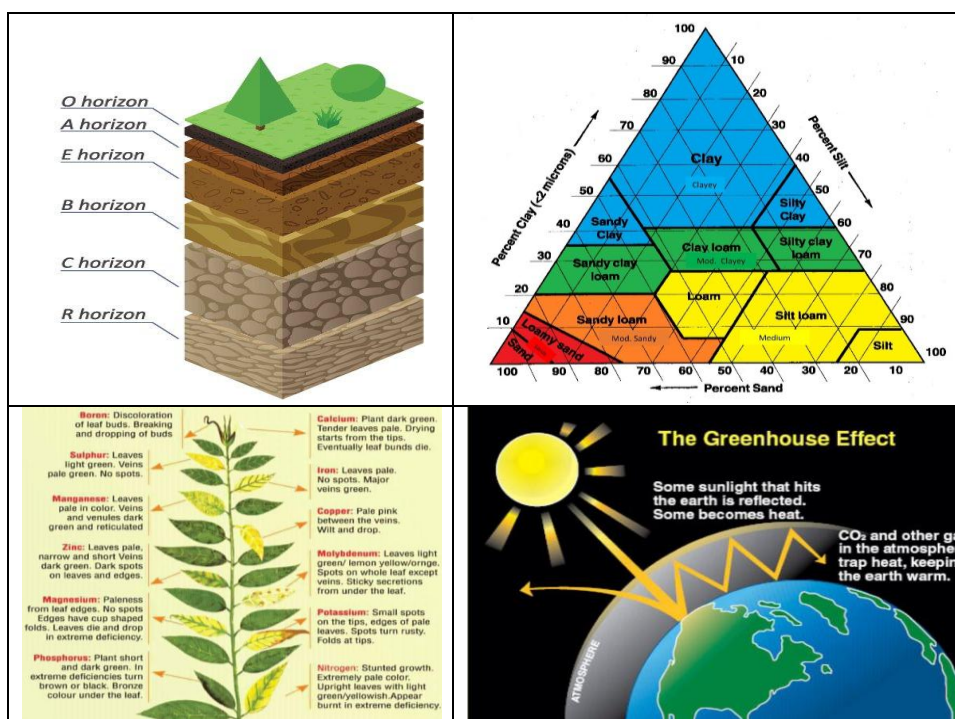


ACHARYA N.G.RANGA AGRICULTURAL UNIVERSITY  
DIPLOMA IN AGRICULTURE



**COURSE MATERIAL**  
**Soil Chemistry and Fertility**  
(Course No.DA-121)  
(Credit hrs: 3 (2+1))  
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## DIPLOMA IN AGRICULTURE

Course No: DA 121

Course title: SOIL CHEMISTRY AND FERTILITY

### Lecture Outlines

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## LECTURE 1 INTRODUCTION TO SOIL SCIENCE

Soil is a unique living ecosystem that provides a wide range of services to people. It is the foundation of life on the planet, home to biodiversity, it regulates the water cycle, stores and filters water, is the basis for producing food and fuel, it facilitates the natural recycling of waste, eliminates pollutants and stores CO<sub>2</sub>.

One teaspoon of soil contains more living organisms than there are people in the world. There would be no life without soil, we depend on it for our very existence.

If planet earth is our mother, then soil must be our father. As we have only one planet, soil is a finite resource, so we have to take good care of its health and wellbeing to ensure it can continue to deliver the many services it provides to humans.

Soil is the nature's gift to the mankind. The top layer of earth surface which is suitable for cultivation of crops is referred as soil. Soils are formed due to weathering of rocks by physical disintegration and chemical decomposition. The rocks and minerals present in the earth surface are continuously influenced by climatic changes like temperature fluctuations, heat waves, intense rainfall, freezing and thawing, burrowing of soil fauna, human and animal interventions, etc and undergo decomposition to form soil.

Soil formation is a very slow process and it is said to take about 500-1000 years to form an inch of soil layer on earth surface. Soil is an important natural source for an agricultural dependent country like India. The fertile soil can support plant life by providing water and nutrients to them. Soil is the habitat for soil biota which will carry out different biological and biochemical processes in soil through which nutrients are supplied to the plants. Hence, adoption of management practices for preserving the soils and maintaining soil fertility is essential to meet the food requirements of human population.

## LECTURE 2 DEFINITION OF SOIL

Soil is a natural body composed of inorganic and organic constituents, having a definite genesis and a distinct nature of its own" —**Dokuchaev (1900)**

"Soil is a natural occurring body that has been evolved owing to combined influence of climate and other organisms, acting on parent material, as conditioned by relief over a period of time"--**Jenny(1941)**

Soil is a dynamic natural body on the surface of the earth, in which plants grow, composed of mineral and organic materials and living forms. ( **Buckman and Brady**)

Soil is the unconsolidated mineral matter on the immediate surface of the earth that serves as a natural medium for the growth of plants”

Soil is the unconsolidated mineral matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of parent material, climate, macro and micro organisms and topography, all acting over a period of time and producing a product, that is soil, that differs from the material from which it is derived in many physical, chemical, biological and morphological properties and characteristics--**SSSA(1970)**

Soil is a natural body synthesized in a profile form from a variable mixture of broken and weathered minerals and decaying organic matter, which covers the earth in a thin layer and which supplies, when containing proper amounts of air and water, mechanical support and in part sustenance to plants”

### **LECTURE 3**

#### **STUDY OF SOIL PROFILE**

A vertical section of soil through all its horizons and extending into the parent material. A vertical exposure of the horizon sequence is termed as “soil profile”.

A soil horizon is a layer of soil, approximately parallel to the soil surface, differing in properties and characteristics from adjacent layers below or above it.

Soil profile is an historic record of all the soil forming processes and it forms the unit of study in pedological investigations. Practically, soil profile is an important tool for soil classification which is applicable for thorough understanding of the soils.

Five master horizons are recognized in soil profile and are designated using capital letters O, A, E, B and C.

**O Horizons:**(Organic) It comprises of organic horizons that form above the mineral soil. They result from litter derived from dead plants and animals. ‘O’ horizons usually occur in forested areas and are generally absent in grass land regions.

**A - Horizon:**It is the top most mineral horizon. It contains a strong mixture of decomposed (humified) organic matter, which tends to impart a darker color than that of the lower horizons.

**E - Horizon:** It is an eluviated horizon. Clay and sesquioxides are invariably leached out, leaving a concentration of resistant minerals such as quartz. An 'E' horizon is generally lighter in color than the 'A' horizon and is found under 'A' horizon.

**B"- Horizon :** (Illuvial) The sub-surface 'B' horizons include layers in which illuviation of materials has taken place from above and even from below. In humid regions, the B horizons are the layers of maximum accumulation of materials such as sesquioxides and silicate clays. In arid and semi-arid regions  $\text{CaCO}_3$ ,  $\text{CaSO}_4$  and other salts may accumulate in the B horizon.

**C' – Horizon:** It is the unconsolidated material underlying the 'Solum' (A & B). It may or may not be the same as the parent material from which the solum formed. The 'C' horizon is outside the zones of major biological activities and is generally little affected by the processes that formed the horizons above it.

**R'-Layer:** Underlying consolidated rock, with little evidence of weathering.

A+B is called solum and solum along with bed rock is called regolith.

## **LECTURE 4**

### **CLASSIFICATION OF SOILS**

In earlier days based on the fertility of soil , soils are classified into two types are 1. Urvara and Ustava. In 1956, according to soil survey staff soils are classified into 12 orders.

1. Alfisols
2. Andisols
3. Aridisols
4. Entisols
5. Gelisols
6. Histosols
7. Inceptisol
8. Mollisols
9. Oxisols
10. Spodosols
11. Ultisols
12. Vertisols

## LECTURE 5

### DIFFERENCES BETWEEN SURFACE AND SUB SURFACE SOIL

Surface soil	Subsurface soil
1. Soil upto depth of 30cm	1. Soil layers beyond 30cm depth
2. Physically loose & granular	2. Comparatively compact
3. More porosity	3. Less porosity
4. More organic matter	4. less organic matter
5. Biological activity is more	5. Biological activity is less
6. Mostly manipulated zone	6. Unmanipulated
7. Root activity is more	7. less
8. It is completely weathered	8. It is partially weathered

“Soil is the interface of the organic and inorganic chemistry of the terrestrial world, combining nitrogen and carbon from the atmosphere with the various elements of mineral lithosphere via the organisms anchored in the soil, intercepting energy of the sun and moisture from the hydrosphere and atmosphere.”

The word “Soil” is derived from Latin word ‘Solum’ means ‘Floor’ or ‘Ground’

### SOIL COMPONENTS

Mineral soil consists of four major components i.e., inorganic or mineral materials, organic matter, water and air. In a representative loam surface soil, the solid mineral particles comprise about 45% of the soil volume and organic matter 5%. At optimum moisture for plant growth, the pore space is divided roughly in half, 25 %, of volume being water space and 25 % air. The proportions of air and water are subjected to rapid and great fluctuations.

The four soil components occur in a thoroughly mixed condition in soil and this mixture encourages interactions within and between the groups and permits marked variations in the environment for the growth of plants.

The proportion of different components in the diagram depicts the good soil condition for plant growth (Loam surface soil). The air and water are extremely variable and their proportions determine in large degree the soil’s suitability for the plant growth.

**Mineral Matter:** The Inorganic portion of soils is quite variable in size and composition. It is composed of small rock fragments and minerals of various kinds.

**OrganicMatter:** It comprises an accumulation of partially disintegrated and decomposed plant and animal residues and other organic compounds synthesized by soil microbes as the decay occurs. It is a transitory soil constituent as it is continuously broken down by soil organisms and lasts from few hours to several hundred years. It requires maintenance by regular addition to the soil of plant and/ or animal residues .Organic matter content varies from 1.0 to 6.0 % by weight in top soil and very less in subsoil. In respect of soil productivity organic matter plays an indispensable role.

## LECTURE 6

### SOIL PHYSICAL PROPERTIES

**SOIL PHYSICS:** Soil Physics is a branch of Soil Science dealing with physical properties of soil, aswellas with the measurement, prediction and control of different processes taking place in and through the soil.

**SOIL PHYSICAL PROPERTIES:** The physical properties include texture, structure, density, porosity, consistency, temperature, colour and water content. The physical properties depend on the amount, size, shape and arrangement and mineral composition of its particles, kind and amount of organic matter and the volume and form of its pores and the way they are occupied by water, air at a particular time.

### LECTURE 6.1

#### SOIL TEXTURE

**SOIL TEXTURE :** Soil texture may be defined as the relative proportion of particles of various sizes (Soil separates / Mechanical fractions) such as sand, silt and clay. It is almost a permanent property of the soil and may change slowly with time.

Textural components and their properties: Soil contains various sized particles; some of which (Gravels, Stones, Cobbles and Boulders) obviously do not behave like soil, but are reported volume fraction and size range) if occupy enough of soil volume to influence soil physical processes significantly. Conventionally the particles smaller than 2.0mm diameter are considered a soil material.

#### Nature and Properties of Soil Separates

**1. Sand:** Sand particles may be rounded or irregular with quite jagged surfaces depending on the abrasion they receive. These particles exhibit no plasticity and stickiness and hence less influenced by changes in moisture content. Their water holding capacity is low, percolation rate is high and facilitate good drainage and good air movement. Soils dominated by sand and other particles bigger than sand are

invariably open, loose and in friable condition. As these fractions are the fragments of the rocks with quartz as chief component, they are chemically inactive and insoluble.

**2. Silt** is intermediate between sand and clay in size (ISSS – 0.02 – 0.002 mm; USDA – 0.05 – 0.002 mm) and irregular in shape. Mineralogically and physically, silt particles greatly resemble sand particles, but since they are smaller and have a greater surface area per unit mass and are often coated with strongly adherent clay, they may exhibit some of the physico-chemical attributes of clay. Silt is dominated by quartz and micas like primary minerals; and possess some plasticity, cohesion and adsorption. They hold moisture but lesser than clay.

**3. Clay** fraction is less than 0.002 mm in size and forms the decisive fraction of the soil, which has most influence on soil behaviour. Clay particles are characteristically plate like or needle like in shape. Clay particles adsorb water and hydrate, thereby causing the soil to swell upon wetting and then shrink upon drying. They are very plastic and sticky in moist condition; and become hard and cloddy when dry. High tenacity of clay makes the cultivation difficult. The relatively inert sand and silt fractions can be called the ‘Soil Skeleton’, while the clay, by analogy, can be thought of as the ‘Flesh’ of the soil.

**Stones, cobbles and Gravel:** Because of their sizes, function as separate particles. Stones, cobbles and gravel may be more or less rounded, irregularly angular or even flat.

## **LECTURE 6.2 SOIL STRUCTURE**

**Soil Structure** may be defined as ‘the arrangement of primary particles (sand, silt and clay), secondary particles (aggregates) and voids (pores) into a certain definite pattern under field conditions. In the broad sense Soil Structure denotes: a) the size, shape and arrangement of particles and aggregates; b) the size, shape and arrangement of the voids or spaces separate the particles and aggregates; and c) the combination of voids and aggregates into various types of structures.

**Peds** – Natural aggregates which vary in their water stability.

**Clod** – It is used for a coherent mass of soil broken into any shape by artificial means such as by tillage.

**Fragment** - It is a broken ped.

**Concretion** – It is a coherent mass formed within the soil by the precipitation of certain chemicals dissolved in percolating waters. Concretions are usually small like shot gun lead pellets

**TYPES:** As per the geometric shape, the aggregates can be broadly divided in to two types.

1. Simple structure
  2. Compound structure
1. **Simple structure:** In this the natural cleavage plains are absent or indistinct.
    - a. Single grain structure: Occur in sandy soils
    - b. Massive structure: Coherent mass with high bulk density occur in soil crusts, paddy soils
    - c. Vesicular or honeycomb structure: Massive or loose aggregates of nodular ferruginous mass. seen in laterites.

**2.Compound Structure:** The natural cleavage plains are distinct. Described with relative length of horizontal and vertical axes and shape of peds.

1. Spheroidal
2. Plate like
3. Block Like
4. Prism – Like

### LECTURE 6.3 SOIL BULK DENSITY AND PARTICLE DENSITY

Density is the weight per unit volume of a substance. It is expressed as gram per cubic centimeter or pound per cubic feet or mega gram per cubic meter ( $Mg\ m^{-3}$ ). Two density measurements like particle density and bulk density are common for soils.

#### Particle density

It is the mass per unit volume of soil solids. Particle density is essentially the same as the specific gravity of solid substances. The chemical composition and crystal structure of a mineral determines its particle density. Particle density is not affected by pore space and therefore is not related to particle size or to the arrangement of particles (Soil structure).

Particle densities for most mineral soils vary between the narrow limits of 2.60 to 2.75  $Mg\ m^{-3}$ . The particle density of soils with very high organic matter content may vary from 0.9 to 1.3  $Mg\ m^{-3}$ . Particle density of soils is almost a permanent character which is not influenced by addition of organic matter, tillage or depth.

Humus	1.3-1.5	Clay	2.2-2.6
Orthoclase	2.5-2.6	Quartz	2.5-2.8
Calcite	2.6-2.8	Muscovite	2.7-3.0
Biotite	2.8-3.1	Apatite	3.2-3.3
Pyrite	4.9-5.2	Hematite	4.9-5.3

## Bulk Density

It is the mass per unit volume of dry soil (volume of solid and pore spaces). The bulk density of a soil is always smaller than its particle density.

Loose and porous soils have low bulk densities as compared to compacted soils. Bulk density is of importance than particle density in understanding physical behaviour of soils. Generally in normal soils bulk density ranges from 1.0 to 1.60  $\text{Mgm}^{-3}$ . Finer the texture of the soil, lesser is the bulk density.

Sand dominated soils	1.7 $\text{Mgm}^{-3}$
Organic peat soils	0.5 $\text{Mgm}^{-3}$
Compacted sub soils	2.0 $\text{Mgm}^{-3}$

## Factors affecting bulk density

- More is the pore space, per unit volume of soil, less is the bulk density.
- Higher is the compactness; more will be the bulk density.
- Higher is the depth of soil, more will be the bulk density.
- Finer is the texture of the soil, lesser is the bulk density.
- High organic matter contents, lead to reduced bulk density.
- Crumb soil structure shows low bulk density than that of platy structure.
- Tillage temporarily reduces the bulk density.
- Cropping increases the bulk density of top soils.

## Importance of bulk density

- Bulk density of the soil determines not only total pore space but the macro and micro pore space also, which in turn governs the soil– water – air relationship, there by facilitate better crop growth.
- Infiltration, permeability, percolation of water and water retention in soil system, have direct relation with bulk density of soil.

## 6.4 LECTURE

### SOIL POROSITY

**Porosity of soils:** Porosity refers to the percentage of soil volume occupied by pore space. Pore spaces (voids) in a soil constitute portion of soil volume not occupied by solids, either mineral or organic. The pore spaces under field conditions are occupied at all times by air and water. Pore spaces directly control the amount of water and air in the soil and indirectly influence the plant growth and crop production.

**Soil pores:**

- a. Macro pores
- b. Micro pores or capillary pores

**Macropores:** Large sized pores (>0.06mm) invariably exist in between sand sized granules and allow air and water movement readily.

**Micro or capillary pores:** Smaller sized pores (<0.06mm) in which movement of air and water are restricted to some extent. These pores are very important for crop growth. Generally clays and clayey soils have a greater number of capillary pores.

Coarse pores	: > 20 $\mu$
Medium pores	: 20-200 $\mu$
Fine pores	: 2-20 $\mu$
Very fine pores	: <2 $\mu$

The existence of approximately equal number of macro and micro pores would facilitate better aeration, permeability, drainage and water retention

**Pore space in different soils**

S.No.	Type of soil	Pore space(%)
1.	Sandy soil	30
2.	Light clay soil	35
3.	Medium clay soil	40
4.	High clay soil	50
5.	Heavy black soils	66

**LECTURE 6.5  
SOIL COLOUR**

Soil colour is one of the obvious characteristics of soil and is frequently used to describe soil, than any other. Soil color, as such, does not have any influence on plant growth, but through its influence on soil temperature and soil moisture, it indirectly influences the plant growth.

**Colour components:**

As the soil color is the important parameter, used to classify the soils, a standard system for accurate colour description has been developed using Munsell color charts. In this system, a small piece of soil is compared to standard colour chips in a soil colour

book. Each colour chip is described by the three components of colour i.e., hue, value and chroma

**Hue** refers to the dominant spectral colour or quality which distinguishes red from yellow etc.

**Value or brilliance** expresses apparent lightness as compared to absolute white. It refers to relative brightness or darkness of colour with in a scale of (0–10) as compared to absolute white. It refers to gradations white to black (lightness or darkness).

**Chroma** defines the gradations of purity of colour, or the apparent degree of departure from neutral grays to white (intensity or brightness) (strength of colour), with in a scale ranging from (0–20).

The numerical notation 2.5YR5/6 suggests a hue of 2.5YR, value of 5 and chroma of 6.

Element	Soil colour
Fe, Mn	Red, brown
ferric	yellow
Ferrous	Ash colour
Ca, N	Black, ash colour
Base salts	White, black
Waterlogged soils	Yellow

## LECTURE.6.6 SOIL TEMPERATURE

Heat is a form of energy and temperature is a measure of the heat energy. Solar radiation is the source of soil heat. The flux of heat (calories or joules) into and out of the soil determines the soil thermal regime, which is characterized in terms of soil temperature (°C).

### Heat capacity or Thermal capacity

The “heat capacity” of a soil is defined as the ratio of heat supplied to a body to the corresponding rise in its temperature.

The heat capacity per unit mass of a body is called the “specific heat (e) and is defined as the quantity of heat required to raise the temperature of a unit body through 1°C.

The heat capacity is expressed as quantity of heat required to raise the temperature of unit volume of soil by 1°C and is known as “Volumetric heat capacity” or simply the “heat capacity”(gram calorie)  $C_v = \text{J/m}^3/\text{°C}$  or  $\text{Cal/cm}^3/\text{°C}$

**Importance of soil temperature:**

- Too low or too high temperatures affect the germination of seeds. Different crops have different optimum temperature for germination.
- Absorption of water and nutrients is impaired under low temperatures.
- Temperature influences nutrient availability by affecting the weathering of minerals and decomposition of organic matter.
- Low soil temperature results in white succulent roots with less branching.
- Low temperature enhances disease incidence by parasitic fungi
- Soil microbial activity and decomposition of organic matter is restricted below 10 °C and ceases below 5°C.
- Biological nutrient transformations like nitrification, ammonification etc are affected by very high or low temperatures.

**LECTURE 6.7  
SOIL WATER**

Soil water is held in soil pores with varying degrees of tenacity depending on the amount of water present and size of the pores. Soil water with its soluble constituents (nutrients) makes up soil solution, which is the critical medium for supplying nutrients to growing plants. Soil water plays significant role in controlling energy balance of the soil and regulates the gaseous exchange in the upper layer of the soil.

The presence of water in different amounts in soil governs its thermal, mechanical, physical, chemical and biological properties.

**Importance of soil water:**

**Saturation**

Saturation water content is the amount of moisture present, when all the pores are filled with water. A soil whose pore spaces are completely filled with water is said to be saturated soil and the water is at zero tension. Such conditions is established only in coarse textured soils but not in fine textured soils as some fine capillary pores are filled with air.

So the soil normally flooded with water will not be saturated as some air is blocked. Hence it is better to define a soil as saturated when the water is at zero tension and majority of its pores are filled with water.

**Aeration– Porosity Limit (Non-capillary porosity):** Aeration porosity of a soil is defined as that part of the pore space volume that is free of water which can be established by creating a tension of water column of 50cms. This corresponds to a pF of 1.7 or 1/20 atmospheres tension. Aeration porosity is the volume of the pores whose diameter is more than 0.06 mm.

### **Field Capacity**

After heavy rain or irrigation to the soil the water drains off rapidly for the first few hours and then starts to drain slowly. After two or three days, this rapid movement becomes slow and negligible later. The soil is said to be at field capacity. At this condition water moves out of macro pores and air occupies their places. The micro pores are still filled with water, which is available to plants. Moisture movement continues but very slowly. The moisture tension corresponds to pF of 2.53.

### **Permanent Wilting Point:** (wilting coefficient or Permanent wilting percentage):

It is the soil moisture content at which plants show wilting symptoms and can't recoup or recover even though it is kept in humid chamber. It occurs at pF value 4.18. The ease of release of water to the plant roots is just barely too small to counter balance the transpiration losses. Sometimes, plants exhibit wilting symptoms but recover with the addition of water or when placed in humid chamber. The water content at this condition is called the temporary wilting point. The water remains in small capillary pores and around the soil particles.

### **Hygroscopic Coefficient**

Hygroscopicity is the ability of a body to adsorb moisture from the atmosphere. It largely depends on amount and type of clay, exchangeable cations and presence of free electrolytes. Soils high in expanding type of clay minerals and organic matter have a high hygroscopic coefficient. This water is not available to plants, but available to certain microbes.

**Available water:** Water held by soil at potential ranging between -15 bars to -1/3 bars, is considered as plant available water.

**Infiltration :** Infiltration is the entry of water at the soil air interface due to sorption and vertical flow of water through the soil profile. This process is of great practical significance, as it determines how much of rain storm or irrigation water enters the soil and how much over flows the land surface as run-off.

Irrespective of soil texture, the infiltration rate in a dry soil would be high, initially and the infiltration rate reduces exponentially with time and attains a steady rate after a long lapse of time. It is expressed as millimeters per hour. Infiltrate rate is high and constant in non-swelling clay soil i.e., laterite soils.

**Percolation** : The downward movement of water through soil. Percolation occurs when the water is under pressure or when the tension is smaller than about  $\frac{1}{2}$  atmosphere or when the hydraulic gradient of the order of 1.0 or less.

Percolation is very important in soil development and land management. Percolation removes some valuable nutrients away from soil i.e. nitrates and calcium.

In coarser textured soils, which are porous in nature (macropores) exhibits greater percolation capacity. As evaporation and transpiration use up much of water that enters the soil, the amount of water that percolates through it decreases with depth. The greatest amount of percolation goes on in the top few centimeters.

**Permeability** : The ease with which water pass through a bulk mass of soil or a layer of soil is the permeability of the soil.

## LECTURE 7 IRRIGATION WATER ANALYSIS

### Collection of water sample:

Water samples should be collected in clean glass/ plastic bottles with tight lid. Minimum 500ml of water sample should be collected. Water sample should be collected from bore wells or tubes after running 10 minutes. After collection of water sample, it should be labelled properly and keep it by addition of toluene chemical for storage. Water samples will be analysed for pH, EC, RSC and SAR.

### Quality Indices:

After analysis of polluted water sample for different parameters like cations and anions, it is imperative to calculate certain indices in order to assess the polluted water quality class & its subsequent effect on soils and crops.

Important indices of water quality used for irrigation purpose are the following:

#### Water pH

<7.0	-	Acidic
>7.0	-	Alkaline
7.0	-	Neutral

### Water Electrical conductivity

<u>Class</u>		<u>Salinity Level</u>
C <sub>1</sub>	→	0-0.25 dSm <sup>-1</sup> (Safe)
C <sub>2</sub>	→	0.25-0.75 dSm <sup>-1</sup> (moderate)
C <sub>3</sub>	→	0.75-2.25 dSm <sup>-1</sup> (high)
C <sub>4</sub>	→	>2.25 dSm <sup>-1</sup> (very high)

### Sodium Adsorption Ratio(SAR):

The SAR gives the relative proportion of sodium ions (Na<sup>+</sup>) with respect to Ca<sup>+2</sup> & Mg<sup>+2</sup> in the water sample. It is calculated to indicate the sodicity /alkalinity hazard of irrigation water.

$$\text{SAR} = \frac{\text{Na}^+}{\sqrt{(\text{Ca}^{+2} + \text{Mg}^{+2})/2}}$$

Where the concentrations of cations is in meq/litre. SAR had no units being it is a ratio. Based on the values of SAR, water can be rated into different categories of sodicity according to Richard's as follows:

<u>SAR</u>	<u>Class</u>
<10	R <sub>1</sub> - Safe for irrigation
10-18	R <sub>2</sub> - Moderately safe for irrigation
18-26	R <sub>3</sub> - moderately unsafe for irrigation
>26	R <sub>4</sub> - Unsafe for irrigation

### Residual Sodium Carbonates (RSC):

This index is important for carbonates and bicarbonates rich irrigation water. It indicates their tendency to precipitate Ca<sup>+2</sup> as CaCO<sub>3</sub>. The RSC is calculated by using a formulae.

$$\text{RSC (meq/litre)} = [(\text{CO}_3^{-2} + \text{HCO}_3^-) - (\text{Ca}^{+2} + \text{Mg}^{+2})]$$

Concentration of both cations and anions is in meq/litre. Alkalinity hazard in terms of RSC is categorized as under.

<u>RSC (meq/litre)</u>	<u>Class</u>
<1.25	S <sub>1</sub> - Safe
1.25-2.5	S <sub>2</sub> - Moderate
>2.5	S <sub>3</sub> - Unsafe

## LECTURE 8

### SOIL PH, EFFECT OF PH ON NUTRIENT AVAILABILITY

**pH** : Sorenson (1909) suggested the term pH (pH puissance dehydrogen or pouvoir hydrogen ), which means the power of hydrogen. pH is the negative logarithm of hydrogen ion activity.

$$\text{pH} = - \log_{10} (\text{H}^+)$$

Classification of soils based on pH: Based on the pH value of soil solution, the soils have been classified into the following categories.

<b>pH Range</b>	<b>Category (Rating)</b>
< 4.5	Extremely acidic
4.5 – 5.0	Very strongly acidic
5.1 – 5.5	Strongly acidic
5.6 – 6.0	Medium acidic
6.1 – 6.5	Slightly acidic
6.6 – 7.5	Neutral
7.5 – 7.8	Mildly alkaline
7.9 – 8.4	Moderately alkaline
8.5 – 9.0	Strongly alkaline
> 9.1	Very strongly alkaline

#### Factors affecting soil pH on nutrient availability

Soil reaction is the important factor which governs the availability of various nutrients by influencing the soil properties like physical, chemical and biological etc.

**Soil reaction and microbial activity:** The activity of microbes is influenced by the variations in soil pH. Bacteria and actinomycetes prefer near neutral to slightly alkaline reaction (pH 6.5 – 8.0). Fungi work satisfactorily at all pH ranges. They face a

large competition at higher pH values with bacteria and actinomycetes. Hence they grow better in acidic reaction of pH between 4.5 to 6.5.

**Nitrogen:** Plants absorb nitrogen in the form of  $\text{NO}_3^-$  whose formation depends on the ability of nitrifying bacteria. The microbes responsible for nitrification are active when the soil pH is between 6.5 to 7.5. Nitrogen fixing bacteria also fail to function below a soil pH of 6.0.

**Phosphorus :** Phosphorus availability is high when soil pH is between 6.0 to 7.5. At pH values less than 5.0, soluble phosphates are fixed as complex and insoluble compounds of Fe, Al and Mn. At pH values of more than 7.5, complex insoluble calcium phosphates like apatites. Excess calcium also hinders the phosphorus absorption and utilisation by the plants.

**Calcium and magnesium** and other basic cations like potassium become deficient due to their leaching.

**Sulphur:** The bacteria responsible for the oxidation of sulphides to sulphates can function satisfactorily at all pH values.

**Micronutrients :** The availability of micronutrients like zinc, iron, copper and manganese are more in the acidic range. Under acidic conditions as in the humid regions because of high rainfall due to leaching of bases, aluminium, iron and micro nutrients become toxic. They are more soluble at low pH. At a soil pH of less than 5.5, aluminium starts to leave the structure of silicate clays. High levels of soluble aluminium are injurious to crops. Aluminium toxicity increases water stress during dry period.

## LECTURE 9 SOIL COLLOIDS AND THEIR PROPERTIES

Thomas Graham (1861) coined the term 'colloid' ( Greek Kolla = glue eidos = like ) In a true solution as sugar or salt in water the solute particles are dispersed in the solvent as single molecules or ions. In this case the diameter of dispersed particles ranges from  $1\text{A}^0$  to  $10\text{A}^0$  (0.00001 to  $0.001\mu$ ).

### General Properties of Colloids

- 1 Shape
- 2 Size
- 3 Surface area
- 4 Electrical charge
- 5 Adsorption

- 6 Plasticity
- 7 Cohesion
- 8 Swelling & Shrinkage
- 9 Flocculation & Deflocculation
- 10 Brownian movement
- 11 Tyndal effect

**Shape :** The mineral colloids are laminated, made up of layers of plates or flakes or even rods. The different units or flakes of clay minerals are held together with varying degrees of force depending upon the nature of the clay mineral.

The edges of clay minerals are of clean cut or frayed or fluffy. In all cases clay minerals are developed more in the horizontal axis than of vertical axis.

Kaolinite----- Hexagonal crystals

Montmorillonite -- Flakes

Humus-----Variable

Halloysite-----Rod shaped

**Size and Surface Area :** Colloids are extremely small in size. The upper limit in diameter for the colloidal state is generally considered to be about one micron. Some with upper limit of  $2\mu$  exhibit colloidal properties but they are not technically colloids.

The colloids expose a large surface area per unit mass. The external surface area of one gram of clay colloid is at least 1000times that of one gram of sand. Certain silicate clays with expanding plate like makeup offer internal surfaces besides external surface area. The total surface area of soil colloids ranges from  $10\text{m}^2/\text{g}$  for clays with only external surfaces to more than  $800\text{ m}^2/\text{g}$  for clays with extensive internal surfaces. The colloidal surface area in the upper 15 cm of a hectare of a clay soil could be as high as 7,00,000 sq.kms.

**Electrical Charge:** The colloidal surfaces, both external and internal characteristically carry negative and / or positive charges. For most colloids electronegative charges predominate, although some mineral colloids in very acid soils have a net positive charge.

**Adsorption :** Adsorption of cations / anions and water is the important consequence of the charges on colloids. The negatively charged colloids are of practical significance, as they attract hundreds of thousands of positively charged ions (cations). This gives rise to an ionic double layer.

The adsorption of ions is governed by the type and nature of ion, ion concentration and the type of colloidal particle.

- Higher is valency, higher the adsorption (excepting H<sup>+</sup>)
- With same valency, the ion with more atomic weight is preferred.
- Concentration of the ion in the solution also determines the adsorption rate.

**Plasticity :** Soil containing more than about 15% clay exhibits plasticity that is pliability and the capability of being molded. This property is due to the plate like nature of the clay particles and the combined lubricating and binding influence of the adsorbed water. Thus the particles of plastic soils easily slide over each other, much like panes of glass with films of water between them.

Plasticity is of practical importance because of its influence on tillage operations. The clayey soils with smectite type clay minerals present a significant problem, by not allowing to obtain a stable granular structure.

#### **Montmorillonite > Illite > Kaolinite**

**Swelling and shrinkage:** Some clays swell when wet and shrink when dry. After prolonged dry period, soils rich in smectite minerals often are criss-crossed by wide deep cracks that, at first, allow rain water to penetrate rapidly. Later, because of swelling, such a soil is likely to close up and become much impervious than one dominated by kaolinite or illite.

Inter crystal expansion; adsorbed ions for water and air entrapped are primarily responsible for swelling.

**Cohesion :** It indicates the tendency of clay particles to stick together. This tendency is due primarily to the attraction of the clay particles for the water molecules held between them. Hydrogen bonding between the clay surfaces and water and also among water molecules is the attractive force responsible for cohesion. It results in the formation of some resistant hard clods. Smectites and fine grained micas exhibit a noticeable degree of cohesion. In contrast, humus reduces the attraction of individual clay particles for each other.

**Brownian Movement:** The continuous rapid zigzag movement executed by a colloidal particle in the dispersion medium is called Brownian movement or Motion (Robert Brown, 1927).

In a colloid suspension, the colloidal particles are under constant rapid motion. They move in a short straight line path in the medium and change their path abruptly due to collision with other colloidal particles or molecules of dispersion medium.

The smaller the particle, the more rapid is its movement and more often does it collide. The Brownian movement is mainly responsible for the coagulation or flocculation of colloidal particles.

**Tyndal Effect** : Dust particles float in air form a colloidal suspension. If a strong beam of light is passed through such suspension the particles appear bigger than original size. This is due to the diffusion of light by the colloidal sized particles, which is called “Tyndal Effect”.

**Flocculation** : Aggregation or clumping together of individual, tiny soil particles is called flocculation.

Clay particles by virtue of carrying negative charge on its surface repel each other and disperse in the medium. When the negative charge is satisfied by cations, which are tightly held on clay surface, the repulsive forces would be very minimum. It leads to coagulation or flocculation of soil particles.

From the stand point of agriculture, flocculation is generally beneficial because it is the first step in the formation of stable aggregates or granules. The ability of common cations to flocculate soil colloids is in the general order of  $\text{Al}^{3+} > \text{H}^+ > \text{Ca}^{2+}$ ,  $\text{Mg}^{2+} > \text{K}^+ > \text{Na}^+$ . Incidentally the colloidal complexes of humid and sub-humid region soils are dominated by aluminum, hydrogen, calcium and magnesium and those of semi-arid regions are high in Calcium and magnesium ions.

**Deflocculation** : It is the dispersion of colloidal particles, due to the repulsion of negatively charged particles. Under deflocculated condition particles move away from each other, and act independently.

Dispersion is encouraged by the large number of water molecules associated with each micelle and with the adsorbed cations. Highly hydrated monovalent cations like  $\text{Na}^+$  do not effectively reduce the electro negativity of the micelle and are loosely held. It makes the individual micelles to repel each other continuously and stay in dispersion.

Dispersion can be reduced by (i) decreasing the pH of the medium (ii) replacing the sodium with  $\text{H}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  and  $\text{Al}^{3+}$  like cations and (iii) increasing the salt concentration in the soil solution.

## LECTURE. 10

### ION EXCHANGE IN SOIL, BASE SATURATION

Ion exchange is defined as a reversible process by which cations and anions are exchanged between solid and liquid phases and between solid phases, if in close contact with each other. Adsorption is defined as a phenomenon by which an increase in concentration or an accumulation of an ion on a solid occurs due to ion exchange or other reactions. Desorption is a phenomenon by which the replacement or release of an adsorbed ion species occurs.

#### Cation Exchange

The process of replacement of cations adsorbed on exchange complex by other cations is called cation exchange. The reaction of cation exchange takes place rapidly and the inter change is chemically equivalent

#### Cation Exchange capacity of soils (Thomas Way,1850)

The sum total of the exchangeable cations that a soil can absorb is known as "Cation Exchange Capacity" of that soil. It is the amount of exchangeable cations per unit weight of dry soil. It is measured in mill equivalents of cations per 100 grams of soil (Recently  $\text{cmol (p}^+) \text{ kg}^{-1}$ )

The mill equivalent is used because the number of negative charge sites in a given sample does not change, but the weights of cations, that may be adsorbed to those sites at one time do change because they have different weights.

**Base Saturation** : The percentage of total CEC satisfied with basic cations is termed base saturation. It is defined as the extent to which the exchange complex of a soil is saturated with exchangeable cations other than hydrogen and aluminum and it is expressed as a percentage of the total cation exchange capacity.

$$\% \text{Base Saturation} = \frac{\text{m.eq. of basic cations per 100g soil}}{\text{Total CEC in m.eq. per 100g soil}} \times 100$$

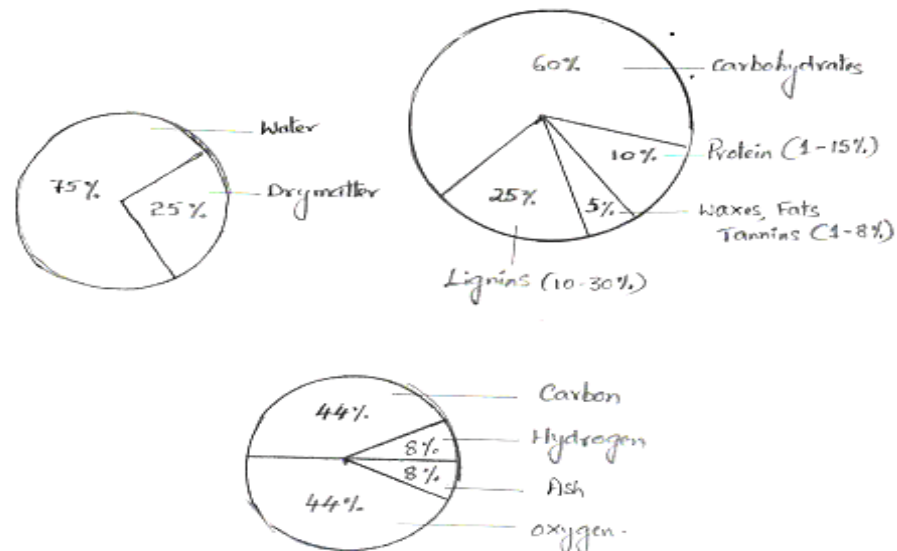
The degree of base saturation is an important property of soil which usually reflects the extent of leaching and weathering of soils. It is an indication of soil fertility. The ease with which adsorbed cations are released to plants depends on the degree of base saturation.

## LECTURE 11

### SOIL ORGANIC MATTER, ORIGIN OF SOIL ORGANIC MATTER, DECOMPOSABILITY OF SOIL ORGANIC MATTER

#### Soil Organic Matter

**Sources of soil organic matter :-** The original source of soil organic matter is plant tissue (leaves, roots and left outs of harvested crops). Animals are the secondary sources of organic matter (their bodies when their life cycles are consummated)



#### DECOMPOSABILITY OF PLANT RESIDUES

- \* Sugars, Starches and simple proteins
- 1 Crude proteins
- 2 Hemicelluloses
- 3 Cellulose
- 4 Fats, Waxes etc.,
- 5 Lignins

Rapid decomposition



Very slow decomposition

#### ORGANIC MATTER DECOMPOSITION

When organic tissue is added to soil three general reactions take place.

- 1 The bulk of the material undergoes enzymatic oxidation with  $\text{CO}_2$ ,  $\text{H}_2\text{O}$  and energy and heat as the major products.
- 2 The essential elements such as nitrogen, phosphorous and sulphur are released and / or immobilized by a series of specific reactions relatively unique for each element.
- 3 Compounds very resistant to microbial actions are formed either through modification of compounds in the original plant tissue or by microbial synthesis.

## LECTURE 12

### BENEFITS OF HUMUS, EFFECT OF HUMUS ON SOIL PROPERTIES

Humus is a complex and rather resistant mixture of brown or dark brown amorphous and colloidal organic substances that results from microbial decomposition and synthesis and has chemical and physical properties of great significance to soils and plants.

#### **Influence of Humus / Organic matter on soil physical, biological and chemical properties.**

- 1 Imparts dark color to soils
- 2 Supplies polysaccharides for binding soil particles for formation of aggregates (genesis of good soil structure)
- 3 Increases infiltration rate of water and provides better drainage
- 4 Reduces plasticity, cohesion, stickiness etc in clay soils
- 5 Reduces bulk density, there by influence porosity favorably
- 6 Through granulation, reduces wind erosion losses
- 7 Provides mulching (raw organic matter) and lowers soil temperature during summer. Acts as an insulator and retards heat movement between atmosphere and soil
- 8 Reduces alkalinity in soils by releasing organic acids and CO<sub>2</sub>
- 9 With high adsorption capacity, it accounts for 30-90% of the adsorbing power of mineral soils ( Carboxylic group – 54% ; phenolic & enolic groups – 36%; imide group – 10%)
- 10 Acts as a buffering agent and reduces the likelihood damage from acids and alkalis.
- 11 With its solubilising effect, increses the availability of nutrients
- 12 Acts as a store house for nutrients. Organic matter is the source of 90-95% of nitrogen in unfertilized soils. Also supplies available 'P', 'S' and micro nutrients like Fe, Mn, Cu and Zn etc.,
- 13 Adsorbs temporarily the heavy metal pollutants and cleans the contaminated waters.
- 14 Serves as a source of energy for macro and micro organisms in soils and helps in performing various beneficial functions in soils (N- fixation, mineralisation etc.)

15 Acts as a chelate and increases the availability of micro nutrients

Various organic substances like vitamins, antibiotics and growth promoting substances namely auxins are produced by different micro organisms during decomposition of organic matter. Also some fungi-toxins are produced to control diseases

### **LECTURE 13**

#### **CARBON SEQUESTRATION**

The burning of fossil fuels, forest fires, animal respiration, and plant degradation are all sources of carbon. These sources are worldwide, though some may be larger producers than others. Another increasingly prevalent source of carbon is plastics. Soil is a large and essential C stock.

It is not only vulnerable to the effects of climate change, it also provides opportunities for mitigating emissions of GHGs. It is already observed that significant changes in (i) temperature, (ii) rainfall, (iii) frequency of extreme events (e.g., droughts, frost, heat waves, and fires) will significantly affect soil properties and biological functioning including soil organic matter pools and GHGs emissions.

Carbon stock is the amount of carbon that has been sequestered from the atmosphere and is stored within the forest ecosystem, mainly within living biomass and soil, and to a lesser extent also in dead wood and litter. Depending on their characteristics and local circumstances, forests can play different roles in the carbon cycle, from net emitters to net sinks of carbon. Forests sequester carbon by capturing carbon dioxide from the atmosphere and transforming it into biomass through photosynthesis.

Carbon stocks can be estimated by applying carbon density values from ground data or national forest inventories across land cover/vegetation maps obtained by remotely-sensed data. Spatial vegetation information from optical satellite sensors can be related to ground-based measurements to estimate carbon stocks.

Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change. The USGS is conducting assessments on two major types of carbon sequestration: geologic and biologic.

## LECTURE 14

### C:N RATIO

- C:N ratio is the intimate relationship between organic matter and nitrogen contents of soil. The ratio of the weight of organic carbon to the weight of total nitrogen in a soil or organic material is known as C:N ratio.
- In general, the C:N ratio of humus is 10:1 to 12:1
- It is usually found that most of the applied fresh organic materials in soils carry large amounts of carbon with relatively very small amounts of total nitrogen.(100:1)
- Large amount of fresh organic materials like crop residues, animal and human wastages, organic materials having wide C:N ratio(100:1) are incorporated into the soil under favourable soil conditions for decomposition. A rapid change will found. The heterotrophic micro-organisms, bacteria, fungi and actinomycetes become active and increases their population with the production of large amount of CO<sub>2</sub>.
- Under, these conditions, nitrate nitrogen (NO<sub>3</sub>-N) disappears from the soil because of the urgent needs by the micro-organisms. And for the time being, little or no nitrogen is available to plants.
- As the decomposition proceeds, the C:N ratio of the organic materials decreased with the loss of carbon and conservation of nitrogen.

The quantity of carbon declines with the advancement of decomposition process.

Similarly, the inorganic element released during mineralization process is also lost, by several means i.e. plant utilization, leaching, volatilization, conversion to insoluble compounds etc.,. It results in a stabilized C:N ratio to the soil i.e. 10:1 or 12:1 (Humus) in which nutrients released (Mineralization) and readily available to plants.

**Mineralization:** The conversion of organic forms of C, N, P and S to inorganic or mineral forms as a result of microbial decomposition is called Mineralization. The heterogeneous group of heterotrophic soil micro-organisms takes part in mineralization of organic nitrogen and converts it to inorganic nitrogen. The reactions go uninterrupted, as long as carbon source is available for microbes. C :N ratio < 20:1

## LECTURE 15

### NUTRIENT CLASSIFICATION, IMPORTANCE OF NUTRIENTS, DEFICIENCIES, CONTROL MEASURES

#### Classification of essential nutrients:

Nutrients are chemical compounds needed for growth and metabolic activities of an organism. The essential plant nutrients may be divided into macronutrients (primary and secondary nutrients) and micronutrients.

A. **Macronutrients:** Macronutrients or major nutrients are so called because they are required by plants in larger amounts. These are found and needed in plants in relatively higher amounts than micronutrients. They include C, H, O, N, P, K, Ca, Mg and S. C, H and O constitute 90 – 95 % of the plant drymatter weight and supplied through CO<sub>2</sub> and water.

Remaining six macronutrients are further sub divided into primary and secondary nutrients.

- I. **Primary nutrients:** Nitrogen, phosphorus and potassium are termed as primary nutrients because the correction of their wide spread deficiencies is often necessary through the application of commercial fertilisers of which these are the major constituents
- II. **Secondary nutrients:** Calcium, magnesium and sulphur are termed as secondary nutrients because of their moderate requirement by plants, localised deficiencies and their inadvertent accretions through carriers of the primary nutrients. For example, the phosphatic fertiliser, single super phosphate (SSP) contains both Ca and S. Similarly, ammonium sulphate, a nitrogenous fertiliser also supplements S.

B. **Micronutrients:** Micronutrient is an element that is required in relatively small quantities but is as essential as macronutrients. These elements have often been called trace elements. They are again classified into micronutrient cations (eg. Fe, Mn, Zn and Cu) and micronutrient anions (eg., B, Mo and Cl) depending upon the form in which they are available.

#### Based on mobility in plant

Mobile	Partly mobile	Immobile
N	Fe	Ca
P	Zn	S
K	Cu	B
Mg	Mo	

**Nitrogen(N):****Functions:**

- It's an essential component of amino acids, proteins, nucleic acids, porphyrins, flavins, purines and pyrimidine nucleotides, flavin nucleotides, enzymes, coenzymes and alkaloids.
- N containing chlorophyll fixes atmospheric CO<sub>2</sub> through photosynthesis.
- Being a constituent of RNA and DNA, N is responsible for transfer of genetic code.
- Improves the quality of leafy vegetables and fodders.
- Improves the quality by increasing protein content.

**Deficiency symptoms:**

Plants having less than 1 % nitrogen are usually regarded as deficient in N. Due to high mobility of N in plants, its deficiency symptoms first appear on the older leaves in the form of light green to pale yellow coloration due to proteolysis.

Stunted growth is the manifestation.

**Corrective measures:**

Nitrogen in the form of NO<sup>3-</sup> is more prone for leaching especially on light textured soils with more permeability. So, split application of nitrogen is recommended. Foliar application in the form of urea @ 2 percent concentration is advocated in dry land areas.

**Phosphorus:****Functions**

1. Essential for cell division and development.
2. Stimulates root development and growth.
3. Responsible for early establishment of seedlings.
4. Strengthens the straw and decreases lodging.
5. Brings about early maturity.
6. Increases grain to straw ratio

**Deficiency symptoms :**

- Because of its faster mobility in plants, P gets translocated from older tissues to the meristematic tissue. Therefore, deficiency symptoms of P first appear on the older leaves.
- Production of dark green color leaves.
- Severe restriction of root growth.
- Thin, erect and spindly plants with sparse and restricted foliage. suppressed lateral bud production.
- Bluish green foliage, and under continued deficiency the older leaves become bronzed or develop reddish purple tip or leaf margins.

**Correction of P deficiency:**

Generally, P is applied as a basal application by band placement. The following are the phosphatic fertilizers like SSP, TSP and basic slag etc.

**Potassium (K)****Functions :**

1. Plays a major role in transport of water and nutrients throughout the plant in xylem.
2. It improves drought tolerance.
3. Enhances crop quality, shelf life of fruits and vegetables.
4. Reduces lodging of crops, enhances winter hardiness. Imparts disease resistance.

**Deficiency symptoms:**

- Reduced crop yields without the appearance of definite symptoms; the phenomenon is called hidden hunger.
- Decrease in resistance to certain plant diseases & decrease in the quality of fruits and vegetables.

**Correction measures:**

Potassic fertilizers are applied as basal dose, but for light textured soils, split application is advocated. In Andhra Pradesh split application of N and K are recommended for light soils

**Calcium(Ca):****Functions:**

1. Essential for the formation of cell wall and calcium pectate in the middle lamella of the cellwall which regulates the entry of only those nutrients which are not toxic to plants. In seeds, calcium is present as calcium phytate.
2. In root tip, calcium is very essential for the meristematic activity.
3. Provides a base for neutralisation of organic acids and other toxins (like Al) produced in plants.
4. Favours the assimilation of nitrogen into organic constituents especially proteins.

**Deficiency:**

- In apple, the discoloration of the fruit meat, the condition generally referred to as “bitter pit”.
- Blossom end rot in tomato is due to Ca deficiency.

**Correction measures :** Calcium as a plant nutrient is more important in calcium deficient acid soils. The application of carbonate or sulphate salts of calcium @ 2 – 4 q ha-1 in furrows could increase the yield by 48 %.

**Magnesium:****Functions :**

- 1.The usual concentration of  $Mg^{+2}$  in crops varies between 0.1 and 0.4 per cent. A large part of Mg is associated with organic anions like malate.
2. Magnesium is the only mineral constituent of chlorophyll located at its centre.
3. Chlorophyll formation usually accounts for about 15 to 20 % of total Mg content of plants as Mg - porphyrin.
4. Serves as a structural component of ribosomes.
5. Seeds contain Mg as salt of phytic acids

**Deficiency symptoms:**

$Mg^{+2}$  is a mobile element and is readily translocated from older to younger plant parts in the event of deficiency and hence deficiency symptoms are manifested in the older leaves.

The magnesium deficient plants usually have less than 0.1% Mg.

Magnesium deficiency is common in the plants grown on coarse textured acidic soils.

In some vegetables, interveinal chlorosis with tints of red, orange and purple colors is observed. Grass tetany : Cattle consuming forages with low Mg may suffer from "Hypomagnesemia" (low level of blood Mg) commonly known as Grass tetany.

Grass tetany : Cattle consuming forages with low Mg may suffer from "Hypomagnesemia" (low level of blood Mg) commonly known as Grass tetany. This happens due to high levels of  $\text{NH}_4^+$  - N and K application.

### **Sulphur :**

#### **Functions :**

1. It is required for the synthesis of the S containing amino acids cysteine, cystine and methionine and for protein synthesis.
2. It activates certain proteolytic enzymes such as papainase and synthesis of papain.
3. It is a constituent of certain vitamins viz., Thiamine and biotin, coenzymes and glutathione, Acetyl coenz A (precursor for fatty acid synthesis), ferredoxin.
4. It is present in the crops like onion, mustard, cabbage and cauliflower as polysulfides.
5. Sulfhydryl (-SH) groups in plants are related to increased cold resistance

#### **Deficiency:**

1. The fading of normal green colour of the young meristem followed by chlorosis.
2. The older leaves become puckered inwardly with raised areas between veins.
3. The older leaves may develop orange or reddish tints and may be shed prematurely.
4. The stem and leaf petiole may become brittle and may collapse.
5. Reduced synthesis of proteins and oil

#### **Correction measures:**

- Application of elemental sulphur or gypsum particularly on alkaline soils.
- Application of sulphur containing fertilizers like single super phosphate (12- 14% S), Magnesium sulphate (30 % S), Ammonium sulphate (24.2% S).
- For correcting deficiencies of sulphur on the standing crop, foliar application of sulphate containing salts like Ferrous sulphate (32.8% S) and ferrous ammonium sulphate (16% S) etc.

**Zinc:****Functions:**

1. Zinc is a constituent of three enzymes viz., Alcoholic dehydrogenase, carbonic anhydrase, superoxide dismutase (SOD).
2. Zn is involved in the synthesis of indole acetic acid, metabolism of gibberellic acid and synthesis of RNA.
3. Zn influences translocation and transport of P in plants.
4. Under Zn deficiency, excessive translocation of P occurs resulting in P toxicity.

**Deficiency symptoms:**

Zn deficiency symptoms show wide variation in different plant species.

- a) Khaira disease of rice: The first symptom of zinc deficiency appear in 3 - 4 week old seedlings when the young leaves develop reddish brown pigmentation
- b) White bud of maize : Soon after the emergence of seedlings, areas between the veins of old leaves become light yellow and develop white necrotic spots, which later develop dark brown necrotic areas that enlarge and coalesce, resulting in the necrosis (death of the entire leaf).

**Corrective measures:**

- Soil application of zinc sulphate (21% Zn) @ 50 kg ha<sup>-1</sup> once for three crops or years is effective and economic to overcome its deficiency. Zinc sulphate need to be applied on the surface and mixed in the soil through light harrowing.
- In case of rice, zinc sulphate can be broadcast after final puddling before transplanting.
- In case of orchards, zinc sulphate can be applied in the basin mixing into the soil.
- When deficiency appears on standing crop, spraying of 0.2 % ZnSO<sub>4</sub> twice or thrice at weekly intervals or at 0.5 per cent concentration with lime.
- In case of alkali soils, the dose of zinc sulphate for soil application needs to be doubled to 100 kg ha<sup>-1</sup>.
- Zinc is also available as zinc chelate (mostly Zn - EDTA form). In case of highly alkaline soils (pH>8.0) zinc chelate is better source than zinc sulphate.
- In calcareous soils, Zn- HEDTA (Hydroxy Ethylene Diamine Tetra Acetic acid) form is efficient for soil application.

## **Copper**

### **functions:**

1. Concentration of  $\text{Cu}^{2+}$  in copper sufficient plants is from 5 to 30 ppm and toxicity occurs between 20 and 100 ppm.
2. Important in imparting disease resistance.
3. Enhances fertility of male flowers.

### **Copper deficiency symptoms:**

- Male flowers' sterility, delayed flowering and senescence are the most important effects of Cu deficiency.
- Chlorosis of the younger shoot tissue, white tips, necrosis, leaf distortion and die back are characteristics of Cu deficiency.
- In cereals symptoms appear as bleaching and withering of young leaves.
- Empty glumes in wheat , Exanthema and dieback in citrus which manifests as dark brown spots on the leaves, terminal twigs and fruits.

### **Correction Soil and foliar application are both effective.**

Soil application @ 1.0 – 5 kg /ha of  $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$  (24 % Cu). Foliar application of  $\text{CuSO}_4$  @ 0.2 % concentration. Cu-EDTA contains 9-13 % Cu.

## **Iron**

### **functions:**

1. Variable valency of iron assigns it a role in biological redox systems.
2. Iron is a constituent of two groups of proteins viz., a) Heme proteins containing Fe – porphyrin complex. eg., peroxidase, leghaemoglobin.
3. Fe-S proteins in which Fe is coordinated with thiol group Eg : Ferredoxin.
4. It is necessary for synthesis and maintenance of chlorophyll in plants. It is structural constituent of pigments in micro-organisms; the black pigment in *Aspergillus niger* contains iron)

### **Deficiency :**

- Deficiency of Fe results in interveinal chlorosis appearing first on the younger leaves with leaf margins and veins remaining green.

- The chlorotic leaves may become white and the leaf tissues devoid of chlorophyll die. Leaves with large necrotic areas fall off and twigs defoliate.
- In graminaceous crops, chlorosis consists of alternate strips with green veins and yellow interveinal tissues. In case of barley, maize and jowar, leaves show reddish brown spots on leaves away from the base on margin.
- Under conditions of severe deficiency, growth cessation occurs with the whole plant turning necrotic.

**Correction** : In general soil application of iron salts such as ferrous sulfate is not practiced because of their rapid oxidation to much less soluble ferric iron. Correction of Fe deficiency is generally done by foliar sprays.

Sources  $\text{FeSO}_4 \cdot 7 \text{H}_2\text{O}$  : 19 %, Fe Iron chelates Na Fe EDTA : 5-14 % Fe,

## **Manganese**

### **Functions :**

1. Because of its variable valence, Mn plays an important role in the photosynthesis and detoxification of superoxide free radicals.
2. Mn is an integral component of the water splitting enzyme associated with photosystem II.
3. It is a constituent of superoxide dismutase (Mn-SOD).

### **Deficiency symptoms :**

- Mn deficient plants contain less than 25 ppm Mn.
- Deficiency symptoms of Mn are more severe on middle leaves than on the younger ones because Mn is preferentially translocated to the younger tissues.
- Interveinal chlorosis in dicotyledons is characterized by the appearance of chlorotic and necrotic spots in the interveinal areas.
- Grey speck of Oats, Speckled yellow of sugar beet, Marshy spot of peas

### **Corrective measures:**

Soil application of  $\text{Mn SO}_4 \cdot 3 \text{H}_2\text{O}$  (26-28 % Mn) @ 10-25 kg/ha and  $\text{Mn SO}_4 \text{H}_2\text{O}$  (30-32 % Mn) @ 10-25 kg/ha

**LECTURE 16**  
**SOIL FERTILITY- MANAGEMENT PRACTICES**

**Soil fertility:** The inherent capacity of the soil to provide nutrients for the growing of crops. **Soil Productivity:** The capacity of the soil to produce crop yields.

All fertile soils are not productive but all productive soils are fertile

**Reasons for decreasing soil fertility:**

1. Lack of application of organic manures( FYM, Vermicompost , Poultry manure etc.
2. Indiscriminative use of major nutrients (N, P and K)
3. Indiscriminative use of complex fertilizers leads to deficiency of secondary nutrients like Ca & S
4. Lack of crop rotations
5. Lack of knowledge on improvement of organic carbon

**Management of organic carbon content in the soil:**

1. Fertilizer application should be done based on the soil sample analysis report
2. Balanced fertilizer application
3. Efficient utilization of fertilizers Eg: Application of nitrate form of nitrogenous fertilizers leads to the leaching losses of  $\text{NO}_3^-$  form into the deeper layers
4. Phosphorus fixation is high in heavy soils.
5. Oxygen deficiency occurred in waterlogged soils.
6. Application of organic manures should be applied 20 – 30 days before the sowing of the crop.
7. To avoid Volatalisation losses of nitrogenous fertilizers should be thoroughly incorporated in the soil.
8. To minimize the losses of N fertlisers should be applied in split doses (2-3 times).
9. Application of urea @ 2% foliar spraying to mitigate the drought situations.
10. Application slow released N fertilizers viz., Neem coated urea, N-Serve, Prilled urea.

### **Integrated nutrient management:**

- Addition of organic manures to the soil
- Integrated use of organic and inorganic fertilizers ( 50:50 / 25: 75)
- Growing of green manure crops and incorporated to the soil at 50% flowering as insitu / green leaf manuring.
- Application of fertilizers based on soil sample analysis results.
- Need based fertilizer application reduces the cost of cultivation.

## **LECTURE 17**

### **SOILS OF ANDHRA PRADESH, SOIL CHARACTERISTICS, MANAGEMENT PRACTICES**

<b>S.No.</b>	<b>Type of soil</b>	<b>Percentage</b>
1.	Red earth with loamy sub soils	30
2.	Red sandy soils	8
3.	Red earth with clayey sub soils	3
4.	Red loams with moderately deep	9
5.	Red loams with deep	3
6.	Red soils with clay base	12
7.	Black cotton soils	10
8.	Black soils	15
9.	Deltaic alluviums	5-6
10.	Coastal sands	3-4
11.	Laterite soils	1

**Red soils** : The red soils include red sandy soils (Dubbas and coarse chalkas), red earth with loamy subsoil (medium and fine chalkas) red loamy soils (shallow to moderately deep), red loamy soils deep to very deep and red soils with clayey sub soils. These soils are in general, rapidly to moderately permeable with good drainage conditions. Soils are neutral in reaction (pH 6.5 to 7.5) and non saline. The clay minerals consist of a

mixture of kaolinite and illite with low to medium Cation Exchange Capacity (CEC). They are prone to erosion.

**Red sandy soils:** These coarse soils have an effective depth ranging from 20 to 60 cm indicating that they are shallow to moderately deep. The pH of the soils varies from 6.5 to 7.5 and these are non saline. The soils are rapidly permeable with intensive leaching exhibited under heavy irrigation or high intensity rain fall conditions. The clay content is usually < 15 per cent . These soils have low base exchange capacity and are poor in fertility.

**Red earths:** These soils show a loamy or clay sub soils. The soils with the former usually exhibit pH ranging from 6.5 to 7.5 and occur on the elevated regions nearer to hills , hill ranges and on sloping terrains. These are non saline and have low CEC. The surface drainage is good to excessive. The soils vary in depth ranging from as low as 8 to 75 cm (shallow to moderately deep). The red earths with clayey subsoil show rapid permeability at surface while the subsoil is moderately permeable. pH of these soils is ranging from 6.5 to 8.0 and these soils show more CEC than the ones with loamy sub soil. The effective depth of these soils ranges from 30 to 75 cm.

**Red loamy soils:**Based on depth, these soils are shallow to moderately deep red loamy soils and deep to very deep red loamy soils. The former usually have depth ranging from 20-39 cm and occur where the area was subjected to severe erosion. The surface coarse texture favor easy drainage while the subsoil is denser tending to show more clay with depth. The latter category exhibits variation in drainage viz., well drainage with light textured sub soil and moderately well to well drainage with clayey subsoil.

**Laterite soils:** Laterite soils are deep (0.9 to 1.8 m) to very deep (> 1.8 m), medium to fine textured with clay subsoil and rapidly permeable and well drained. These soils are formed under conditions of high rainfall with alternate wetting and drying period. The leaching of the bases leads to development of soil acidity with soil reaction (pH ) values as low as 4.0 to 5.0, in a general pH range of 4.0 to 6.0. Soils are non saline. The soils have very low CEC and ,hence, are poor in fertility.

**Black Soils :** These soils have a local name as regur. Deep black soils (Vertisols) have high clay content (30- 60 per cent or more) and , hence, are slowly permeable and ill drained. They exhibit an effective depth of over 180 cm. The pH ranges between 8.0 to 9.0. These soils are usually non saline at surface but salt content increases with depth. The soils exhibit high base exchange capacity due to high clay content. Moderately deep soils are loamy to clay loamy with clay sub soil, moderately drained, neutral to moderately alkaline in reaction (pH 7.0 to 8.5), non saline but have higher salt content than red soils. These soils are also having similar fertility characteristics as above.

**Deltaic alluvium:** These soils occurring in major river deltas have finer fraction ranging from 60 to 70 per cent. They are very deep (> 1.8 m) and lack of profile development. Drainage is a main constraint in these soils. Water table occurs within 5 cm depth coming up to ground level in basins. These soils are neutral to alkaline (pH 7.0 to 9.0) and marginal to highly saline. Clay mineral composition shows wide variations. The CEC of soils is usually high and, hence, they are productive. Taxonomically, these are Entisols and Vertisols.

**Coastal soils :** These are very deep (1.8 to 5.0 m and above), coarse textured with sandy sub soil, belonging to the order Entisols. The soils are rapidly permeable, neutral in reaction (pH 6.5 to 7.5) with sub soil salinity due to shallow water table and low CEC due to very low clay contents.

**Salt affected soils ;** It is estimated that about 1 per cent of the total area of the state is under the problem soils like saline, saline-alkali and non saline alkali soils mainly occurring along the sea coast, streams and are usually interspersed in black, red and alluvial soils.

**Saline soils:** These soils occupy considerable area in coastal districts of the state with salts contents exceeding even 0.2 per cent reaching a high concentration of even more than 4.0 per cent. The soils have low Exchangeable Sodium Percentage (ESP) of less than 15. The pH is around 7.0 and seldom goes beyond 8.5. The high water table can cause moist conditions at the surface.

**Saline – alkali soils;** These soils are also occurring in the coastal districts and in some hinterland areas along the stream sides. The pH ranges from 8.0 to 10.0 while the salt content was found ranging from 0.3 to 1.5 per cent or even above. The water table is usually shallow showing not only high salt contents but also the presence of alkali carbonates.

**Non saline alkali soils:**

Though the pH values are similar to the above category, the salt content generally is low. The ESP values exceed 15. These soils have poor physical conditions and exhibit even water logging due to dispersion of clay clogging the pores. Though depending upon the salt content, the saline soils can be of some fertility value, the other two categories exhibit poor fertility and physical conditions affecting the crop production seriously. Management of these soils requires implementation of technologies generated so far specific to the given type of problem soil to improve its productivity .

## LECTURE 18 PROBLEM SOILS

### 18.1 Acid soils-reclamation/management

### 18.2 Saline soils-reclamation/management

### 18.3 Black alkali soils-reclamation/management

### 18.4 Light soils, waterlogged soils with less drainage soils

Problem soils are the soils whose productivity is lowered due to inherent unfavourable soil conditions viz., salt content and soil reaction.

In India, the extent of salt affected soils increased enormously to 10 M ha. Soil salinity is one of the major problems restricting crop production in the arid and semi arid regions of the world.

#### Formation of acid soils

1. Acid parent material
2. Leaching of bases due to heavy rainfall
3. Using of acidic residual fertilizers like ammonium sulphate
4. Acid rains due to industries

#### Rating chart for soil acidity

S.No.	pH	Type of acidity
1.	<4.5	Very high strongly acidic
2.	4.6-5.0	High strongly acidic
3.	5.1-5.5	High acidic
4.	5.6-6.0	Medium acidity
5.	6.0-6.5	Slightly acidic
6.	6.6-7.0	neutral

### Units of expression for salinity and alkalinity :

Salinity is measured in terms of electrical conductivity (EC) which is the ability of salt solution to conduct electricity. It is expressed in terms of deci Siemens per metre (dS m<sup>-1</sup>).

$$1 \text{ dS m}^{-1} = 1 \text{ m mho cm}^{-1} = 1000 \text{ } \mu\text{mho cm}^{-1}$$

Sodium is involved in alkalinity. It is expressed in terms of exchangeable sodium percentage (ESP), which is the degree of saturation of exchangeable complex with sodium; and sodium adsorption ratio (SAR) which is a comparative ratio of Ca<sup>2+</sup>, Mg<sup>2+</sup> and Na<sup>+</sup>.

$$\text{ESP} = \frac{\text{Exchangeable Na [c mol (p}^+) \text{ kg}^{-1}]}{\text{CEC [c mol (p}^+) \text{ kg}^{-1}]} \times 100$$

$$\text{SAR} = \frac{\text{Na}}{\sqrt{\text{Ca} + \text{Mg}}}$$

Salinity Class	EC (dSm <sup>-1</sup> )
Salinity effect negligible	: 0 – 2
Yield of very sensitive crops restricted	: 2 - 4
Yield of many crops restricted	: 4 - 8
Only tolerant crop yields are satisfactory	: 8 – 16
Yield of a few tolerant crops are satisfactory	: Critical value for EC : 4

**Characteristics of saline soils :** Saline soils contain neutral soluble salts of chlorides and sulfates of sodium, calcium and magnesium. The electrical conductivity of saturated extract of the soil is more than 4 dS m<sup>-1</sup>. ESP is less than 15 and pH is less than 8.5. Because of the presence of excess salts and low amount of Na<sup>+</sup>, these soils are in a flocculated state and their permeability is higher than alkali soils. Their physical condition is good and water can pass through them. These soils have a white crust of salts on their surface. Salinisation refers to the accumulation of neutral soluble salts in soils.

**Characteristics of saline - Alkali soils:** These soils have both soluble salts and exchangeable sodium. The soil reaction becomes strongly alkaline because of hydrolysis of exchangeable sodium. The physical condition of the soil is deteriorated. The EC of saturated extract is more than 4 dS m<sup>-1</sup>, ESP is more than 15 and pH is around 8.5. They are transitional soils that they may be converted into saline or into sodic soils.

**Characteristics of alkali or sodic soils:** Most of the  $\text{Na}^+$  is in exchangeable form. EC of saturated extract is less than  $4 \text{ dS m}^{-1}$ . ESP is more than 15 and pH more than 8.5. Such soils are not in a good physical condition and the surface of these soils is sometimes black due to dispersion of organic matter and humus. Such soils if ploughed when wet, turn into slick furrow slice referred to as slick spots.

#### Comparison of characteristics of salt affected soils

Characteristic	Saline soil	Alkali soil	Saline – alkali
Content in soil	Excess soluble salts of calcium, magnesium and sodium	Presence of excess exchangeable sodium on the exchange complex	These are transition soils. They contain sodium saturation and
Exchangeable calcium/sodium	Exchangeable calcium	Exchangeable sodium	---
Colour	White	Black	---
Dominant salts	Sulphates, chlorides and nitrates of calcium, magnesium and sodium	Sodium carbonate and bicarbonate	
SAR	<13	>13	>13
ESP	<15	>15	>15
Soil pH	~ 8.5	>8.5	~ 8.5
Physical condition of the soil	Flocculated, permeable to water and air	Deflocculated, permeability to water and air is poor.	Flocculated or deflocculated
Morphological character	White crust on the surface	High amounts of exchangeable sodium leads to dispersion of the clay, which together with humus may form dark coloured	---
Organic matter content	Slightly less than normal soil	Very low	Variable
Total soluble salt content	>0.1 %	<0.1%	>0.1%
EC	> $4 \text{ dS m}^{-1}$	< $4 \text{ dS m}^{-1}$	> $4 \text{ dS m}^{-1}$

**Acid soils** : Soils with pH < 5.5 have been defined as acid soils by USDA. However, soils with pH < 6.5 can also be categorized as acidic soils. Out of 157 M ha of cultivable land in India, 49 M ha are acidic, of which 26 M ha land is having a pH of less than 5.6 and the rest 23 M ha of land is having a soil pH in the range of 5.6 to 6.5.

**Formation** : The leaching of bases is the prerequisite for the formation of acid soils which are dominantly found to occur in regions with high rainfall. The major process involved in the formation of acid soils is podzolisation in areas of temperate climate; laterization of varying degrees, marshy conditions with significant amounts of partly decomposed organic matter. Acid soils occur in almost all major soil groups except the black soils (Vertisol). Acid soils occur in Assam, Manipur and Tripura, peaty and marshy soils of West Bengal and Kerala. Very low pH (4 or less) is an indication of the presence of sulfuric acid as in the cat clays in Kerala, the soils are referred to as acid sulfate soils.

#### **Characteristics Nutrient availability**

Low pH, high exchangeable H<sup>+</sup> and Al<sup>3+</sup>, low CEC and high base unsaturation are the characteristics of acid soils. Adverse effect is due to toxic concentration of Al, Mn and Fe and deficiency of Ca and Mg. Acid soils are low in available P and have high P fixing capacity. Available micronutrient status is adequate except molybdenum. The population of bacteria and actinomycetes is lower and those of fungi higher.

#### **Calcareous soils**

Calcareous soils are soils in which a high amount of calcium carbonate dominates the problems related to agricultural land use. They are characterized by the presence of calcium carbonate in the parent material and by a calcic horizon, a layer of secondary accumulation of carbonates (usually Ca or Mg) in excess of 15% calcium carbonate equivalent and at least 5% more carbonate than an underlying layer.

These soils are formed under arid or semi-arid climatic conditions when the carbonate concentration in the soil solution remains high. In some soils the calcium carbonate deposits are concentrated into layers that may be very hard and impermeable to water (also called "Caliche"). These caliche layers are formed by insufficient rainfall (at nearly constant annual rates) leaching the salts to a particular depth in the soil at which the carbonates precipitate. They are also formed by salts moving upward from a water table (caused by irrigation) and precipitating near the top of the capillary fringe.

The total extent of calcisols is estimated at 800 million hectares worldwide mainly concentrated in arid or Mediterranean climates.

The land use of calcareous soils is highly variable: it ranges from non-used wastelands (deserts) to intensively cultivated irrigated areas.

## **\*Reclamation of salt affected soils :**

### **I. Mechanical amelioration of salt affected soils**

The commonly followed physical or mechanical method of amelioration of salt affected soils include deep ploughing, sub soiling, sanding, profile inversion and scraping.

- The first two methods break the impermeable layer, hard pan or cemented sub soil layer existing at various depths in soil profile to improve the internal drainage of the soil and to facilitate the transportation of salts dissolved in water to deeper layers.
- Incorporation of sand in salt affected soils is done to bring about
- permanent changes in texture, increase permeability and to improve water relations in the root zone.
- Profile inversion can be adopted only under conditions where surface soil is good but the soil below is sodic or saline.
- Scraping is adopted to remove the few centimeters of salt encrustation.

### **II. Chemical amelioration**

#### **A. Reclamation of a saline soil**

**Leaching** : The main objective in reclamation of these soils is to leach the salts below the root zone (hence, drainage system should be installed if necessary). Leaching requirement (LR) has been defined as that fraction of water that must be leached through the root zone to control soil salinity at a specified level.

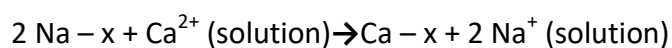
This is achieved by flooding and draining. To make it effective, bunds are raised around plots prepared and water is applied depending on their water requirement to leach salts.

**Leaching requirement (LR) =  $EC_{aw} / EC_{dw}$**   $EC_{aw}$  is the EC of applied water.

$EC_{dw}$  is the EC of drainage water.

In saline soils with high water table artificial drainage should be practiced (Drainage is the removal of excess water from the soil).

**B. Reclamation of alkali (Sodic) soil** : Reclamation of sodic soils involve two stages. First, the replacement of sodium by another cation and second, the leaching of the desorbed sodium salts out of the root zone. This may be done with gypsum ( $CaSO_4 \cdot 2H_2O$ ) and leaching with good quality irrigation water.



Where x is the soil exchange complex

**Gypsum requirement** : Gypsum requirement is the calculated amount of gypsum necessary to add to reclaim the soil. It is the amount of gypsum required to be added to a sodic soil to lower its ESP (Exchangeable Sodium Percentage) to a desired level.

$$\text{Gypsum requirement (me of Ca/ 100 soil)} = \frac{\text{ESP (initial)} - \text{ESP (final)} \times \text{CEC}}{100}$$

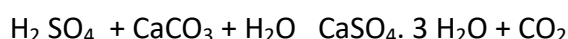
ESP (Initial) is the ESP of soil before application of gypsum;

ESP (Final) is the ESP of soil after bringing it to desired level.



This should be followed by application of good quality water to leach salts. Rate of gypsum application depends on soil pH and the amount of exchangeable sodium present on the soil exchangeable complex. Gypsum is suitable for alkali soils upto a pH of 9.0.

Elemental sulphur or pyrites are effective on alkali soils which are calcareous (contain calcium carbonate) in nature



H<sub>2</sub>SO<sub>4</sub> produced also reduces soil pH.

### III. **Biological amelioration** Organic materials and the activity of plant roots

improve biological activity in the soil. During the decomposition of organic materials CO<sub>2</sub> is released which forms carbonic acid thus dissolving calcium compounds. This can be accomplished by greenmanuring, incorporation of crop residues, application of FYM, pressmud and other organic materials.

**Classification of crops based on salt tolerance** plant tolerance to salt concentration is due to

- 1) Accumulation of high level of sodium and chloride in shoots
- 2) Exclusion of salts by root cells,

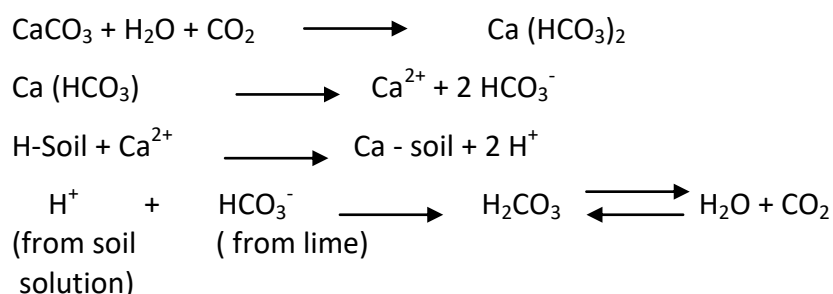
3) Excretion of adsorbed salts from the plant by means of salt glands as in halophytes.

### Salt tolerance of crops

- |                         |   |
|-------------------------|---|
| 1. Highly tolerant      | eg : <i>Sesbania</i> , rice, sugarcane, oats sugarbeet, Turnip, palm, ber |
| 2. Moderately tolerant  | eg : Castor, cotton, sorghum, maize, wheat, spinach, guava, pomegranate.  |
| 3. Moderately sensitive | eg : Radish, cabbage, tomato, sweet potato.                               |
| 4. Highly sensitive     | eg : Carrot, onion, lemon, orange, grape, apple, pulses, sesamum, pea.    |

Green manure crop is to be raised and incorporated at flowering stage into the soil immediately after reclamation. Rice crop is preferred to be grown after the green manure crop owing to its high tolerance to soil sodicity.

**Management of acid soils:** Acid soils can be managed by either growing crops suitable for particular soil pH or by ameliorating the soils through the application of amendments which will counteract soil acidity. Acid soils are made more suitable for agricultural use by liming which raises the soil pH. Liming increases the exchangeable base status, influences nutrient uptake, reduces toxic concentration of aluminium and manganese by neutralizing effect, improves the soil structure and promotes root distribution.



The higher the soil moisture, the rapid is the rate of reaction.

**Lime requirement of acid soil** is the amount of a liming material that must be added to raise the soil pH to some prescribed value usually in the range of 6.0 to 7.0. The buffer method was proposed by Shoemaker et al. (1961). Liming material is the material which contains Ca and Mg that can neutralize soil acidity.

Lime stone, marketable lime, lime shells, paper mill sludge and basic slag are some of the liming materials available in the market.

The efficiency of liming materials can be judged on the basis of the following factors

i) Neutralizing value (N.V) or CaCO<sub>3</sub> equivalent (CCE) is defined as the acid neutralizing capacity of an agricultural liming material expressed as a weight percentage of calcium carbonate.

$$\text{CCE of liming material} = \frac{\text{Molecular weight of CaCO}_3}{\text{Mol. Wt. of a liming material Whose CCE is to be determined}} \times 100$$

The CaCO<sub>3</sub> equivalent of burnt lime is calculated as

$$\frac{\text{Molecular weight of CaCO}_3}{\text{Mol. Wt. of Cao}} \times 100$$

$$= 100/56 = 1.786$$

Rock phosphate is the suitable P fertilizer than soluble phosphate

ii) Purity of liming material: The more purer the material the higher will be the effectiveness.

iii) Degree of fineness of liming material: The rate of reaction of liming materials with an acid soil depends upon the fineness of the material.

Light soils: Light soils containing more than 70 per cent sand fractions occur in coastal areas, river delta and in the desert belts. Excessive permeability of the sandy soils results in poor water retention capacity, very high hydraulic conductivity and infiltration rates. These soils being devoid of finer particles and organic matter, the aggregates are weakly formed, the non-capillary pores dominating with very poor soil structure, loss of nutrients and water, it is not providing anchorage to the crops grown.

#### **Management technology :**

The soils should be ploughed uniformly. Then shallow ploughing should be given and crops can be raised. Application of clay soil up to a level 100 t ha<sup>-1</sup> based on the severity of the problem and availability of clay materials. Application of organic materials like farm yard manure, compost, press mud, sugar factory slurry, composted coir pith, sewage sludge etc. Providing polythene sheets below the soil surface to reduce the infiltration rate. Crop rotation with green manure crops like Sunhemp, sesbania, daincha, kolinchi etc. Frequent split application of fertilizers and slow release fertilizers like neem coated urea

**Slow permeable soils/Clayey soils:** Very high clay content, Infiltration rate < 6cm/day, Soil erosion and nutrient removal. Since the capillary porosity is high it leads to impeded rainage, poor aeration and reduced conditions.

**Remedial measures:**

- (i) Incorporation of organics
- (ii) Formation of ridges and furrows
- iii) Formation of broad beds
- iv) providing open/ subsurface drainage
- v) Huge quantity of sand /red soil application to change the texture
- vi) Contour /compartmental bunding to increase the infiltration
- vii) Application of soil conditioners like vermiculite to reduce runoff and erosion

**LECTURE 19**  
**SOIL ORGANISMS**

The soil is teeming with millions of living organisms which make it a living and a dynamic system. Under microscope it reveals a complex arrangement of soil particles and pore spaces filled with air and water. It is in these pore spaces that plant roots and millions of organisms develop, ranging from microscopic to macroscopic in size.

The organisms in the soil, not only help in development of soils but carryout a number of transformations facilitating the availability of nutrients to the plants. In the absence of the activities of these organisms, in soil, life on earth would have come to a halt, as all available nutrients would have ended up locked in the organic, disrupting the nutrient cycles.

Greek word Bios= life, logos=study

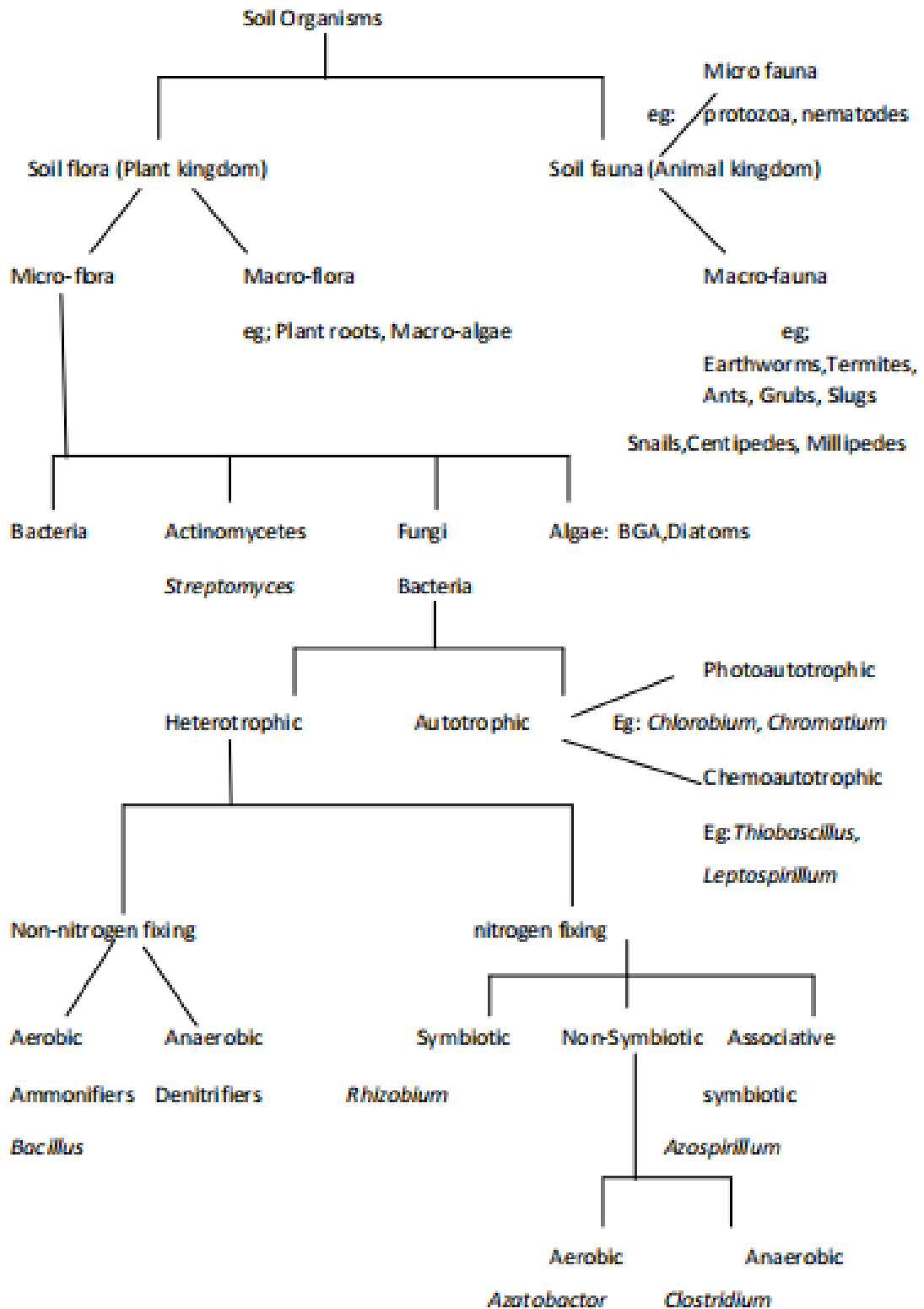
The study of living organisms in soil is called Soil biology.

**Benefits of soil organisms**

1. Organic matter decomposition O.M ? humus
2. Inorganic Transformations
3. Nitrogen fixation
4. Solubilisation of insoluble phosphorous compounds
5. Solubilisation of insoluble Sulphur compounds( S oxidizing and reducing organisms)
6. Formation and development of soil
7. Production of soil enzymes, growth promoting substances and antibiotics

8. Detoxification of soil pollutants

9. Protect plant roots from invasion by soil parasites and pathogens



Fungi is divided into Yeast, Moulds, Mushroom

In Moulds Ex; Aspergillus

**MINERALIZATION:**

Mineralization is the conversion of an element from an organic form to an inorganic as a result of microbial decomposition. The heterogeneous group of heterotrophic soil micro-organisms takes part in mineralization of organic nitrogen and converts it to inorganic nitrogen. The reactions go uninterrupted, as long as carbon source is available for microbes.

**IMMOBILIZATION:**

The conversion of the element from the inorganic to the organic form in microbial tissues or in plant tissues, thus rendering the element not readily available to other organisms or to plants, is called immobilization.

**LECTURE 20**  
**ENVIRONMENTAL POLLUTION**

Environmental pollution is defined as the undesirable change in physical, chemical and biological characteristics of our air, land and water. As a result of over-population, rapid industrializations, and other human activities like agriculture and deforestation etc., earth became loaded with diverse pollutants that were released as by-products.

Pollutants are generally grouped under two classes:

(a) Biodegradable pollutants - Biodegradable pollutants are broken down by the activity of microorganisms and enter into the biogeochemical cycles. Examples of such pollutants are domestic waste products, urine and faecal matter, sewage, agricultural residue, paper, wood and cloth etc.

(b) Non- Biodegradable pollutants - Non-biodegradable pollutants are stronger chemical bondages, do not break down into simpler and harmless products. These include various insecticides and other pesticides, mercury, lead, arsenic, aluminum, plastics, radioactive waste etc.

## **LECTURE 21**

### **GREEN HOUSE EFFECT- GLOBAL WARMING**

The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without this atmosphere.

**Green House Effect:** When sunlight reaches Earth's surface some is absorbed and warms the earth and most of the rest is radiated back to the atmosphere at a longer wavelength than the sun light. Some of these longer wavelengths are absorbed by greenhouse gases in the atmosphere before they are lost to space. The absorption of this long wave radiant energy warms the atmosphere. These greenhouse gases act like a mirror and reflect back to the Earth some of the heat energy which would otherwise be lost to space. The reflecting back of heat energy by the atmosphere is called the "greenhouse effect". The major natural greenhouse gases are water vapor, which causes about 36-70% of the greenhouse effect on Earth (not including clouds); carbon dioxide CO<sub>2</sub>, which causes 50%; carbon monoxide CO, which causes 20%, methane, Methanol, Chloro fluoro Carbons and Hydro fluoro carbons, which causes 12%, Nitrogen Oxides, which causes 7%, other gases, which causes 11% and ozone, which causes 3-7%. Almost 100% of the observed temperature increase over the last 50 years has been due to the increase in the atmosphere of greenhouse gas concentrations like water vapour, carbon dioxide (CO<sub>2</sub>), methane and ozone. Greenhouse gases are those gases that contribute to the greenhouse effect. The largest contributing source of greenhouse gas is the burning of fossil fuels leading to the emission of carbon dioxide.

#### **Effects of Green House effect:**

1. The rise in temperature empowers the green house effect and the thawing of the ice mass causing rise in sea level.
2. Flooding in coastal areas
3. Changes occur in weather conditions
4. Disruption of the water cycle
5. Effect on the ozone layer
6. Effect on the oceanic climate

#### **Control Measures of Global Warming:**

1. Forest protection /Reforestation reduces green house gases

2. Composting and recycling of Agricultural waste materials
3. Use alternative sources of energy, instead of using coolers, fridges and air conditioners which releases green house gases like CFC, HFC
4. Recovery of Methane from garbage
5. Following of Anti pollution measures to control global warming.

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