Chemical characteristics of Soil

Soil chemical properties include:

- Concentrations of specific chemicals (e.g. phosphorus, nitrogen, carbon, sulphur).
- Major cations (calcium, magnesium, sodium, potassium).
- Trace metals and elements.
- pH, cation exchange capacity, base saturation, salinity, sodium adsorption ratio, enzymes, and electrical conductivity.

Cations

- Cations are positively charged elements.
- Major cations in soil include calcium (Ca_2^+), magnesium (Mg_2^+), sodium (Na^+), and potassium (K^+).
- These elements are utilized in smaller quantities than phosphorus or nitrogen, but are essential plant nutrients since they are involved in a variety of plant functions and metabolic processes, while deficiency of all four can have adverse effects on soil or plants.

- These cations can affect the fate of other elements in soil. Examples include:

1. Excess calcium may affect the availability of phosphorus, potassium, magnesium, boron, copper, iron, or zinc.

2. Excess sodium can be toxic to plants and disperse clays, resulting in reduced infiltration and soil surface crusting.

3. Excess potassium can affect plant uptake of nutrients.

4. Excess magnesium can form soil crusting and negatively affect soil structure.

Cation exchange capacity

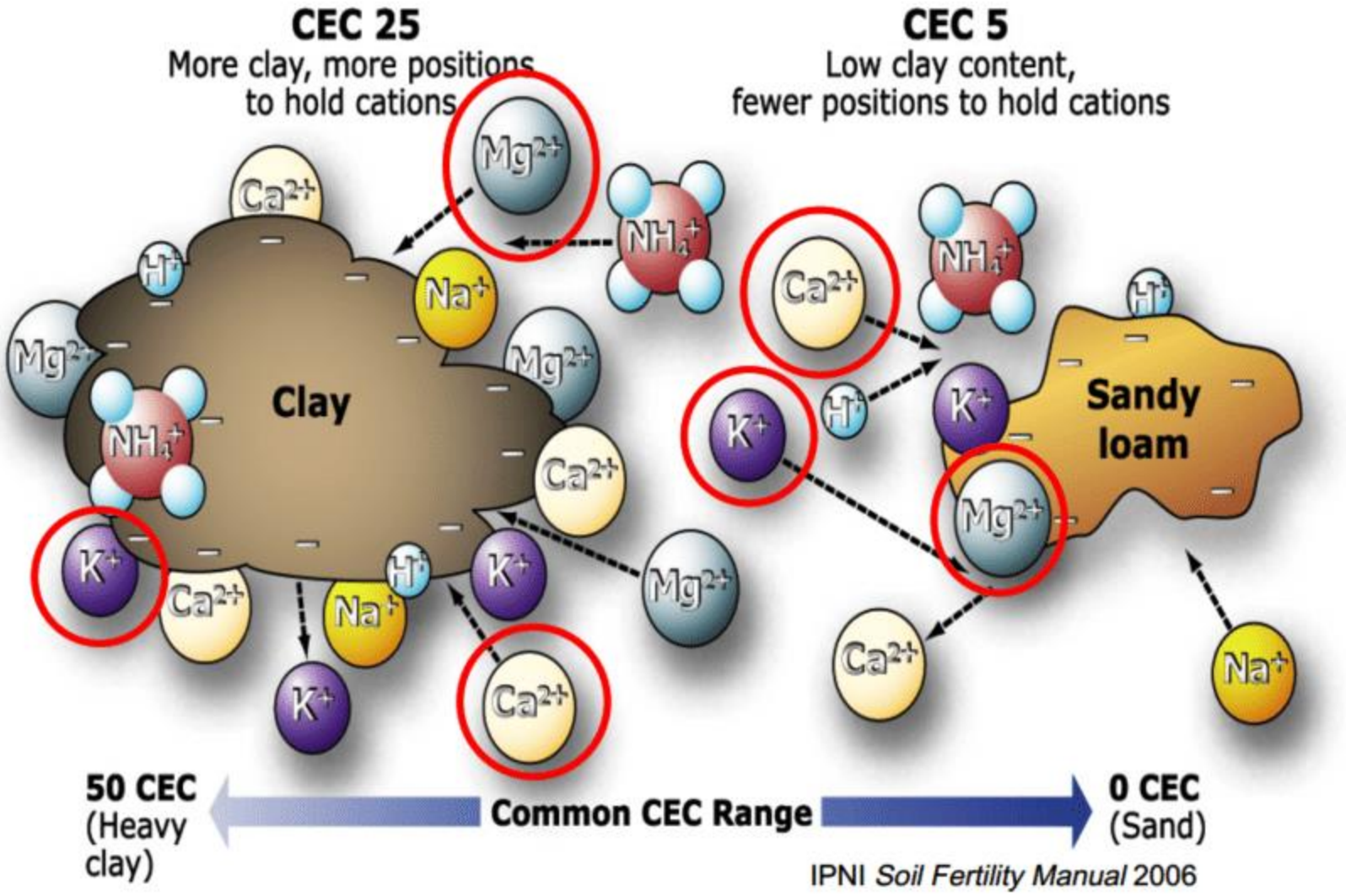
- Cation exchange capacity (CEC) is the total capacity of a soil to hold **exchangeable cations**.

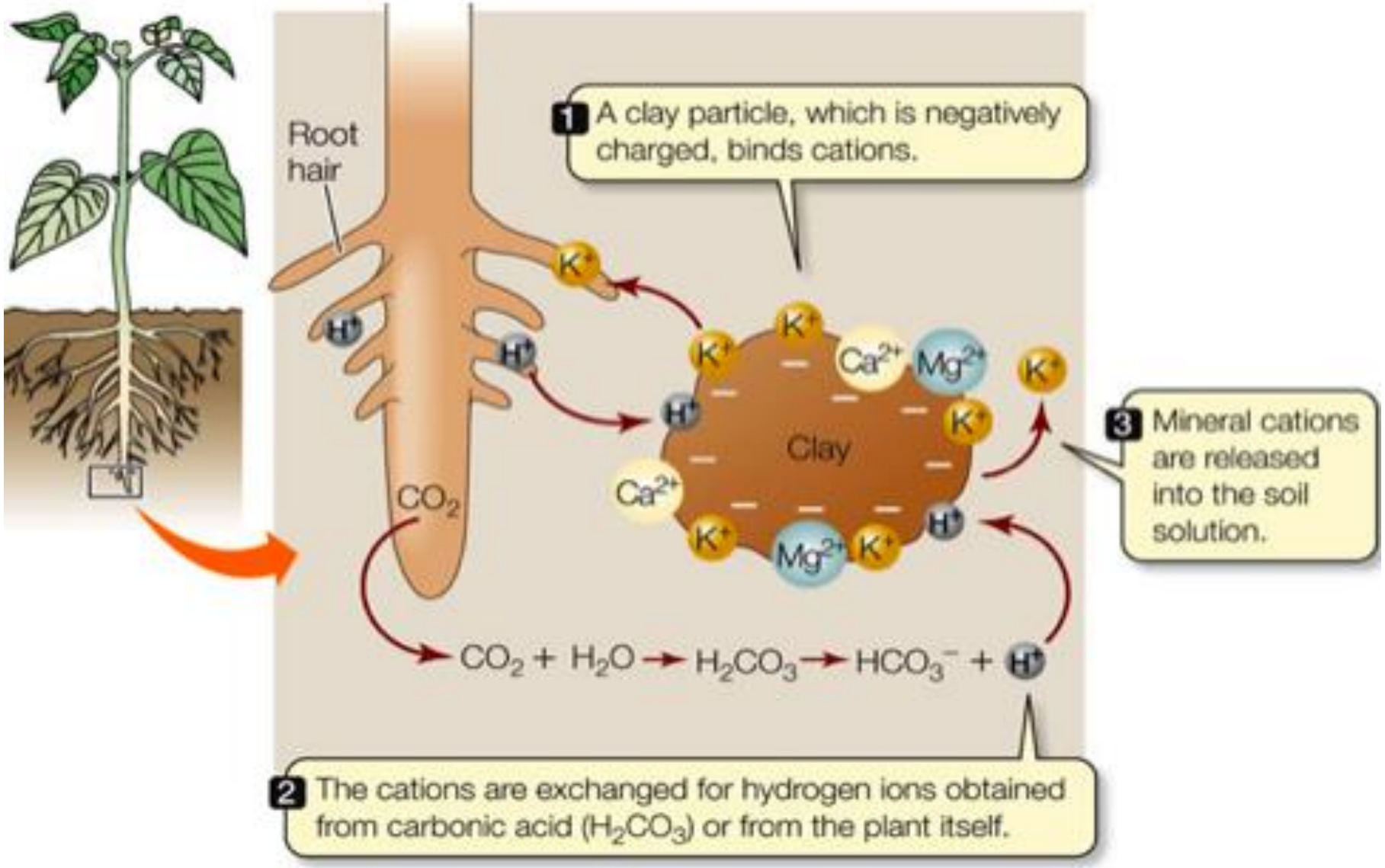
- It affects the fate of other soil chemicals, including nutrients and pollutants, and provides a buffer against soil acidification.

- The main ions associated with CEC are calcium (Ca_2^+), magnesium (Mg_2^+), sodium (Na^+) and potassium (K^+).

- Clay soils have a higher CEC than sandy soils, but soil organic matter has the greatest effect on a soil's CEC.

- In acidic soils, aluminum (Al_3^+) and manganese (Mn_2^+) are important.


CEC 25
More clay, more positions to hold cations
CEC 5
Low clay content, fewer positions to hold cations
Clay
Sandy loam
50 CEC (Heavy clay)
Common CEC Range
0 CEC (Sand)
IPNI Soil Fertility Manual 2006


Root hair
1 A clay particle, which is negatively charged, binds cations.
K+
H+
Ca2+
Mg2+
Clay
CO2
3 Mineral cations are released into the soil solution.
CO2 + H2O → H2CO3 → HCO3− + H+
2 The cations are exchanged for hydrogen ions obtained from carbonic acid (H2CO3) or from the plant itself.

Base saturation

- Base saturation is calculated as the percentage of CEC occupied by base cations (calcium, magnesium, potassium, sodium, hydrogen).

- As base saturation increases, pH increases.

- In soils where CEC is dominated by aluminum, base saturation is low and plant growth may be inhibited by the elevated aluminum concentration.

Salinity and Electrical conductivity

- Salinity is a measure of the salt concentration in a soil.
- Electrical conductivity (EC) is the ability of a material to conduct (transmit) an electrical current.
- EC is primarily used to assess salt concentration in soil.

pH

- Soil pH is a measure of soil acidity or alkalinity.

- It is an important soil property that affects plant suitability, nutrient availability, soil microorganism activity, chemical cycling, and mobility of pollutants such as metals.

Enzymes

- Enzymes in soil mediate numerous chemical reactions involved in soil nutrient cycling, transformation of plant and microbial debris, mineralization and transformation of organic matter within the carbon cycle, and transformation and degradation of potentially hazardous pollutants.

- The potential enzymes playing major roles in maintaining soil health are amylase, arylsulphatase, β-glucosidase, cellulase, chitinase, dehydrogenase, phosphatase, protease, and urease.

Trace metals

- Trace metals include cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), and zinc (Zn).

- Arsenic (As), boron, and selenium are metalloids but are usually included in discussions of metals in soil.

- Heavy metals refers to metals with a density of more than 7 g/cm^3 (Pb, Cd, Ni, Hg, Cr). Minerals (rocks) are the primary source of most trace metals in soil.

- Some trace metals are essential micronutrients (e.g. boron, zinc, manganese, copper, molybdenum). In higher concentrations, trace metals are environmental pollutants and may be toxic to plants and soil biota.