SOIL AS A MEDIUM OF PLANT GROWTH

Dr. V. K. Venugopal
Former Professor & Head
Department of Soil Science and Agricultural Chemistry
College of Agriculture, Vellayani
Consultant, Digital University, Kerala

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Soil definition

- Traditional definition- Material which nourishes and supports growing plants, includes rocks, water, snow, and air
- Component definition- A three phase system consisting of a mixture of mineral matter, organic matter, water and air intimately mixed together
- As a portion of the land scape- Joffe (1949)
- Soil is a natural body differentiated into horizons of mineral and organic constituents, usually unconsolidated, of variable depth, which differs from the parent material below in morphology, physical properties and constitution, chemical properties and composition and biological characteristics.

Pedology (Pedon-Greek word- meaning soil or earth)

- The origin of soil, its classification and description come under pedology which considers soil as a natural body and does not focus on soils immediate practical use. The soils are studied and classified in their natural environment.

Edaphology (Greek word- meaning soil or earth)

- It involves the study of various properties of soils from the point of view of growth of plant production. The ultimate aim is the production of food and fibre. Edaphologist determines the reasons for variation in productivity of soils and find out means to maximize productivity.

Soil formation Two step process

Step 1 Rock weathering Step-2 Soil Development

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Physical weathering

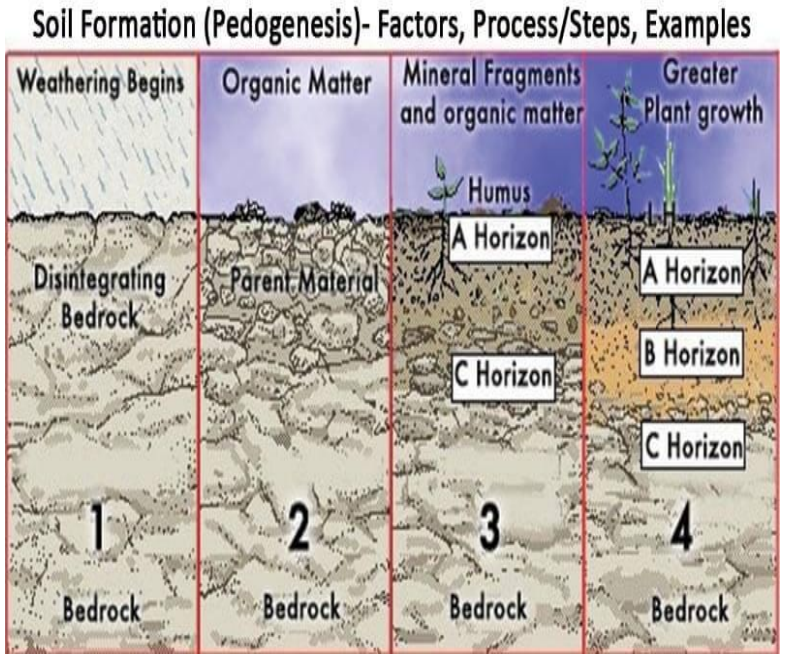
Chemical weathering

Biological weathering

↓

Unconsolidated parent material- Regolith

Soil development/soil profile forming processes



ScienceDirect.com

Transformations (within)

OM,decomposition,

structure developmen,

+hard pan formation

Additions (to)

water,

solar energy

dust,

oxygen

Lossess (from)

water –evaporation

Heat-radiation,

soil-erosion,

Co2 – OM decomposition

Transocation (within)

clay, Water suspension

hydrous oxide, Eluviation

OM Illuviation

Soluble salts

Nutrients recycled by plants

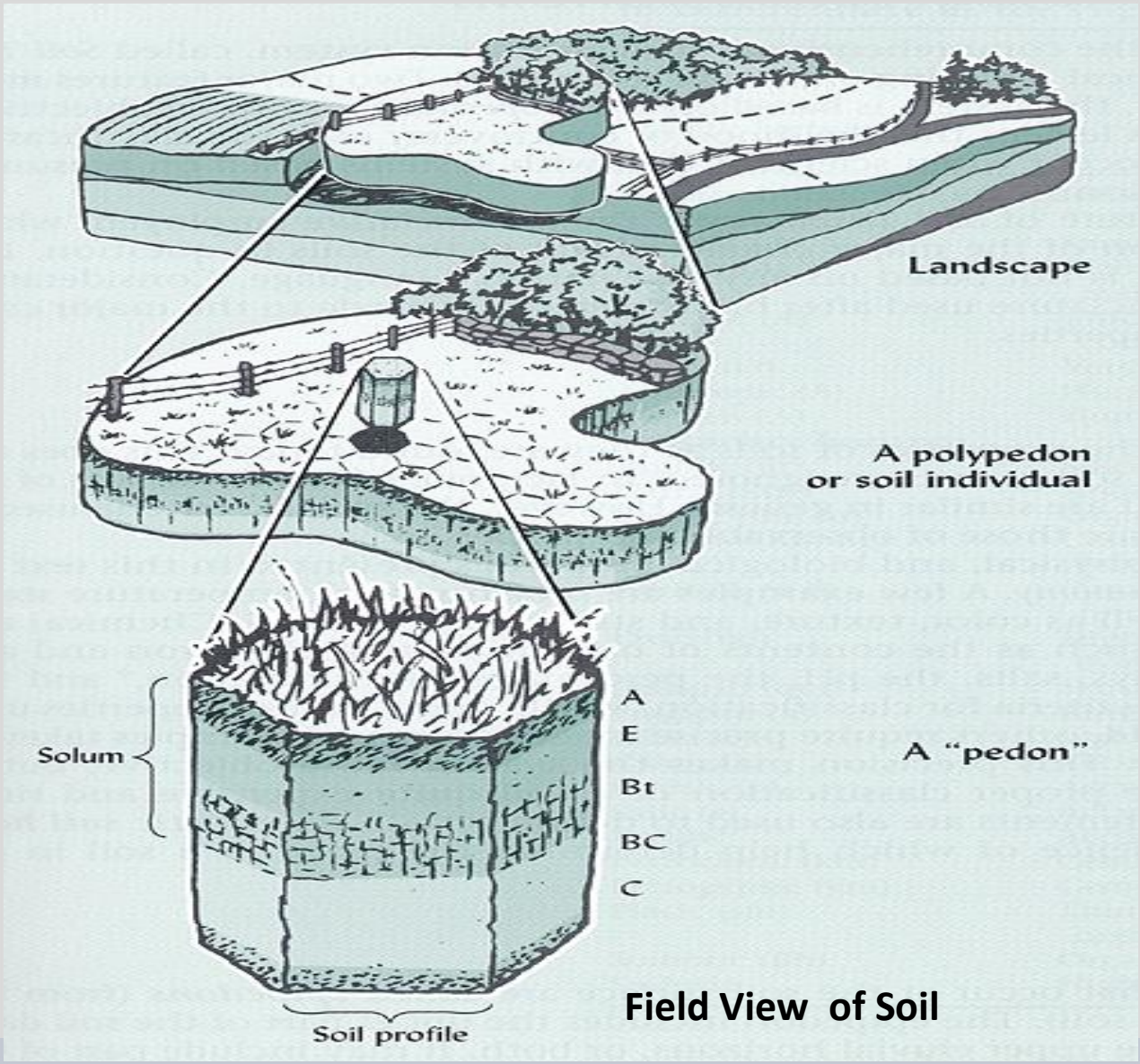
Factors of Soil Formation

CL,O,R,P,T

1	Climate	Precipitation, Temperature
2	Organism	Forest types Grasslands, Deciduous, Coniferous
3	Relief/Topography	Slope , terrain - decides erosion, drainage
4	Parent material	Geology, rock type, sediment, mineral composition
5	Time	Period for which parent material is exposed to weathering

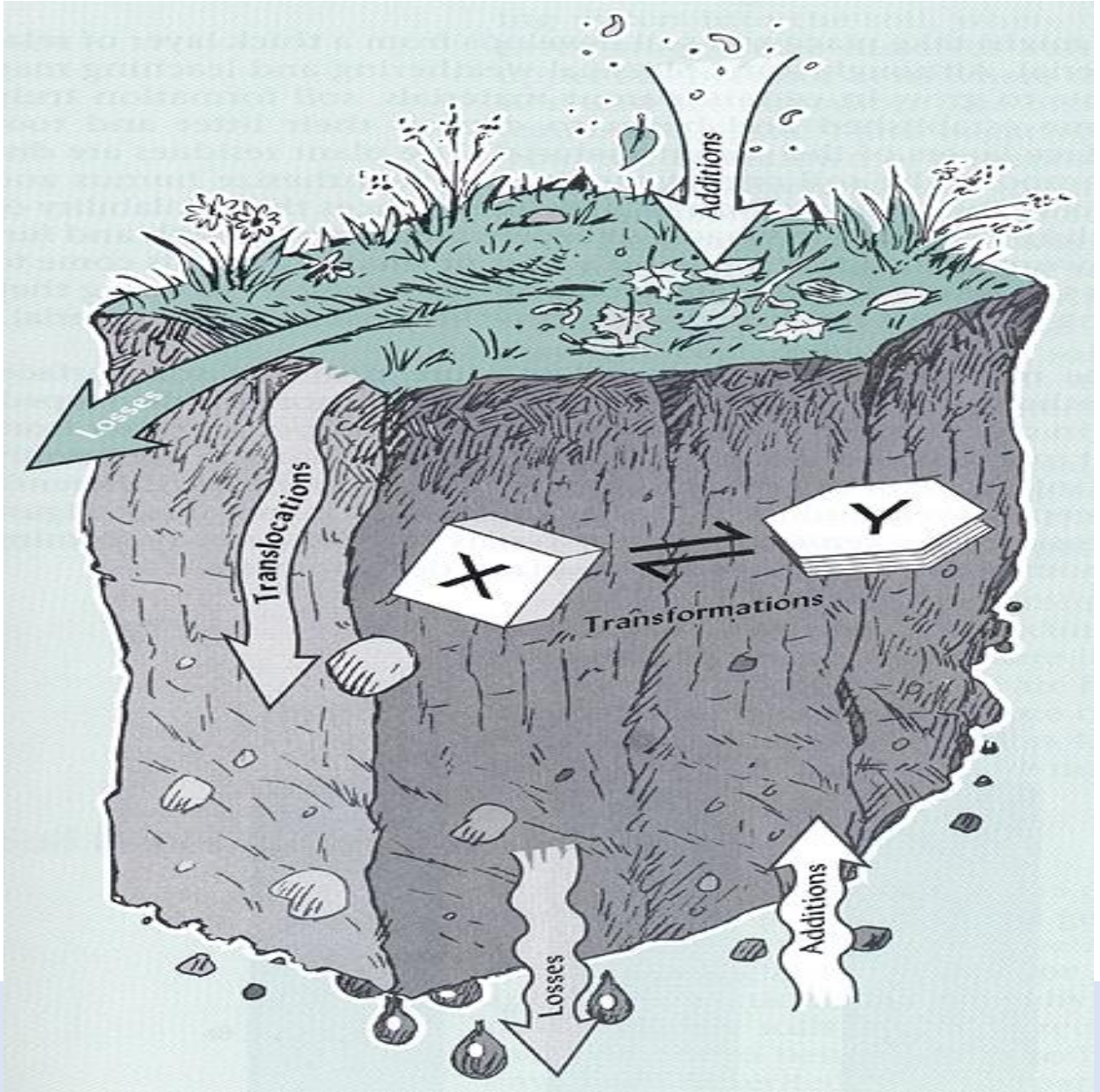
Soil heterogeneity

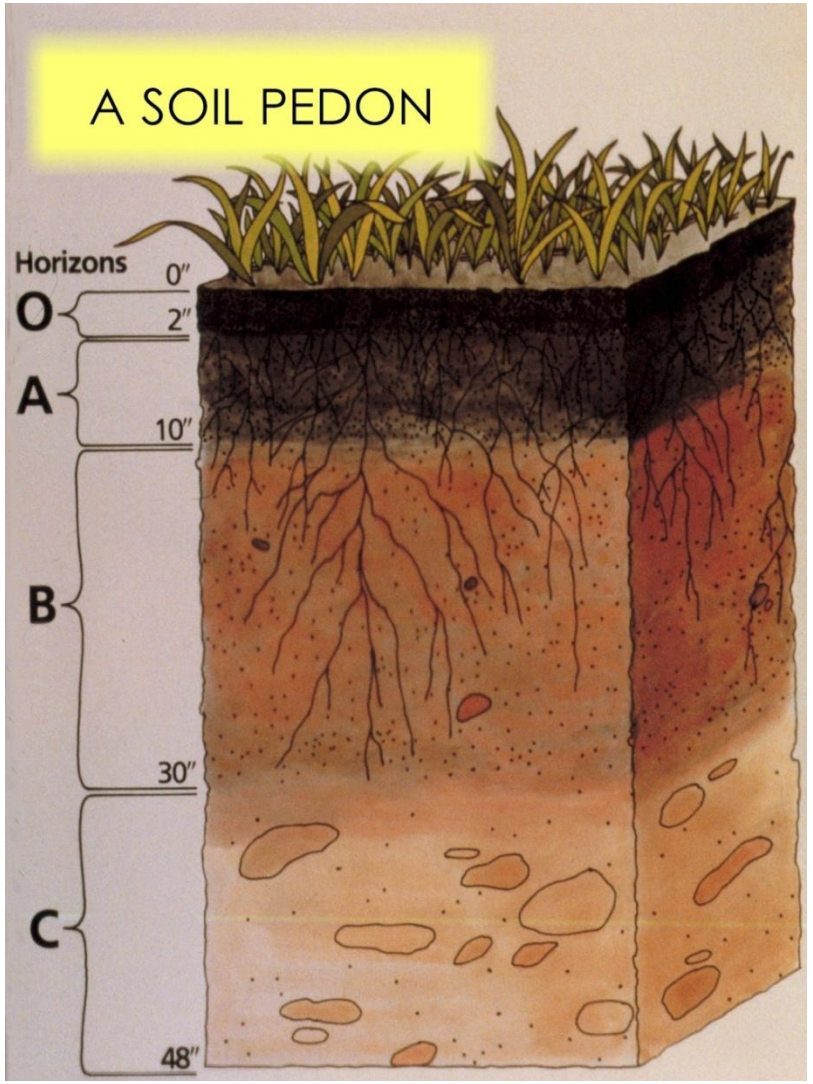
- Wide variations observed in soil properties on the surface of the earth
- Characteristics of soils in terms of morphology, physico -chemical Properties, mineralogy etc. in an area are decided upon by the activities of the particular combination of the five factors of soil formation viz., climate, organisms, relief, parent material and time
- Different permutations and combinations of these five factors are responsible for the wide heterogeneity observed in soils



Field View of Soil

Pedogenic processes – Field View





Master horizons and layers

O – Organic,slightly decomposed

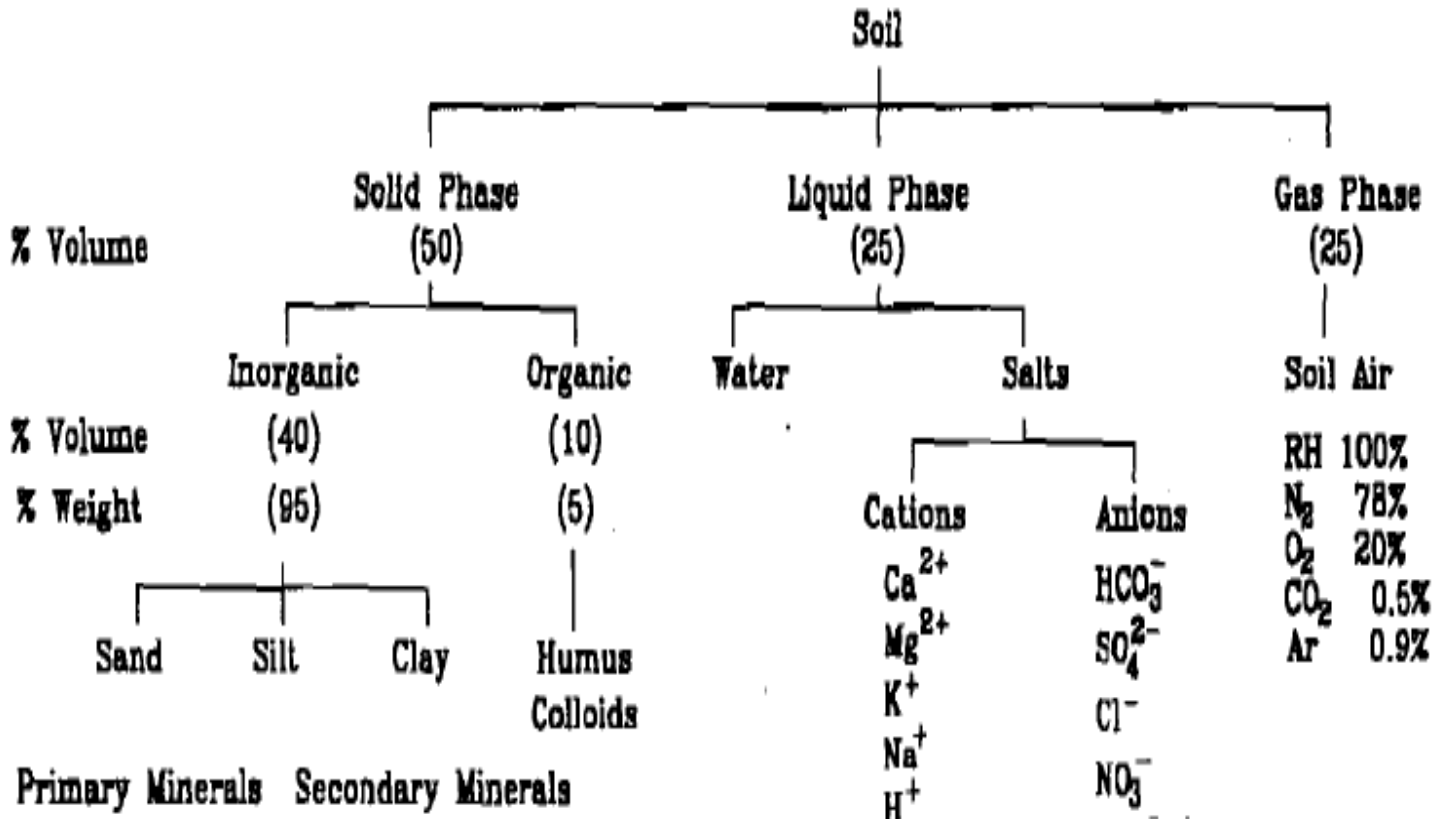
A –Minerals, mixed with humus, dark coloured

B – Most clearly expressed portion of B horizon – Illuvial horizon

C – Unconsolidated material

A and B together called Solum

From a physical standpoint, soil may be viewed as a combinatiof solid, liquid and gas. Approximate composition of these in a typical top soil can be represented in Figure 1.1.



Inorganic constituents of soil

Primary mineral

- Owe their origin to the parent rock
- Type of minerals depend on the mineralogy of rocks
- Observed mostly in the coarse fraction of the soil

Secondary minerals or clay minerals

- Transformed primary minerals by weathering
- Observed mostly in the clay fraction of soil
- Are of colloidal size
- Have characteristic shape, size, surface area,
- Surface charge, and CEC

Clay minerals

Classification based on the crystal structure

- **1:1 structure - Kaolinite**
- **2:1 structure - Montmorillonite, Vermiculite, Illite**
- **Oxide and hydroxides of Si, Al and Fe**
- **Silicate clays dominate the temperate regions**
- **Oxide and hydroxide clays dominate the tropical regions**

Soil organic matter

- All plant and animal residues at different stages of decomposition
- Energy source of microbes and key component of all biochemical reactions
- Decomposition releases many nutrient elements by mineralization
- End product of decomposition is humus, the organic colloidal fraction
- Imparts many beneficial, chemical and physical properties to soil
- Is a transient component and has to be replenished

Soil water

- Held on the colloidal surface with different degrees of tension
- Constitute the soil solution along with the dissolved salts
- Present as free water in the pores

Available water capacity (AWC)

- Soil moisture/water that is available for plant growth
- Held between tensions of 1/3 and 15 bar
- (AWC) is decided upon by soil properties like
- Texture, content and nature of clay, organic matter
- Pore space, gravel content and presence of soluble salts

Soil air

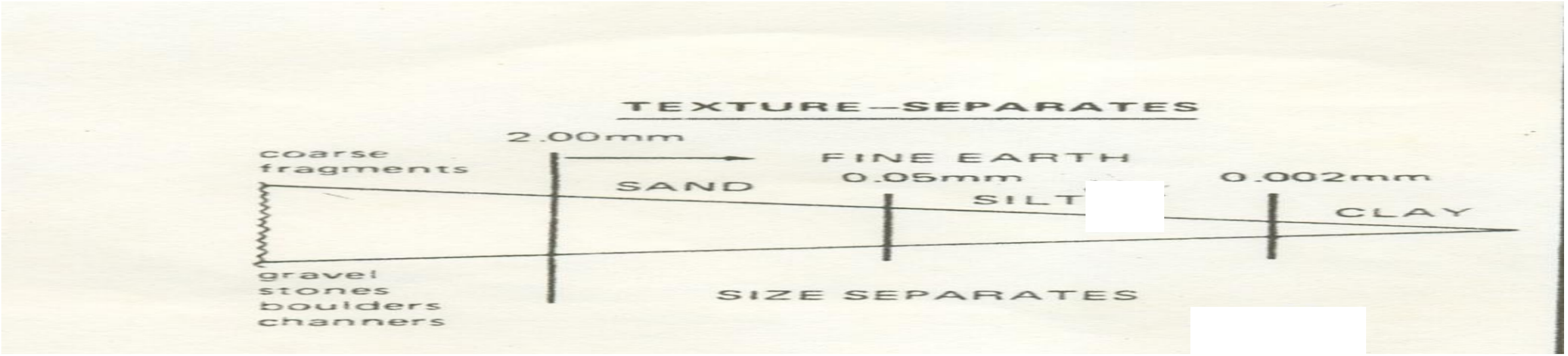
- Present in the soil pores
- Composition varies with atmospheric air
- Aeration status of soil is a very important property referred to as redox potential
- Expressed as Eh (Electrode potential)

Soil physical properties

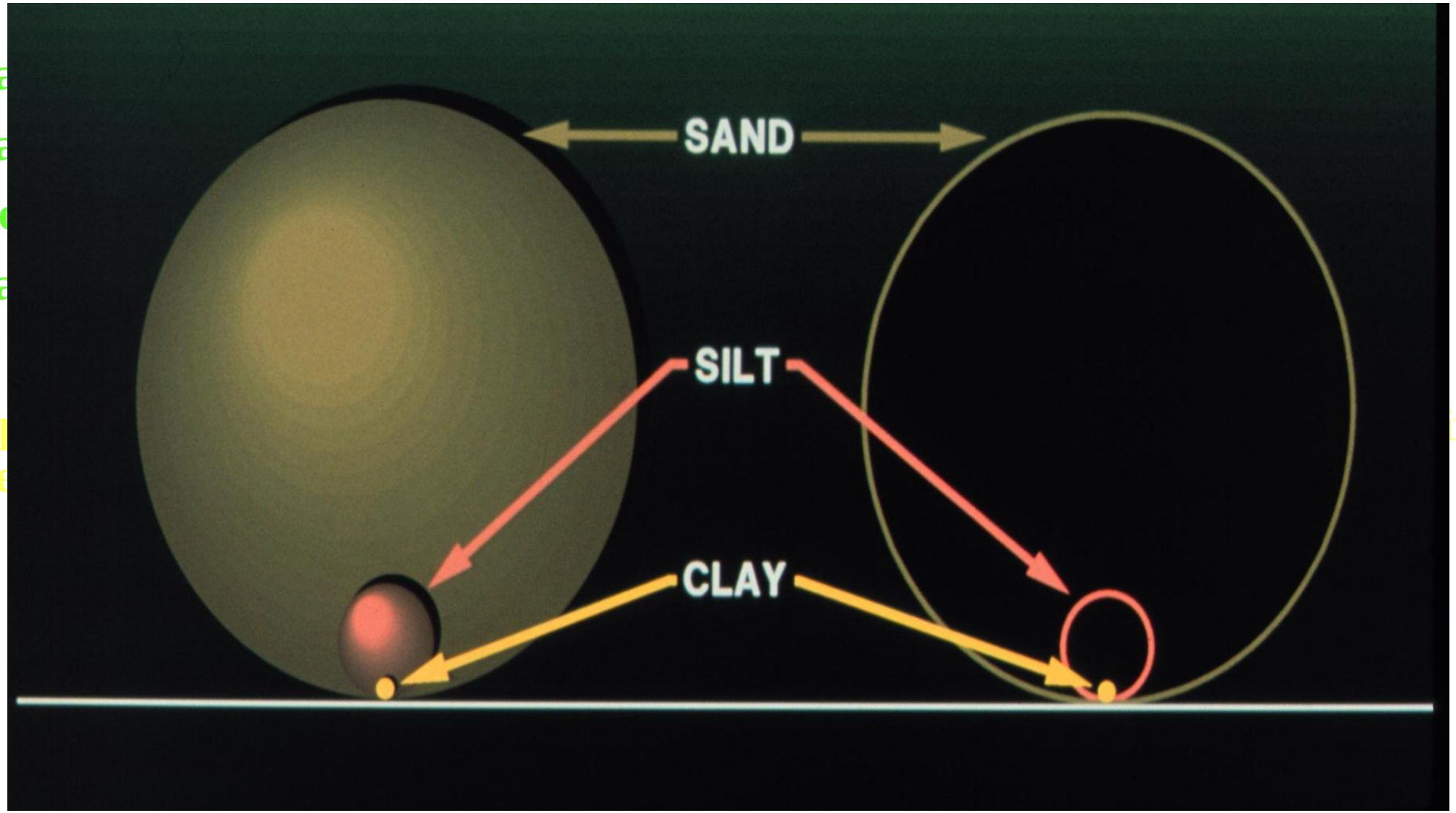
Texture

- Relative proportion of various size separates in the soil
- Inherent property, does not change

- **Textural class** – Name is given based on the relative proportion of size separates. Found out using the Textural triangle



Relative size of particle fractions



USDA Soil Textural Triangle

Textural class names

Sand	Clay loam
Loamy sand	Silt
Sandy loam	Silt loam
Sandy clay loam	Silty clay loam
Loam	Silty clay
Sandy clay	Clay

Mechanical Analysis

- Laboratory procedure of separating the size separates and estimating the percentage

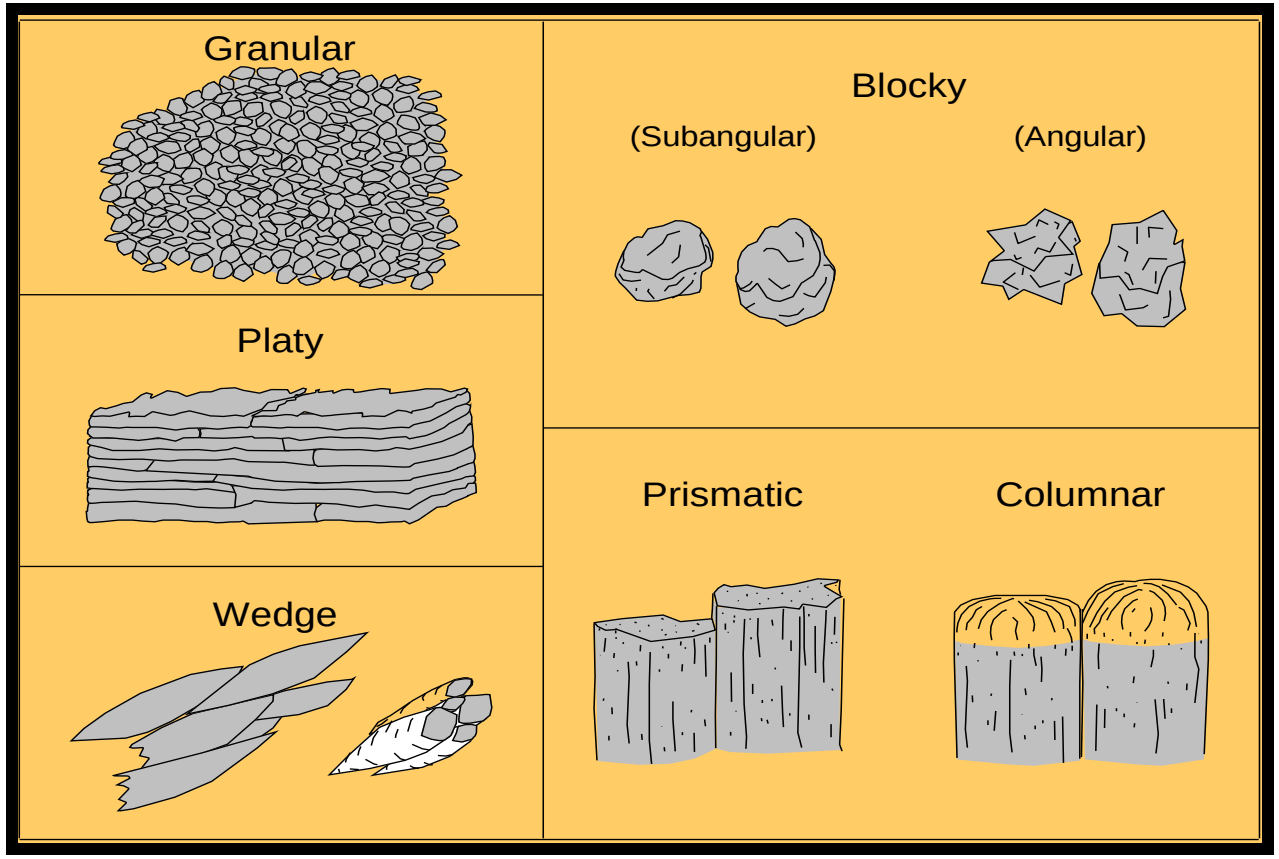
Soil structure

- Grouping and arrangement of soil particles
- Soil profile may have single structure or multiple types
- Influence, water and air movement, heat transfer, bulk density and porosity

Classification of structure

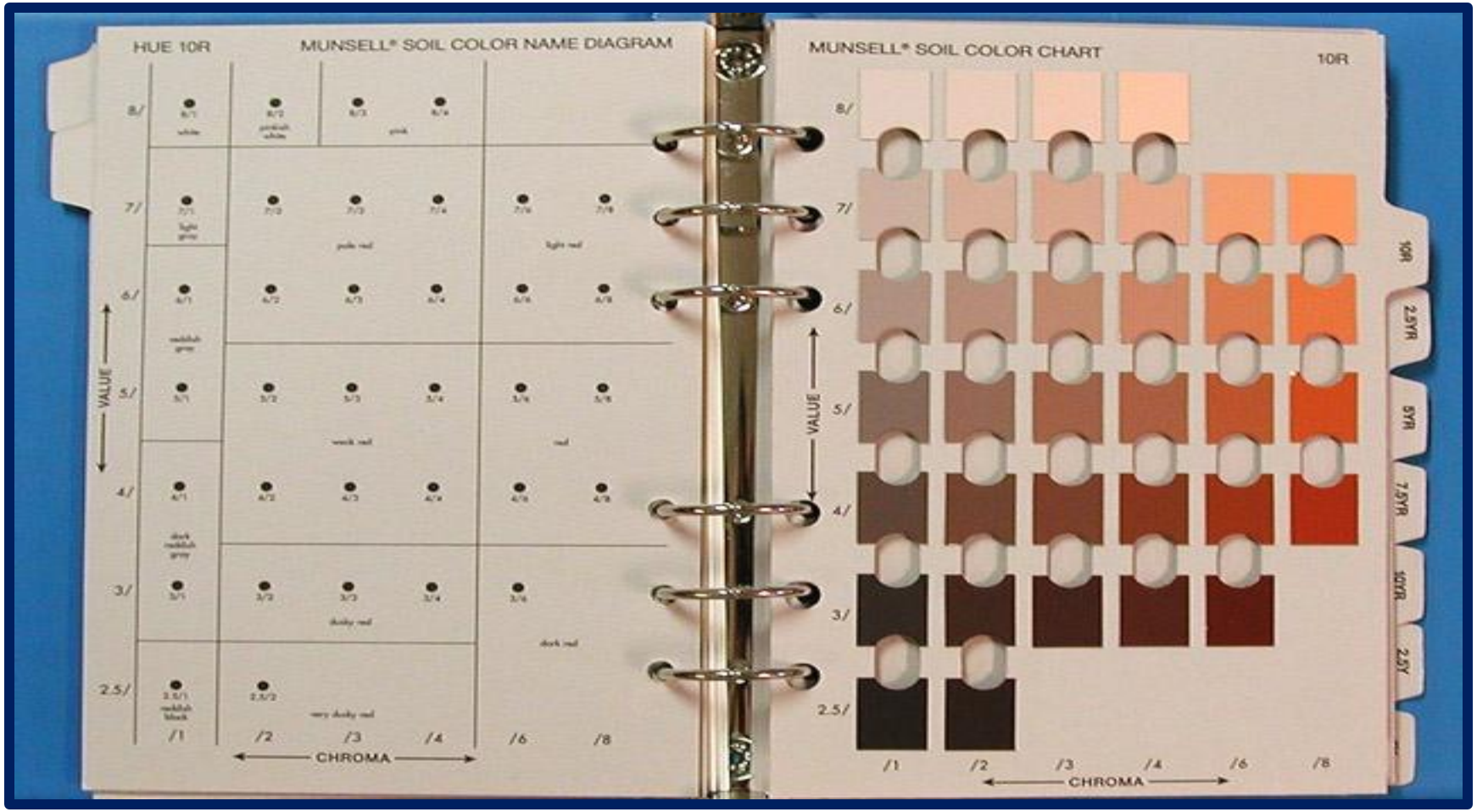
1. Single grained
2. Massive
3. Granular
4. Crumb
5. Platy
6. Angular blocky
7. Sub angular blocky
8. Prismatic

Typesm of Soil Structure



Soil Colour

- Provides ready clues to soil conditions and properties observed in the field
- Colours due to mineral matter, organic matter, soil drainage ,sodium saturation
- Red, yellow, brown colours due to iron oxides in different stages of hydration
- Calcareous soils, are whitish or greyish
- Deep red colours are due to intense weathering
- Bluish or greyish colous due to ill drained conditions
- Colour is described using the Munsell colour notation with a Munsell colour chart.


HUE 10R
MUNSELL® SOIL COLOR NAME DIAGRAM
VALUE
CHROMA
/1
/2
/3
/4
/6
/8
8/
7/
6/
5/
4/
3/
2.5/
MUNSELL® SOIL COLOR CHART
10R
2.5YR
5YR
7.5YR
10YR
2.5Y

Infiltration

- **Downward entry of water received on the surface through rain or irrigation**
- **Expressed as inches or cm h^{-1}**

Infiltration classes identified

- **Low 0.1cm h^{-1}**
- **Very rapid 25cm h^{-1}**

Permeability or hydraulic conductivity

- **Readiness or ease with which soil transmit water through the soil**
- **Closely related to texture, structure, porosity, consistency, exchangeable bases, organic matter**
- **Measured in the field using a piezometer and expressed as inches or cms / hour**

Permeability classes identified

- **Very slow < 8 cm h^{-1}**
- **Very rapid 12.5 cm h^{-1}**

Chemical properties

Elemental composition

- Total elements - derived from inorganic and organic fraction
- Exchangeable - ions held or adsorbed on the surface of colloids
- Water soluble - present in the soluble form in the soil solution

Cation exchange

- Ability of cations held on colloidal surface to exchange with other cations
- Very important property, prevents applied nutrients from loss by leaching
- Cation exchange capacity (CEC)
- Varies with type of colloid
- Expressed as me100g^{-1} soil or c mol kg^{-1} in the International System

CEC of soil colloids

Kaolinite	3-15	c mol kg^{-1}
Montmoillonite	60-100	c mol kg^{-1}
Illite	20-40	c mol kg^{-1}
Humus	200-750	c mol kg^{-1}

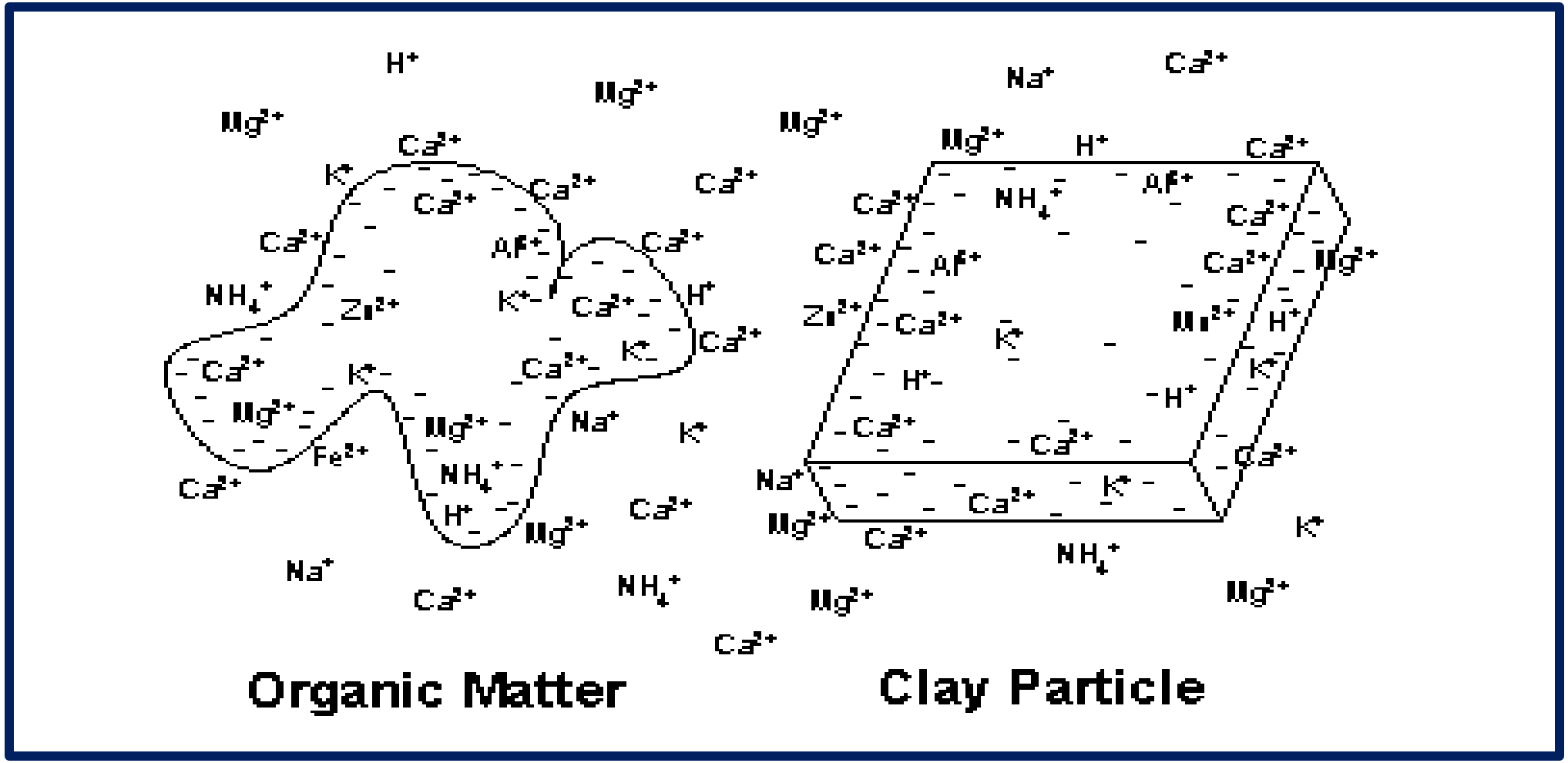
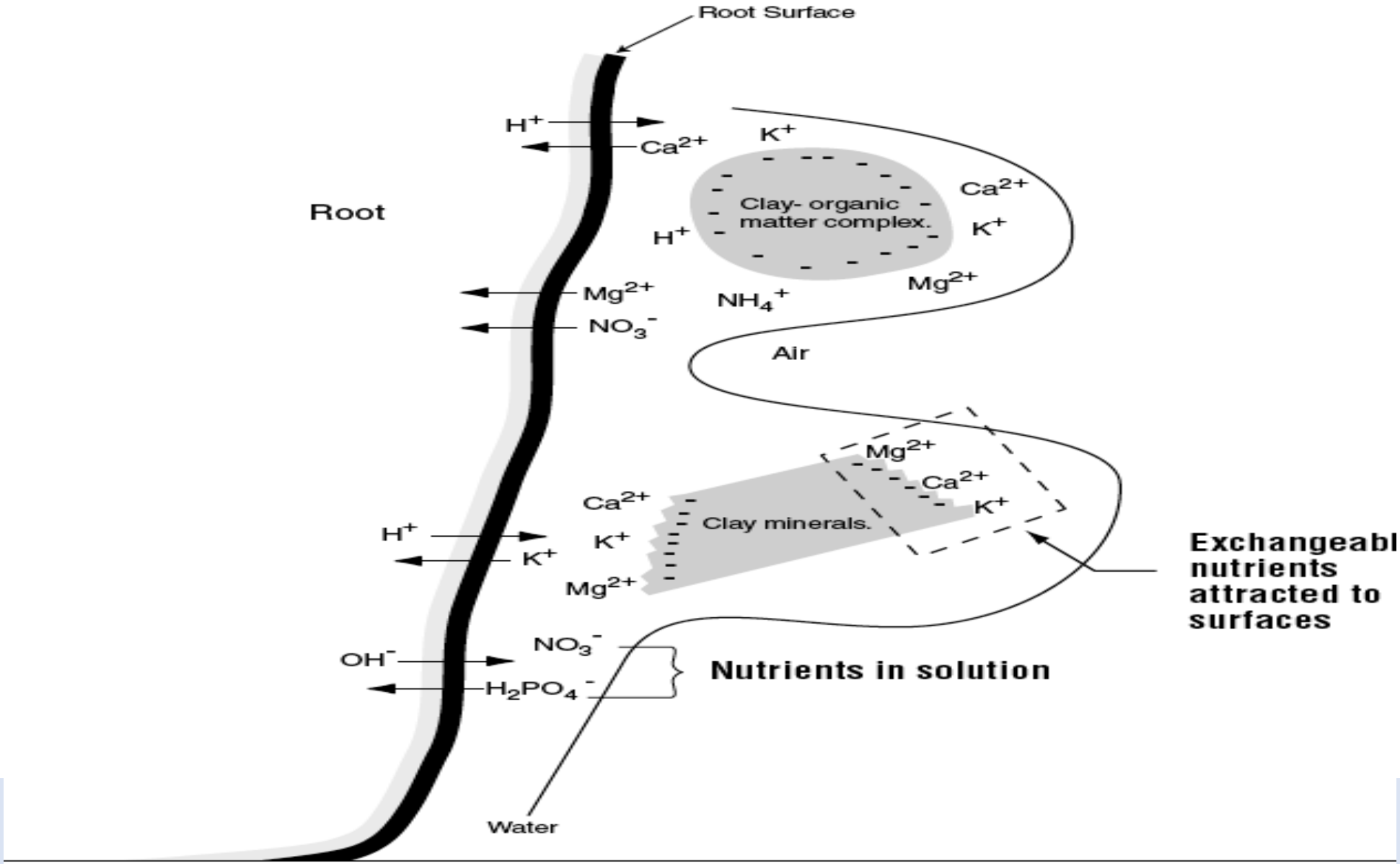

Organic Matter
Clay Particle

FIGURE 3-1. Cation exchange



Anion exchange capacity (AEC)

- **Colloids have +ve charged sites and anion exchange capacity**
- **Adsorb nitrates phosphates, sulphates**
- **Kaolinites and oxide clays have higher AEC**

Percentage Base Saturation (PBS)

- **Cations held on the colloidal surface decides the soil properties.**
- **Sum total of the base cations expressed as percentage of the CEC is PBS**
- **Base saturated soils, characteristic of arid/semiarid regions and soils from base poor parent materials and high rainfall regions are acidic**

Colloido- Biological complex

- **The colloidal fraction Clay and humus are the seat of all chemical activity**
- **Soil microbes along with organic matter control all biochemical transformations and nutrient cycles in soil**

Soil Biota

- Represents a large portion of the earth's biodiversity
- Home to over 25 percent of species observed on the earth.
- Only one percent of them have been identified
- A diverse, balanced and active soil biota provide soil conditions necessary for sustainable crop production with little negative environmental effect
- **Classification of soil organisms**
- Four major groups identified based on body size
- Microflora (bacteria, fungi, algae and actinomycetes)
- Mesofauna (collembola, mites)
- Macrofauna (earthworms, beetles, termites)
- Part-time soil residents (moles, snakes, lizards, mice, rabbits)

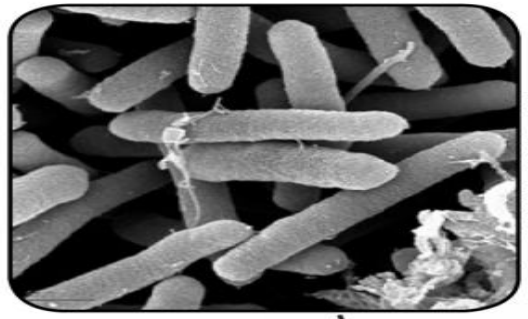
References

ISSS ,2012, Fundamentals of Soil Science, Revised, Indian Society of Soil Science, New Delhi

Nyle C. Brady, Ray R. Weil (2016), The Nature and Properties of Soils

Dreamstime .com

Life in the soil



Gordon Vrdoljak, UC Berkley

Nematode

Plant root hair

Bacterial colonies

Mycorrhizal hyphae

Actinomycete hyphae and spores

Decomposing plant cells

Clay organic matter complex

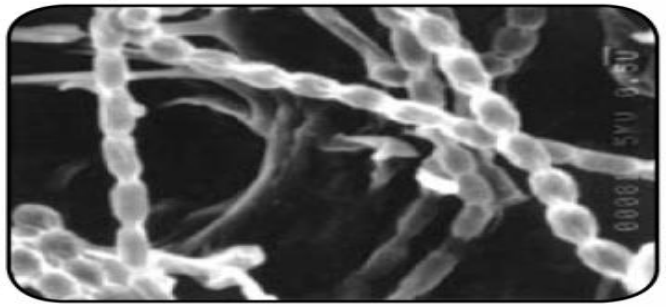
Flagellate

Fungal hyphae and spores

Cililate

Amoeba

Microarthropods



P.R. August


Thank You