SOIL SCIENCE

Soil is a valuable resource of India. Much of the Indian agriculture depends upon the extent and qualities of soil. Weathering prepares loose materials on the surface of the Earth and mixed with decayed organic matters it forms soil.

India is a large country and witness's diverse range of climatic and other natural conditions. The nature of soil in a place is largely influenced by such factors as climate, natural vegetation and rocks.

The various types of soil found in India includes alluvial soil, Laterite soil, Red soil, Black soil, Desert soil, and Mountain soil.

◆ Major types and characteristics of soils in India:

Indian soils may be divided into six major types based on their character and origin:

1. Alluvial soil: Materials deposited by rivers, winds, glaciers and sea waves are called alluvium and soils made up of alluvium are alluvial soils. In India alluvial soils are mainly found on the Indo-Ganga Brahmaputra Plains, Coastal Plains and the broad river valleys of South India. They are also found along the river basins of some plateau and mountain regions.

In the Indo-Ganga plain two other types of alluvium are found. The old alluviums are clayey and sticky, have a darker colour, contain nodules of lime concretions and are found to lie on slightly elevated lands. The new alluviums are lighter in colour and occur in the deltas and the flood plains.

In comparison to old alluvial soil, the new alluvial soils are very fertile. The alluvial soil is regarded as the best soil of India for its high fertility and the rich harvest, it gives rice, wheat, sugarcane, jute oilseeds and pulses are the main crops grown on this soil. It is geographically of two types –

• Khaddar or newly formed alluvial, more sandy
• **Bhangar** or older alluvium, more clayey soils

**Influence on Agriculture:** Alluvial soil is very productive. Abundant of wheat, sugarcane, oilseeds, pulses, rice and jute is grown on this soil.

2. **Laterite and Lateritic soils:** Laterite is a kind of clayey rock or soil formed under high temperature and high rainfall. By further modification laterite is converted into red colored lateritic soils charged with iron nodules. Laterite and lateritic soils are found in South Maharashtra, the Western Ghats in Kerala and Karnataka, at places on the Eastern Ghat, in some parts of Assam, Tamil Nadu, Karnataka, and in western West Bengal (particularly in Birbhum district). These soils are generally infertile. Some plants like tea, coffee, coconut, areca nut, etc. are grown in this soil.

**Influence on Agriculture:** They are unsuitable for agriculture. Some plants like the cashew can thrive on lateritic soils. Root crops like tapioca also do reasonably well on these soils.

3. **Red Soils:** Red soils develop on granite and geneses rocks under low rainfall condition. The dissemination of red oxides of iron gives the characteristic red colour of the soil. These soils are friable and medium fertile and found mainly in almost whole of Tamil Nadu, South-eastern Karnataka, Northeastern and South-eastern Madhya Pradesh, Jharkhand the major parts of Orissa, and the Hills and Plateaus of North-east India. But these have capacity to grow good crops after taking help of irrigation and fertilizers. Wheat, rice, millets, gram, pulses, oil-seeds and cotton are cultivated here.

4. **Black Soils or Regur soils:** The regur or black soils have developed extensively upon the Lava Plateaus of Maharashtra, Gujarat, Madhya Pradesh mainly Malwa. Black soils have also developed on gneisses of north Karnataka and north and west of Andhra Pradesh. The regur is clayey, becomes very sticky when wet. Its special merit lies in its water holding capacity. These soils are very fertile and contain a high percentage of lime and a moderate amount of potash. The type of soil is especially suited to the cultivation of cotton and hence sometimes called ‘black cotton soil.’ Sugarcane, wheat, and groundnut are also cultivated.
Influence of Agriculture: They are able to retain water. Crops grow without much irrigation. These soils are fertile and suitable for the production of cotton, jowar, sugarcane, wheat and groundnut. Green skinned bananas grow here in abundance.

5. Desert soil: The soils of Rajasthan, Haryana and the South Punjab are sandy. In the absence of sufficient wash by rain water soils have become saline and rather unfit for cultivation. In spite of that cultivation can be carried on with the help of modern irrigation. Wheat, bajra, groundnut, etc. can be grown in this soil.

Influence on Agriculture: These soils are not suitable for agriculture due to scanty rainfall; however, agriculture can be carried on with the help of irrigation. Bajra, wheat, groundnut can be grown on these soils.

6. Mountain soil: Soils are varied in mountains. Alluvium is found at the valley floor, brown soil, rich in organic matter, in an altitudinal zone lying between about 700-1800 m. Further up podzol soils, grey in color and acidic in reaction, are found associated with coniferous vegetation. In the Alpine forest belts the soils are thin and darker in colour. This type of soil is suitable for the cultivation of potatoes, fruits, tea, coffee and spices and wheat.

Influence on Agriculture: They are fertile and suitable for cultivation of potatoes, rice, wheat, fruits and tea. Oak trees are good for the growth of Oak trees. Potato and barley grows in Podzolic soil.

◆ Major Types of Soil found in India

In the higher regions of the Himalayas, Glaciated rocky soils are found just below the snow line. Below this boulder clay is found. Further south, Podsol type of soil is found.

The great plain of North India has been built up of alluvium brought down by the great rivers. Here the soil is of two kinds: Old alluvium and New alluvium.

In the northern parts of Punjab, U. P., and Bihar, the soil is old alluvium.
New alluvium is found in those parts where fresh silt is deposited every year. Alluvium soils in India is of three types:

• Sandy soil,
• Clayey soil
• Loamy soil.

The sandy soil has the highest percentage of large grained sand. As water can easily sink through it, it is not suitable for the cultivation of rice. Clayey soil is fine grained, impermeable and can retain water. The deltaic regions have this type of soil. It is good for the cultivation of rice and jute. The grain of loamy soil is intermediate between sand and clay and most suitable for a wider range of crops. In Punjab, Haryana, U. P., and Bihar this type of soil is found. It is suitable for the production of rabi as well as kharif crops.

In South India river valleys and coastal plains are made up of alluvial soil. Lava soil is found in the north-western part of Deccan. As this soil can retain moisture, it is very suitable for the production of cotton even in a rain shadow area. So it is known as ‘Black Cotton Soil’. Maharashtra, Gujrat and certain parts of Madhya Pradesh have this of soil.

The Red soil which is found in Kerala, Karnataka and Andhra Pradesh is light red in colour. Laterite soil is found in Tamil Nadu, Karnataka and Chhota Nagpur. It is not suitable for cultivation of crops other than millets.

◆ Soil Orders

<table>
<thead>
<tr>
<th>SN</th>
<th>Soil Order</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Inceptisols</td>
<td>It is largest soil order in world (20%) of total soil. Young, embryonic soil. These soils found in all India except arid and hot regions.</td>
</tr>
<tr>
<td>2.</td>
<td>Entisols</td>
<td>They do not show any profile development other than an A horizon.</td>
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<tr>
<td>No.</td>
<td>Type</td>
<td>Description</td>
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<tr>
<td>3.</td>
<td>Vertisols</td>
<td>They have high content of expansive clay that forms deep cracks in drier seasons. They form from highly basic rocks such as basalt (black cotton soils). Found in Deccan Plateau of India.</td>
</tr>
<tr>
<td>4.</td>
<td>Oxisols</td>
<td>They are always a red or yellowish color due to high concentration of iron and aluminum oxides and hydroxides. (laterite soils).</td>
</tr>
<tr>
<td>5.</td>
<td>Alfisols</td>
<td>They have at least 35% base saturation meaning calcium, magnesium and potassium is relatively abundant. Found mostly in laterite and red soil regions.</td>
</tr>
<tr>
<td>6.</td>
<td>Histosols</td>
<td>(peat or muck soil) Organic material rich soil. Stores large quantities of organic carbon.</td>
</tr>
<tr>
<td>7.</td>
<td>Aridosols</td>
<td>(desert soils) Found in western and northwestern India. Water deficient. Accumulation of salt on the surface can result in salinization.</td>
</tr>
<tr>
<td>8.</td>
<td>Spodosols</td>
<td>(podzol) Mostly found in cool and humid areas.</td>
</tr>
<tr>
<td>10.</td>
<td>Mollisols</td>
<td>Found in semi-arid to semi-humid regions usually under grassland covers. Have deep, high, organic matter, nutrient enriched surface soil.</td>
</tr>
<tr>
<td>11.</td>
<td>Andisols</td>
<td>Formed in volcanic ash. Have high proportions of glass and amorphous colloidal materials. (support crops of fruit, maize, tea, coffee, forests)</td>
</tr>
<tr>
<td>12.</td>
<td>Gelisols</td>
<td>Churning soils. Found in cold climate. Known as cryosols. They are not found in India.</td>
</tr>
</tbody>
</table>
◆ SOIL FERTILITY

**Soil fertility:** Soil fertility is defined as the quality that enables the soil to provide proper nutrient compounds in proper amounts and in proper balance for the growth of specified plants. Soil fertility is also defined as the ability of soil to supply adequately the nutrients normally taken from the soil by plants.

This refers to the ability of the soil to supply essential plant nutrients and soil water in adequate amounts and proportions for plant growth and reproduction in the absence of toxic substances which may inhibit plant growth. Soils are composed of five main components:

- **mineral particles derived from rocks by weathering;**
- **organic materials - humus from dead and decaying plant material;**
- **soil water - in which nutrient elements are dissolved;**
- **soil air - both carbon dioxide and oxygen;**
- **Living organisms including bacteria that help plant decomposition.**

Soils differ because they have different proportions of these components and because the mineral particles have been affected to different degrees by weathering. Age of soil minerals, prevailing temperatures, rainfall, and leaching and soil chemistry are the main factors which determine how much a particular soil will weather. Vanuatu soils, because they are geologically young, are often less weathered than soils of neighboring Pacific countries.

The major and micro or trace elements are made available to plants by breakdown of the mineral and organic matter in the soil. Availability of these nutrients depends on how much is present, the form in which it is present in the soil, the rate at which it is released from organic matter or mineral particles and the soil pH i.e. its acidity or alkalinity.

The proportion of nutrients held on the clay and humus particles influence deficiencies e.g. potassium(K), calcium(Ca) and magnesium(Mg) are held on the surface of clay particles and are directly taken up by plant roots or from the soil solution. An excess of K can create a deficiency of Ca or the reverse can occur. Acid soils high in Manganese (Mn) often cannot supply enough Cobalt (Co) for rhizobium bacteria with a consequent effect on nitrogen (N)
fixation by legumes. Also on very acid soils Manganese and Iron (Fe) make phosphorus (P) unavailable to plants by ‘fixing’ it in insoluble complexes. The chemical relationships influencing soil fertility are complex and affected by the parent material from which soil develops, the type of clay present, the proportions of different sized particles, e.g. sand, silt, clay, which also have important effects on soil structure.

◆ **Soil Chemistry:**

It deals with the chemical constitution of the soil - the chemical properties and the chemical reactions in soils. It is the study of chemical composition of soil in relation to crop needs. Traditional soil chemistry focuses on chemical and biochemical reactions in soils that influence nutrient availability for plant growth, and potential environmental consequences associated with inorganic and organic fertilization. Soil chemistry has increasingly focused on the environment over the past few decades, especially as related to ground and surface water quality.

The overall goal of soil chemistry/fertility research is a more fundamental understanding of chemical and biochemical reactions in soils related to plant growth, sustainability while maintaining soil and environmental quality. Soil is the major factor that limits the type of vegetation and crops. Under similar climatic conditions, a loose and porous soil that retains little water will support sparse vegetation when compared to deep, fertile loam or clay. The basic need of crop production is to maintain soil fertility and soil productivity.

<table>
<thead>
<tr>
<th><strong>SOIL FERTILITY</strong></th>
<th><strong>SOIL PRODUCTIVITY</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>It is the inherent capacity of the soil to provide essential chemical elements for plant growth</td>
<td>Soil productivity emphasizes the capacity of soil to produce crops and is expressed in terms of yield.</td>
</tr>
<tr>
<td>A combination of soil properties and an aspect of soil – plant relationships.</td>
<td>An economic concept and not a property of soil</td>
</tr>
</tbody>
</table>
Soil fertility is vital to a productive soil. But a fertile soil is not necessarily a productive soil. Many factors can limit production, even when fertility is adequate. For eg., soils in arid region may be fertile but not productive.

Soil fertility is one factor among all the external factors that control plant growth like air heat (temp.), light, mechanical support, soil fertility and water. Plant depends on soil for all these factors except for light.

Organic matter in the soil improves soil fertility by mineralization of nutrients.

Organic matter also improves soil productivity by improving soil porosity, aggregation and physical condition of soil thus modifying the soil environment for crop growth.

All fertile soils are not productive

All productive soils are fertile

◆ Soil as a source of plant nutrients

Soils are complex natural formations on the surface of the earth and consist of five main components:

Mineral matter, organic matter, water, air and living organisms.
The rocks and minerals on weathering release nutrients into the soil. The most important part of the soil with respect to plant nutrition is the colloidal fraction which consists of inorganic colloids (clay) and organic colloids (humic substances).

Most of soil colloids possess electronegative adsorption sites available for attracting cations including calcium, magnesium, potassium, ammonium etc. as well as H+ arising from the biological activity. Organic matter on decomposition releases nutrients. The cations adsorbed on the surface of the colloids are capable of exchanging rapidly and reversibly with those in soil solution. The principal immediate source of mineral nutrients to plant roots is ions in the soil solution.

This nutrient supply is gradually depleted by absorption of nutrient ions by plant roots and continuously replenished by desorption of exchangeable ions on the clay-humus complex and break down of readily decomposable organic debris. The microbes in the soil also help in supplementing nutrients by the way of nutrient transformations. These sources represent the reserves that serve to replace but only at a relatively slow rate. For intensive cultivation of crop plants, however, application of mineral salts to soil is required.

**Methods of Soil Fertility Evaluation**

Different Methods of Soil Fertility Evaluation are:

1. **Biological Method:**
   a) Field trials
   b) Pot culture
   c) Neubauer seedling method
   d) Aspergillus Niger method.

2. **Use of visual symptoms of nutrient deficiency or toxicity method.**

3. **Plant Analysis Method:**
   a) Total elemental analysis
b) Plant tissue tests

4. **Soil Analysis Method**: Soil testing has been used by soil scientist as an aid in determining soil fertility level.

◆ **Important Points about Soil Science**

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
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<tbody>
<tr>
<td>Canker nodules are mostly found in</td>
<td>Red Soils</td>
</tr>
<tr>
<td>Process of moving out of sesquioxide from soil is known as</td>
<td>Podzolization</td>
</tr>
<tr>
<td>Process of mixing of soils is known as</td>
<td>Pedoturbation</td>
</tr>
<tr>
<td>Soils having more than 20% organic matter known as</td>
<td>Organic soils</td>
</tr>
<tr>
<td>Law of minimum was proposed by:</td>
<td>J. V. Liebig, 1840</td>
</tr>
<tr>
<td>O' horizon is absent in which soils:</td>
<td>Arable soils</td>
</tr>
<tr>
<td>Top most mineral horizon is:</td>
<td>A' horizon</td>
</tr>
<tr>
<td>Diameter of clay particle is</td>
<td>Less than 0.002 mm</td>
</tr>
<tr>
<td>Soil structure which is best for cultivation is</td>
<td>Crumby structure</td>
</tr>
<tr>
<td>Particle density of most of the soil is:</td>
<td>2.65 g/cc</td>
</tr>
<tr>
<td>Bulk density of general soil:</td>
<td>1.33 g/cc</td>
</tr>
<tr>
<td>Total pore space highest in:</td>
<td>Clay soils</td>
</tr>
<tr>
<td>Kaolinite is a type of mineral:</td>
<td>1:1 nonexpanding</td>
</tr>
<tr>
<td>Montmorillonite is a type of mineral:</td>
<td>2:1 expanding type</td>
</tr>
<tr>
<td>Vermiculate is a type of mineral:</td>
<td>2:1 limited expanding</td>
</tr>
<tr>
<td>Chlorites are type of mineral:</td>
<td>2:1 : 1 type mineral</td>
</tr>
<tr>
<td>Recently developed soils formed from soil which order that has no diagnostic horizons:</td>
<td>Entisols</td>
</tr>
<tr>
<td>Black cotton soils are found in:</td>
<td>Maharashtra, MP</td>
</tr>
<tr>
<td>The weight of <strong>furrow slice</strong> of soil is:</td>
<td>$2.25 \times 10^6$ kg/ha</td>
</tr>
<tr>
<td>One cm of surface soil over one ha of land weight is:</td>
<td>150 tonnes.</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Permissible soil loss by water is:</td>
<td>12 t/ha.</td>
</tr>
<tr>
<td>Chief constitute of sandy fraction is:</td>
<td>Quartz.</td>
</tr>
<tr>
<td>Most dominant mineral on the earth crust is:</td>
<td>Feldspars (48%)</td>
</tr>
<tr>
<td>Which pulse crop does not fix N from the atmosphere:</td>
<td>Rajma</td>
</tr>
<tr>
<td>First manufactured fertilizer in India is:</td>
<td>SSP</td>
</tr>
<tr>
<td>Classification of soils by ICAR in:</td>
<td>8 groups</td>
</tr>
<tr>
<td>The adverse effect of salinity on plants is due to increased:</td>
<td>Osmotic pressure</td>
</tr>
<tr>
<td>Apical bud dominance is caused by which hormone:</td>
<td>Auxin</td>
</tr>
<tr>
<td>The crops which absorb the nitrogen in ammonical form directly are:</td>
<td>Paddy &amp; potato</td>
</tr>
<tr>
<td>In rice ammonical fertilizers should be applied in:</td>
<td>Reduced zone of soil</td>
</tr>
<tr>
<td>While nitrate fertilizer should be applied in:</td>
<td>Oxidized zone of soil</td>
</tr>
<tr>
<td>Major source of nitrogen absorption by plants is:</td>
<td>Nitrate (NO₃) form</td>
</tr>
<tr>
<td>Pascal (Pa) is the SI unit of</td>
<td>Pressure.</td>
</tr>
<tr>
<td>The smallest volume of soil (1 to 10 m²) is called as:</td>
<td>Pedon</td>
</tr>
<tr>
<td>Most of the exchange of gases in soil is due to:</td>
<td>Diffusion</td>
</tr>
<tr>
<td>In addition of organic matter bulk density:</td>
<td>Decreases</td>
</tr>
<tr>
<td>In red soils the dominant clay mineral is:</td>
<td>Kaolinite</td>
</tr>
<tr>
<td>The red soils are red in colour due to presence of:</td>
<td>Iron oxide</td>
</tr>
<tr>
<td>Black soils are best suitable for:</td>
<td>Dry land agriculture.</td>
</tr>
<tr>
<td>In black soils the dominant clay mineral is:</td>
<td>Montmorillonite</td>
</tr>
<tr>
<td>Black cotton soils are deficient in:</td>
<td>Nitrogen &amp; O.M.</td>
</tr>
<tr>
<td>Azolla is widely used as a bio fertilizer in:</td>
<td>Rice crop</td>
</tr>
<tr>
<td>Soil particles &lt; 0.001 mm diameter have:</td>
<td>Colloidal property</td>
</tr>
<tr>
<td>The term 'Colloids' was given by:</td>
<td>Grahm (1861)</td>
</tr>
<tr>
<td>Formula of backing soda is:</td>
<td>NaHCO₃</td>
</tr>
<tr>
<td>Formula of castic soda is:</td>
<td>NaOH</td>
</tr>
<tr>
<td>USA is the first country to introduce:</td>
<td>Zero tillage</td>
</tr>
<tr>
<td>Urea in the presence of enzyme urease converted into:</td>
<td>Ammonium Carbamate</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Electrical conductivity (EC) is used to express:</td>
<td>Salinity of the soil</td>
</tr>
<tr>
<td>Pollen sterility in wheat is due to:</td>
<td>Boron-deficiency</td>
</tr>
<tr>
<td>Ballast elements are:</td>
<td>Al and Silicon</td>
</tr>
<tr>
<td>In which state red soils are dominant:</td>
<td>Tamil Nadu</td>
</tr>
<tr>
<td>In which states lateritic soils are dominant:</td>
<td>Karnataka and Kerala</td>
</tr>
<tr>
<td>Organic matter content in Indian soils is generally:</td>
<td>Less than 0.5%</td>
</tr>
<tr>
<td>Most outstanding green manure crop is:</td>
<td>Sunhemp (Crotalaria juncea)</td>
</tr>
<tr>
<td>Wood is mainly decomposed by:</td>
<td>Actinomycetes</td>
</tr>
<tr>
<td>Nif: gene responsible for</td>
<td>N-fixation</td>
</tr>
<tr>
<td>Population of actinomycetes is higher in:</td>
<td>Alkaline soils</td>
</tr>
<tr>
<td>Fine texture soils are more sensitive to:</td>
<td>Water erosion</td>
</tr>
<tr>
<td>The soils which are most suitable for the most of the crops are:</td>
<td>Sandy loam</td>
</tr>
<tr>
<td>Rice can tolerate very low level even complete _______ of oxygen in the soil.</td>
<td>absence</td>
</tr>
<tr>
<td>Desired size of the soil sample for soil testing is:</td>
<td>0.5-1.0 kg</td>
</tr>
<tr>
<td>Crop having the highest tolerance to boron is:</td>
<td>Sugar beet</td>
</tr>
<tr>
<td>Insoluble fraction of organic matter is:</td>
<td>Humin</td>
</tr>
<tr>
<td>Lowering of the bulk density of a soil indicates:</td>
<td>Better physical properties</td>
</tr>
<tr>
<td>ppm = per cent/10000 or ppm equal to</td>
<td>0.0001 %</td>
</tr>
<tr>
<td>Or 1 ppm equal to</td>
<td>1 mg</td>
</tr>
</tbody>
</table>

- Red soils are found in Tamil Nadu
- The element required for seed formation: Phosphorous
Oxidation: means addition of oxygen or loss of electron

Reduction means: addition of 1-12 or removal of 02 or gain of electron

On the number basis population of microbes in normal soil is:
Bacteria > Actinomycetes > Fungi

The first antibiotic penicillin was discovered by Alexander Flemming, 1929

Oldest method of breeding for improving variety is: Selection

Zinc deficiency is produced in: Calcarious soil

In weed infested pond mostly fishes are suddenly died due to: O2 deficiency

Due to water logging the availability of which nutrient is increased in rice field is: Manganese

Bulk density of sub soil is higher as compared to surface soils.

Active acidity: it is due to presence of H+ & Al+3 in soil solution. Soil texture is an inherent property of soil it can’t be changed.

Provision of adequate drainage is the basic principle in reclamation of saline and alkali soils.

Alluvial soils most recently developed soils with no diagnostic horizons

Red soils are best suitable for agriculture.

Many Pedon within defined limit is called as soil series that is basic unit of soil classification.

Chisel ploughs are also used to break hard pans of soil even at 60-70 cm deep.

In general ploughs are used for primary tillage and harrows for secondary tillage.

In zero tillage, primary tillage is completely avoided and secondary tillage is restricted to seed bed preparation in the root zone only.

Soil erosion: detachment and transportation of soil particles by water/wind is soil erosion.

Portion of capillary water lying between field capacity (1/3 atm.) to wilting coefficient (15 atm) is known as: Available water

Tillage is the mechanical manipulation of soil for loosen the surface crust and brings about favorable condition for the germination of seeds.

Tilth is the physical condition of soil in relation to plant growth.
Stages of wind erosion: Saltation (75% of wind erosion)- suspension surface creep

Stages of water erosion: Splash, Sheet, Rill & Gully

Total N content of soils ranges from less than 0.02% in sub soil to more than 2.5% in peals.

Warabandi: rotational supply of water in canal irrigated area.

Cabbage is highly sensitive to boron toxicity (< 0.33ppm)

Most common inhibitor commercially available is Agrotain or NBPT (N-serve in India), recently ATS (ammonium thiosulphate) as an inhibitor.

H₂PO₄ is greatest absorbed at acidic Pᴴ 6.5 or less. (IFFCO-09)

PO₄ absorbed at higher value of Pᴴ (slightly alkaline).

Chelate: organic compound with combine Fe, Mn, Cu, Zn. E.g. EDTA (slow released micro organic fertilizer).

Pedalfer: an absolute term used for a group of a soil with an accumulation of sesquioxide (Fe & Al) in lower part of Solum.

Adsorption: gathering of molecules on a surface.

Sun hemp best suited crop for green manuring, it accumulate higher amount of N 134 kg/ha followed by dhaicha (Seshania acculata).

Foliar spraying is useful in apply small quantity of fertilizers e.g. micronutrients

Organic matter is the major source for nitrogen, phosphorus (5- 60%) and sulphur (80%).

The temperature of surface soil is always higher than atmosphere. For each unit increase in pH the concentration of Mn⁺², Fe⁺² decreased by 100 fold.

Ideal NPK ratio should be: **4 : 2 : 1 for cereals and 1 : 2 : 1 for pulses.**

The most widely occurring clay mineral in soil is kaolinite

Underground reservoirs are usually found in porous rock formation called: Aquifer.

The fertilizer prepared with Rhizobium culture is known as "Nitrogin” Nif gene is responsible.

Alkali soil: ESP > 15, EC < 4 dsm⁻¹, pH > 8.5 also called Sodic or soil. (RPSC, AO-09)

Mostly plants absorbed micronutrients in reduced form (Mn⁺², Fe⁺²).

A unit change in pH represent a 10 fold change in H⁺ or OH⁻ activity.
- Fertilizer which is most concentrates used for nutrient supply to crops is **Anhydrous ammonia** (82% N).
- Complementary reactions between intercrops is: **Annidation**
- **Sandy soils** have higher bulk density than clay soils.
- Sheet stage of water erosion most dangerous because it's not noticed by farmers
- **Plant geometry** refers to the shape of plant
- **Crop geometry** refers to the shape of space available for individual plants.
- **Muck soil**: are having highly decomposed organic matter
- **Peat soil**: organic matter partially decomposed and found under excessive moisture condition. The pH of peat soils is 3.9 hence suitable for **paddy**.
- **Secondary clay mineral**: A mineral has been formed as a result subsequent changes in rocks is known as secondary mineral. Eg. Kaolinite, montmorillonite, illite, gypsum.
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 or fertiliser (in British English) is any material of natural or synthetic origin (other than liming materials) that is applied to soils or to plant tissues (usually leaves) to supply one or more plant nutrients essential to the growth of plants. This also depends on its soil fertility as well as organic things such as humic acid seaweed and worm castings.
Fertilizers enhance the growth of plants. This goal is met in two ways, the traditional one being additives that provide nutrients. The second mode by which some fertilisers act to enhance the effectiveness of the soil by modifying its water retention and aeration. This article, like most on fertilizers, emphasises the nutritional aspect. Fertilizers typically provide, in varying proportions: Three **primary** macronutrients:

- Nitrogen (N): leaf growth;
- Phosphorus (P): Development of roots, flowers, seeds, fruit;
- Potassium (K): Strong stem growth, movement of water in plants, promotion of flowering and fruiting;

Three **secondary** macronutrients: calcium (Ca), magnesium (Mg), and sulphur (S);

**Micronutrients**: copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn), boron (B), and of occasional significance there are silicon (Si), cobalt (Co), and vanadium (V) plus rare mineral catalysts.

The nutrients required for healthy plant life are classified according to the elements, but the elements are not used as fertilizers. Instead compounds containing these elements are the basis of fertilisers. The macronutrients are consumed in larger quantities and are present in plant tissue in quantities from 0.15% to 6.0% on a dry matter (DM) (0% moisture) basis. Plants are made up of four main elements: hydrogen, oxygen, carbon, and nitrogen. Carbon, hydrogen and oxygen are widely available as water and carbon dioxide. Although nitrogen makes up most of the atmosphere, it is in a form that is unavailable to plants. Nitrogen is the most important fertilizer since nitrogen is present in proteins, DNA and other components (e.g., chlorophyll). To be nutritious to plants, nitrogen must be made available in a "fixed" form. Only some bacteria and their host plants (notably legumes) can fix atmospheric nitrogen (N₂) by
converting it to ammonia. Phosphate is required for the production of DNA and ATP, the main energy carrier in cells, as well as certain lipids.

Micronutrients are consumed in smaller quantities and are present in plant tissue on the order of parts per-million (ppm), ranging from 0.15 to 400 ppm DM, or less than 0.04% DM. These elements are often present at the active sites of enzymes that carry out the plant's metabolism. Because these elements enable catalysts (enzymes) their impact far exceeds their weight percentage.

◆ Classification

Fertilizers are classified in many ways. They are classified according to whether they provide a single nutrient (say, N, P, or K), in which case they are classified as "straight fertilizers." "Multi – nutrient fertilizers" (or "complex fertilizers") provide two or more nutrients, for example N and P. Fertilizers are also sometimes classified as inorganic (the topic of most of this article) vs organic. Inorganic fertilizers exclude carbon-containing materials except ureas. Organic fertilizers are usually (recycled) plant- or animal-derived matter. Inorganic are sometimes called synthetic fertilizers since various chemical treatments are required for their manufacture.

◆ Single nutrient ("straight") fertilizers

The main nitrogen-based straight fertilizer is ammonia or its solutions. Ammonium nitrate (NH₄NO₃) is also widely used. About 15M tons were produced in 1981. Urea is another popular source of nitrogen, having the advantage that it is a solid and non-explosive, unlike ammonia and ammonium nitrate, respectively. A few percent of the nitrogen fertilizer market (4% in 2007) is met by calcium ammonium nitrate (Ca(NO₃)₂•NH₄NO₃•10H₂O).

The main straight phosphate fertilizers are the super phosphates. "Single super phosphate" (SSP) consists of 14–18% P₂O₅, again in the form of Ca(H₂PO₄)₂, but also phosphogypsum (CaSO₄ • 2 H₂O). Triple super phosphate (TSP) typically consists of 44-
48% of $P_2O_5$ and no gypsum. A mixture of single super phosphate and triple super phosphate is called double super phosphate. More than 90% of a typical super phosphate fertilizer is water-soluble.

◆ **Multinutrient fertilizers**

These fertilizers are the most common. They consist of two or more nutrient components.

*Binary (NP, NK, PK) fertilizers*

Major two-component fertilizers provide both nitrogen and phosphorus to the plants. These are called NP fertilizers. The main NP fertilizers are mono ammonium phosphate (MAP) and di ammonium phosphate (DAP). The active ingredient in MAP is $NH_4H_2PO_4$. The active ingredient in DAP is $(NH_4)_2HPO_4$. About 85% of MAP and DAP fertilizers are soluble in water.

◆ **NPK fertilizers**

NPK fertilizers are three-component fertilizers providing nitrogen, phosphorus, and potassium.

NPK rating is a rating system describing the amount of nitrogen, phosphorus, and potassium in a fertilizer. NPK ratings consist of three numbers separated by dashes (e.g., 10-10-10 or 16-4-8) describing the chemical content of fertilizers. The first number represents the percentage of nitrogen in the product; the second number, $P_2O_5$; the third, $K_2O$. Fertilizers do not actually contain $P_2O_5$ or $K_2O$, but the system is a conventional shorthand for the amount of the phosphorus (P) or potassium (K) in a fertilizer. A 50-pound bag of fertilizer labeled 16-4-8 contains 8 pounds of nitrogen (16% of the 50 pounds) an amount of phosphorus and potassium equivalent to that in 2 pounds of $P_2O_5$ (4% of 50 pounds) and 4 pounds of $K_2O$ (8% of 50 pounds). Most
fertilizers are labeled according to this N-P-K convention, though Australian convention, following an N-P-K-S system, adds a fourth number for sulfur.

◆ **Micronutrients**

The main micronutrients include sources of iron, manganese, molybdenum, zinc, and copper. As for the macronutrients, these elements are provided as water-soluble salts. Iron presents special problems because it converts to insoluble (bio-unavailable) compounds at moderate soil pH and phosphate concentrations. For this reason, iron is often administered as a chelate complex, e.g., the EDTA derivative. The micronutrient needs depend on the plant. For example, sugar beets appear to require boron, and legumes require cobalt.

◆ **Organic Fertilizer**

**Organic fertilizers** are fertilizers derived from animal matter, human excreta or vegetable matter. (E.g. compost, manure). Naturally occurring organic fertilizers include animal wastes from meat processing, peat, manure, slurry, and guano.

Organic chemicals have Carbon integral to their structure. In the process of composting, the balance of Carbon (browns) and Nitrogen (greens) is essential. Compost is the usual amendment to achieve healthy soil. Healthy soil grows healthy plants.

In contrast, the majority of fertilizers used in commercial farming are extracted from minerals (e.g., phosphate rock) or produced industrially (e.g., ammonia).

✧ **Sources**

The main organic fertilizers are, peat, animal wastes (often from slaughter houses), plant wastes from agriculture, and treated sewage sludge.

✧ **Mineral**
The main source of organic fertilizer is compost. Peat is a substrate. As a substrate, Peat itself offers no nutritional value to the plants, but improves the soil by aeration and absorbing water.

Mined powdered limestone rock phosphate, and Chilean salt peter are inorganic (not of biologic origins) compounds, which can be energetically intensive to harvest Animal sources.

These materials include the products of the slaughter of animals. Blood meal, bone meal, hides, hoofs, and horns are typical precursors. Fish meal, and feather meal are other sources.

Plant

Processed organic fertilizers include compost, humic acid, amino acids, and seaweed extracts. Other examples are natural enzyme-digested proteins. Decomposing crop residue (green manure) from prior years is another source of fertility.

Other ARS studies have found that algae used to capture nitrogen and phosphorus runoff from agricultural fields can not only prevent water contamination of these nutrients, but also can be used as an organic fertilizer. ARS scientists originally developed the "algal turf scrubber" to reduce nutrient runoff and increase quality of water flowing into streams, rivers, and lakes. They found that this nutrient-rich algae, once dried, can be applied to cucumber and corn seedlings and result in growth comparable to that seen using synthetic fertilizers. Treated sewage sludge

Although night soil (from human excreta) was a traditional organic fertilizer, the main source of this type is nowadays treated sewage sludge, also known as bio solids.

Bio solids as soil amendment is only available to less than 1% of US agricultural land. Industrial pollutants in sewage sludge prevents recycling it as fertilizer. The USDA prohibits use of sewage sludge in organic agricultural operations in the U.S. due to
industrial pollution, pharmaceuticals, hormones, heavy metals, and other factors. The USDA now requires 3rd-party certification of highnitrogen liquid organic fertilizers sold in the U.S.

Sewage sludge use in organic agricultural operations in the U.S. has been extremely limited and rare due to USDA prohibition of the practice (due to toxic metal accumulation, among other factors).

◇ **Urine**

Animal sourced urea and urea-formaldehyde from urine are suitable for organic agriculture; however, synthetically produced urea is not. The common thread that can be seen through these examples is that organic agriculture attempts to define itself through minimal processing (e.g., via chemical energy such as petroleum — see Haber process), as well as being naturally occurring or via natural biological processes such as composting.

◇ **Soil Erosion**

Soil erosion is the detachment, transport & deposition of soil particle on land surface - termed as loss of soil.

Soil erosion is one form of soil degradation. Soil erosion is a naturally occurring process on all land. The agents of soil erosion are water and wind, each contributing a significant amount of soil loss each year. Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil. The loss of soil from farmland may be reflected in reduced crop production potential, lower surface water quality and damaged drainage networks.

While erosion is a natural process, human activities have increased by 10-40 times the rate at which erosion is occurring globally. Excessive (or accelerated) erosion causes both "on-site" and "off-site" problems. On-site impacts include decreases in agricultural productivity and (on natural landscapes) ecological collapse, both because of loss of the
nutrient-rich upper soil layers. In some cases, the eventual end result is desertification. Off-site effects include sedimentation of waterways and eutrophication of water bodies, as well as sediment-related damage to roads and houses. Water and wind erosion are the two primary causes of land degradation; combined, they are responsible for about 84% of the global extent of degraded land, making excessive erosion one of the most significant environmental problems world-wide.

- Measured as mass/unit area - tonne/ha or Kg/sq.m
- Soil loss is of interest primarily on site effect of erosion such as loss of crop productivity
- Offsite effect of erosion are siltation in ditches streams, reservoirs
- Sediment generated by erosion process are prime carrier of agricultural chemical that pollutes stream or lakes

◆ Soil Erosion Problems

- Soil is the most precious gift of nature -Prime resource -for food, fodder etc. -Soil mismanaged less productivity.
- In India, more than 100 million hectares soil degraded eroded unproductive
- About 17 tones/ha soil detached annually->20% of this is transported by river to sea
  -> 10% deposited in reservoir results 1 to 2% loss off storage capacity.
- When a raindrop hits soil that is not protected by a cover of vegetation and where there are no roots to bind the soil, it has the impact of a bullet.
Soil particles are loosened, washed down the slope of the land and either end up in the valley or are washed away out to sea by streams and rivers.

Erosion removes the topsoil first. Once this nutrient-rich layer is gone, few plants will grow in the soil again.

Without soil and plants the land becomes desert like and unable to support life.

Soil erosion deteriorates soil quality & reduces productivity of natural, agricultural & forest ecosystem.

Soil erosion deteriorates quality of water.

Increased sedimentation causes reduction of capacity of water bodies.

◆ **Causes of soil erosion**

Erosion occurs when farming practices are not compatible with the fact that soil can be washed away or blown away. These practices are:

- Inappropriate farming techniques such as deep ploughing land 2 or 3 times a year to produce annual crops.
- Lack of crop rotation.
- Planting crops down the contour instead of along it.

◇ **Human Induced & Natural Causes**

- Land use - Over grazing by cattle, Deforestation arable land use, faulty farming, construction, mining etc.
- Climatic conditions: precipitation & wind velocity.
- Soil: soil characteristics - texture, structure water retention and transmission properties.
- Hydrology: Infiltration, surface detention, overland flow velocity, and subsurface water flow.
- Land forms: Slope gradient, slope length and shape of slope.

◆ **Types of Soil Erosion** - Geological erosion, Natural erosion & Erosion from activities of human & animals.

- Geological erosion:- Soil forming and distribution.
• Human and animal: Tillage, removal of plants and other vegetarian -> Accelerated erosion
• Stream bank erosion
• Landslide, Volcanic eruption, flooding
• Water and wind: major factors of soil erosion

◆ Soil Erosion Parameters

Soil erosion – function of:

- Erosivity – depends on rainfall
- Erodibility – property of soil
- Topography – property of land
- Management – contributed by man
- Erodibility – Detachability & transportability
- Topography – Slope, length, relation to other land
- Management – Land use & crop management