
- The value of gypsum in preserving the N of manure has been known and it has been used for many years in foreign countries.
- The reaction of gypsum with ammonium carbonate (intermediate product from decomposition of urea present in urine) is:

\[
(NH_4)_2CO_3 + CaSO_4 \rightarrow CaCO_3 + (NH_4)_2SO_4
\]
As long as the manure is moist, no loss of NH₃ will occur, but if the manure becomes dry, the chemical reaction is reversed and the loss of NH₃ may occur.

As such, under Indian conditions, use of gypsum to decrease N losses, does not offer a practical solution.

Superphosphate has been extensively used as a manure preservative:

\[
2\text{CaSO}_4 + \text{Ca(H}_2\text{PO}_4)\text{_2} + 2\ (\text{NH}_4)\text{_2 CO}_3 \rightarrow \text{Ca}_3(\text{PO}_4)\text{_2} + \\
2\ (\text{NH}_4)\text{_2 SO}_4 + 2\text{H}_2\text{O} + 2\text{CO}_2
\]

In this reaction, tricalcium phosphate is formed which does not react with ammonium sulphate, when manure becomes dry. As such, there is no loss of NH₃.
Since FYM becomes dry due to high temperature under Indian conditions, the use of superphosphate will be safely recommended as a preservative to decrease N losses.

Use of superphosphate as a chemical preservative will have three advantages

- It will *reduce loss* of N as ammonium from FYM.
- It will *increase the percentage of P* in manure thus making it a balanced one.
- Since, tricalcium phosphate produced with the application of superphosphate to the FYM is in inorganic form, which is *readily available to the plants*, it will *increase the efficiency of phosphorus*.

It is recommended that *one or two pounds of SSP* should be applied per day per animal in the cattle shed where animal pass urine.
Supply of plant nutrients through FYM:

On an average, FYM applied to various crops by the cultivators contains the following nutrients:

Based on this analysis, an average dressing of 10 tones of FYM supplies about

50 Kg N
20 Kg P₂O₅
50 Kg K₂O

% N : 0.5    % P₂O₅ : 0.2    % K₂O : 0.5
➢ All of these quantities are not available to crops in the year of application, particularly N which is very slow acting.
➢ Only 1/3 of the N is likely to be useful to crops in the first year.
➢ About 2/3 of the phosphate may be effective and most of the potash will be available.
➢ This effect of FYM application on the yield of first crop is known as the direct effect of application.
➢ The remaining amount of plant food becomes available to the second, third and to a small extent to the fourth crop raised on the same piece of land. This phenomenon is known as the residual effect of FYM.
➢ When FYM is applied every year, the crop yield goes on increasing due to direct plus residual effect on every succeeding crop. The beneficial effect is also known as cumulative effect.
Compost:

- Compost is composed of organic materials derived from plant and animal matter that has been decomposed largely through aerobic decomposition.

- The process of composting is simple and practiced by individuals in their homes, farmers on their land, and industrially by industries and cities.

- Composting is largely a bio-chemical process in which microorganisms both aerobic and anaerobic decompose organic residue and lower the C : N ratio.

- The final product of composting is well rotted manure known as compost.

- Rural compost: Compost from farm litters, weeds, straw, leaves, husk, crop stubble, bhusa or straw, litter from cattle shed, waste fodder, etc. is called rural compost.

- Urban compost: Compost from town refuse, night soil and street dustbin refuse, etc is called urban compost.
Composition of town compost:

- Compared to FYM, town compost prepared from Katchara and night soil is richer in fertilizer value.

Mechanical Composting Plants:

- Mechanical composting plants with capacities of 500 – 1000 tonnes per day of city garbage could be installed in big cities in India and 250 tonnes per day plants in the small towns.

- Refined mechanical compost contains generally about 40% mineral matter and 40% organic materials with organic carbon around 15%.

- The composition would vary depending on the feed but typically the nutrient content is about 0.7% N, 0.5% P$_2$O$_5$ and 0.4% K$_2$O.

- There are trace elements like Mn, B, Zn and Cu and the material has C : N ratio of nearly 15-17.

<table>
<thead>
<tr>
<th>Nitrogen (%N)</th>
<th>Phosphorus (%P$_2$O$_5$)</th>
<th>Potassium (%K$_2$O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
<td>1.0</td>
<td>1.4</td>
</tr>
</tbody>
</table>
Decomposition:

- The animal excreta and litter are not suitable for direct use as manure, as most of its manurial ingredients are present in an unavailable form.
- However urine, if collected separately, can be used directly.
- The dung and litter have to be fermented or decomposed before they become fit for use.
- Hence, the material is usually stored in heaps or pits, where it is allowed to decompose.
- Under suitable conditions of water supply, air, temperature, food supply and reaction, the microorganisms decompose the material.
- The decomposition is partly aerobic and partly anaerobic.
- During decomposition the usual yellow or green colour of the litter is changed to brown and ultimately to dark brown or black colour; its structural form is converted into a colloidal, slimy more or less homogenous material, commonly known as humus.
- A well decomposed manure has a typical black colour and a loose friable condition. It does not show the presence of the original litter or dung.
Factors controlling process of decomposition:

1) Food supply to micro-organisms and C : N ratio:
   - The suitable ratio of carbonaceous to nitrogenous materials is C:N 40, if it is wider than this, the decomposition takes place very slowly and when narrow it is quick.
   - C:N ratio of the dung of farm animals varies from 20 to 25, urine 1 to 2, poultry manure 5-10, litters-cereals straw 50, and legume refuse 20.

2) Moisture:
   - About 60-70 per cent moisture is considered to be the optimum requirement to start decomposition and with the advance in decomposition, it diminishes gradually being 30-40 per cent in the final product.
   - Excess of moisture prevents the temperature form rising high and retards decomposition, resulting in loss of a part of the soluble plant nutrients through leaching and drainage.
   - Hence, in regions receiving heavy rainfall, it is advisable to store the manure or prepare compost in heaps above ground level.
   - In the absence of sufficient moisture, microbial activity ceases and the decomposition practically comes to an end.
3) Aeration:
   Most of the microbial processes are oxidative and hence a free supply of oxygen is necessary.
   Reasons for poor aeration in pit/heap
   ➢ Excessive watering
   ➢ Compaction
   ➢ Use of large quantities of fine and green material as litters
   ➢ High and big heaps or deep pits.

4) Temperature:
   ➢ Under the optimum conditions of air moisture and food supply, there is a rapid increase in the temperature in the manure heap or pit.
   ➢ The temperature usually rises to 50°C–60°C and even to 70°C. The high temperature destroys weed seeds, worms, pathogenic bacteria, etc; which prevents fly breeding and makes the manure safe from hygienic point of view.
5) Reaction:
- The microorganisms liberate certain organic acids during the course of decomposition, which, if allowed to accumulate, retards fermentation and some time even stop it completely.
- Hence, it is necessary to control the reaction of the material.
- A neutral or slightly alkaline reaction between pH 7.0 and 7.5 is considered the most suitable.
- The addition of alkaline substances like lime and wood ashes neutralized the excess acidity.
- Since in the preparation of FYM it is a common practice to add household ashes to the manure pit, it is not necessary to add additional alkaline substances.
### Heap V/S Pit decomposition:

<table>
<thead>
<tr>
<th>Heap</th>
<th>Pit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aerobic</td>
<td>1. Anaerobic</td>
</tr>
<tr>
<td>2. Turning is required</td>
<td>2. No turning is required</td>
</tr>
<tr>
<td>3. Physical disintegration</td>
<td>3. Very little physical disintegration</td>
</tr>
<tr>
<td>4. Quick oxidation</td>
<td>4. Slow rate of decomposition</td>
</tr>
<tr>
<td>5. High temp. 60° – 70°C. Kill weed seeds and pathogenic organisms</td>
<td>5. High temp. is not developed but weed seeds and MO destroyed due to toxic products of decomposition.</td>
</tr>
<tr>
<td>6. Loss of is about 50%</td>
<td>6. Loss is about 25%</td>
</tr>
<tr>
<td>7. If not properly protected, moisture loss is high. Watering is necessary</td>
<td>7. Moisture loss is minimized. No watering is necessary</td>
</tr>
<tr>
<td>8. If rainfall is high, leaching takes place</td>
<td>8. Protected form leaching but anaerobic condition occurs.</td>
</tr>
</tbody>
</table>
Vermicomposting:

- Vermicompost is the product of composting utilizing various species of worms, usually red wigglers, white worms, and earthworms to create a heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and vermicast.

- Vermicast is also known as worm castings, worm humus or worm manure, is the end-product of the breakdown of organic matter by species of earthworm.[16]

- The earthworm species (or composting worms) most often used are Red Wigglers though European nightcrawlers could also be used.

- Users refer to European nightcrawlers by a variety of other names, including *dendrobaenas*, *dendras*, and *Belgian nightcrawlers*.

- Containing water-soluble nutrients, vermicompost is a nutrient-rich organic fertilizer and soil conditioner.
Vermiculture means artificial rearing or cultivation of worms (Earthworms) and the technology is the scientific process of using them for the betterment of human beings.

Vermicompost is the excreta of earthworm, which is rich in humus.

Earthworms eat cow dung or farm yard manure along with other farm wastes and pass it through their body and in the process convert it into vermicompost.

The municipal wastes; non-toxic solid and liquid waste of the industries and household garbage’s can also be converted into vermicompost in the same manner.

Earthworms not only convert garbage into valuable manure but keep the environment healthy.

Conversion of garbage by earthworms into compost and the multiplication of earthworms are simple process and can be easily handled by the farmers.
Method of preparation of Vermicompost Large/community Scale:

- A thatched roof shed preferably open from all sides with unpaved(katcha) floor is erected in East-West direction length wise to protect the site from direct sunlight.
- A shed area of 12’X12’ is sufficient to accommodate three vermicibeds of 10’X3’ each having 1’ space in between for treatment of 9-12 quintals of waste in a cycle of 40-45 days.
- The length of shed can be increased/decreased depending upon the quantity of waste to be treated and availability of space.
- The height of thatched roof is kept at 8 feet from the centre and 6 feet from the sides.
- The base of the site is raised at least 6 inches above ground to protect it from flooding during the rains.
- The vermicibeds are laid over the raised ground as per the procedure given below.
The site marked for vermicibeds on the raised ground is watered and a 4”-6” layer of any slowly biodegradable agricultural residue such as dried leaves/straw/sugarcane trash etc. is laid over it after soaking with water.

This is followed by 1” layer of Vermicompost or farm yard manure.

Earthworms are released on each vermiibed at the following rates:

- For treatment of cowdung/agriwaste: 1.0 kg. per
- For treatment of household garbage: 1.5 kg. per
- The frequency and limits of loading the waste can vary as below depending upon the convenience of the user

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>2&quot; /bed/day</td>
</tr>
<tr>
<td>In Bulk</td>
<td>12-15&quot; (3-4q/bed/cycle of 45 days)</td>
</tr>
</tbody>
</table>
The loaded waste is finally covered with a Jute Mat to protect earthworms from birds and insects.

Water is sprinkled on the vermicibeds daily according to requirement and season to keep them moist.

The waste is turned upside down fortnightly without disturbing the basal layer (vermibed).

The appearance of black granular crumbly powder on top of vermicibeds indicate harvest stage of the compost.

Watering is stopped for atleast 5 days at this stage.

The earthworms go down and the compost is collected from the top without disturbing the lower layers (vermibed).

The first lot of Vermicompost is ready for harvesting after 2-2 ½ months and the subsequent lots can be harvested after every 6 weeks of loading.

The vermibed is loaded for the next treatment cycle.
Multiplication of worms in large scale:

- Prepare a mixture of cow dung and dried leaves in 1:1 proportion.
- Release earthworm @ 50 numbers/10 kg.
- Of mixture and mix dried grass/leaves or husk and keep it in shade.
- Sprinkle water over it time to time to maintain moisture level.
- By this process, earthworms multiply 300 times within one to two months.
- These earthworms can be used to prepare vermicompost.
Advantages of Vermicomposting:

- Vermicompost is an ecofriendly natural fertilizer prepared from biodegradable organic wastes and is free from chemical inputs.
- It does not have any adverse effect on soil, plant and environment.
- It improves soil aeration, texture and tilth thereby reducing soil compaction.
- It improves water retention capacity of soil because of its high organic matter content.
- It promotes better root growth and nutrient absorption.
- It improves nutrient status of soil—both macro-nutrients and micro-nutrients.
Precautions during vermicomposting:

- Vermicompost pit should be protected from direct sunlight.
- To maintain moisture level, spray water on the pit as and when required.
- Protect the worms from ant, rat and bird.

Nutrient Profile of Vermicompost and Farm Yard Manure:

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Vermicompost</th>
<th>Farm Yard Manure</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td>1.6</td>
<td>0.5</td>
</tr>
<tr>
<td>P (%)</td>
<td>0.7</td>
<td>0.2</td>
</tr>
<tr>
<td>K (%)</td>
<td>0.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Ca (%)</td>
<td>0.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Mg (%)</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Fe (ppm)</td>
<td>175.0</td>
<td>146.5</td>
</tr>
<tr>
<td>Mn (ppm)</td>
<td>96.5</td>
<td>69.0</td>
</tr>
<tr>
<td>Zn (ppm)</td>
<td>24.5</td>
<td>14.5</td>
</tr>
<tr>
<td>Cu (ppm)</td>
<td>5.0</td>
<td>2.8</td>
</tr>
<tr>
<td>C:N ratio</td>
<td>15.5</td>
<td>31.3</td>
</tr>
</tbody>
</table>
Night Soil:

Night soil is human excrement i.e. solid and liquid. Night soil is richer in N, P$_2$O$_5$ and K$_2$O as compared to FYM or compost. On oven dry basis, it has an average chemical composition of:

<table>
<thead>
<tr>
<th>N%</th>
<th>P$_2$O$_5$%</th>
<th>K$_2$O%</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>4.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

- In India it is applied to a limited extent directly to the soil. Pits or trenches of 10 to 12 ft. long, 2 to 3 ft. wide and 9 inches to 1 foot deep are made.
- In these pits, night soil is deposited and covered over on top with a layers of earth or Katchara.
- This is known as the Poudrette System. Since the material formed in the above trenches after they become dry, is known as poudrette.
Improved methods of handling night soil:

- Since night soil is an important bulky organic manure, supplying a good deal of organic matter and plant nutrients to the soil, it is important that night soil is used by the following improved methods:
- Night soil should be protected from flies and fly breeding should be controlled.
- It should be stored in such a way that it does not pollute the supply of drinking water.
- Pathogens, protozoa, cysts, worms and eggs should be destroyed before the night soil is applied to the land.
- Attempts should be made to compost the night soil with other refuse in urban centres by municipal or town authorities and in rural areas by the farmer himself.
Sewage and Sludge:

- In the modern system of sanitation adopted in cities, water is used for the removal of human excreta and other wastes.
- This is called the sewage system of sanitation.
- In this system, there is a considerable dilution of the material in solution and in dispersion in fact, water is the main constituent of sewage, amounting often to 99.0%.

  In general sewage has two components, namely

  - Solid portion, technically known as sludge and
  - Liquid portion, commonly known as sewage water.

- Both the components are used in increasing crop production as they contain plant nutrients.
- Both components of sewage as separated and are given a preliminary fermentation and oxidation treatments to reduce the bacterial contamination, the offensive smell and also to narrow down the C:N ratio of the solid portion.
(i) Sludges:
- In the modern system of sewage utilization, solid portion or sludge is separated out to a considerable extent and given a preliminary treatment (i.e. fermentation and oxidation) before its use as manure.
- Such oxidized sludge is also called activated sludge which is of inoffensive smell and on dry weight basis contains up to 3 to 6 per cent N, about 2 per cent P\textsubscript{2}O\textsubscript{5} and 1 per cent K\textsubscript{2}O in a form that can become readily available when applied to soil.

(ii) Sewage irrigation:
- When raw sewage is treated to remove the solid portion or sludge the water, technically known as treated effluent, is used for irrigation purpose. Such a system of irrigation is known as sewage irrigation.
- Thus, both the activated sludge and the effluent can be used with safely for manuring and irrigating all field crops except the vegetables which are eaten raw or uncooked.
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 *plowed* under and incorporated into the soil.
- Green manures usually perform multiple functions that include soil improvement and soil protection:
  - *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** 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.

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**Types of green manuring:**

Broadly two types of green manuring can be differentiated.

- Green manuring *in situ* and
- Green leaf manuring
i) Green manuring in situ:
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 Sannhemp, dhaincha and guar.

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.

The former system is followed in northern India, while the latter is common in eastern and central India.
Advantages of Green Manuring:

- It adds organic matter to the soil. This stimulates the activity of soil micro-organisms.
- The green manure crops return to the upper top soil, plant nutrients taken up by the crop from deeper layers.
- It improves the structure of the soil.
- It facilitates the penetration of rain water thus decreasing run off and erosion.
- The green manure crops hold plant nutrients that would otherwise be lost by leaching.
- When leguminous plants, like sannhemp and dhaincha are used as green manure crops, they add nitrogen to the soil for the succeeding crop.
- It increases the availability of certain plant nutrients like phosphorus, calcium, potassium, magnesium and iron.
Disadvantages of green manuring:

- When the proper technique of green manuring is not followed or when weather conditions become unfavourable, the following disadvantages are likely to become evident.

- 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.

- 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.

- 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.

- An increase of diseases, insects and nematodes is possible.

- 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:

<table>
<thead>
<tr>
<th>Leguminous</th>
<th>Non-leguminous</th>
</tr>
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<tbody>
<tr>
<td>1. Sannhemp</td>
<td>1. Bhang</td>
</tr>
<tr>
<td>2. Dhaincha</td>
<td>2. Jowar</td>
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<tr>
<td>5. Guar</td>
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<td>6. Senji</td>
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<td>7. Khesari</td>
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<td>8. Berseem</td>
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</tbody>
</table>
Selection of Green manure crops *in situ*:

Certain green manure crops are suitable for certain parts of the country. Suitability and regional distribution of important green manure crops are given below:

Sannhemp: This is the most outstanding green manure crop. It is well suited to almost all parts of the country, provided that the area receives sufficient rainfall or has an assured irrigation. It is extensively used with sugarcane, potatoes, garden crops, second crop of paddy in South India and irrigated wheat in Northern India.

Dhaincha: It occupies the second place next to sannhemp for green manuring. It has the advantage of growing under adverse conditions of drought, water-logging, salinity and acidity. It is in wide use in Assam, West Bengal, Bihar and Chennai with sugarcane, Potatoes and paddy.

Guar: It is well suited in areas of low rainfall and poor fertility. It is the most common green manure crop in Rajasthan, North Gujarat and Punjab.
Technique of Green Manuring *in situ*:

The maximum benefit from green manuring can not be obtained without knowing:

- When the green manure crops should be grown,
- When they should be buried in the soil and
- How much times should be given between the burying of a green manure crop and the sowing of the next crop.
(i) **Time of sowing:**

The normal practice usually adopted is to begin sowing immediately after the first monsoon rains. Green manure crops usually can be sown/broadcast preferably giving some what higher seed rate.

(ii) **Stage of burying green manure crop:**

- From the results of various experiments conducted on different green manure crops, it can be generalized that a green manure crop may be turned in soil at the stage of flowering.
- The majority of the green manure crops take about six to eight weeks from the time of sowing to attain the flowering stage.
- The basic principle which governs the proper stage of turning in the green manure crops, should aim at maximum succulent green matter at burying.
(iii) Time interval between burying of green manure crop and sowing of next crop.

Following two factors which affect the time interval between burring of green manure crop and sowing of next crop.

- Weather conditions
- Nature of the buried green material
  - In paddy tracts the weather is humid due to the high rainfall and high temperature.
  - These favour rapid decomposition.
  - If the green material to be buried is succulent there is no harm in transplanting paddy immediately after turning in the green manure crop.
  - When the green manure crop is woody, sufficient time should be allowed for its proper decomposition before planting the paddy.
Regions not suitable for green manuring:

- The use of green manures in dry farming areas in arid and semiarid regions receiving less than 25 inches of annual rainfall is, as a rule, impracticable.
- In such areas, only one crop is raised, as soil moisture is limited.
- Such dry farming areas are located in Punjab, Maharashtra, Rajasthan, M.P. and Gujarat (Kutch and Saurashtra).
- On very fertile soils in good physical condition, it is not advisable to use green manures as a part of the regular rotation.
- In areas where *rabi* crops are raised on conserved soil moisture, due to lack of irrigation facilities, it is not practicable to adopt green manuring.
- If green manuring is followed in this areas, there is danger of incomplete decomposition of the green matter and as such less moisture for the succeeding crop.