THE COLLOIDAL FRACTION

SEAT OF CHEMICAL AND PHYSICAL ACTIVITY

INTRODUCTION

- Clay and humus (OM) colloids are highly reactive materials with electrically charged surfaces
  - Provide an enormous amount of reactive surface area
  - Colloids allow the soil to serve as a great electrostatic chemical reactor

INTRODUCTION

- Each colloid carries cations and anions attracted to its surface
- Ions are held tightly enough by soil colloids to:
  - Greatly reduce their loss due to drainage waters
  - Loosely enough to allow access by plant roots

INTRODUCTION

- Other modes of adsorption include:
  - Holding ions more tightly making them unavailable for:
    - Plant uptake
    - Reaction with soil solution
    - Leaching loss to the environment

INTRODUCTION

- Soil colloids bind with:
  - Water molecules
  - Bio-molecules
  - Viruses
  - Toxic metals
  - Pesticides
  - Other minerals and organic substances

INTRODUCTION

- There are different types of clay in soils
- Certain clay materials elicit different types of:
  - Physical and chemical behavior
    - Some are more reactive than others
    - Influenced by soil pH
    - Environmental factors

INTRODUCTION

- Knowledge of soil colloid **structure**, **origin**, and **behavior** will aid in understanding/making:
  - Soil chemical and biological processes
  - Appropriate management decisions regarding use of soil resources

PROPERTIES AND TYPES OF SOIL COLLOIDS

- **Size**
  - **Colloidal fraction** – clay and humus particles in the soil
  - Too small to be seen with a microscope
  - < 1 um in diameter, but up to 2 um

PROPERTIES AND TYPES OF SOIL COLLOIDS

- **Surface area**
  - Smaller the size of a particle, the greater the surface area
  - Colloids expose large **external surface area** per unit mass
  - More than 1,000 times surface area of sand
  - Some silicate clays possess extensive **internal surface area** between plate-like crystal units

PROPERTIES AND TYPES OF SOIL COLLOIDS

- Total surface areas range from:
  - $10 m^2/g$ of clay with external surface area
  - $800 m^2/g$ for clays with internal surface area

- ***Perspective:*** An area the size of a football field at a 3 ft. depth would have an exposed surface area of 8.7 million km^2 (entire land area of US)

PROPERTIES AND TYPES OF SOIL COLLOIDS

- **Surface charges**
  - Generally more negative than positive
  - Vary greatly among various soil colloid
  - Affected by soil pH
  - Colloid surface charges attract or repulse substance in soil solution and neighboring colloid particles
  - Reactions greatly influence soil chemical and physical behavior

PROPERTIES AND TYPES OF SOIL COLLOIDS

- **Adsorption of cations and anions**
  - **Micelle** (colloid particle) have negative charge and attract cations such as:
    - Al, Ca, Mg, K, H, and Na
  - Most cations exist in a **hydrated state** and loosely held or **adsorbed** on colloid surface

PROPERTIES AND TYPES OF SOIL COLLOIDS

- **Adsorption of cations and anions**
  - Cations “swarm” about the soil particle and then break away into the soil solution
    - Also called **exchangeable ions**
  - Another cation will replace the one that left and is called cation exchange (Figure 8.1)

PROPERTIES AND TYPES OF SOIL COLLOIDS

- **Adsorption of cations and anions**
  - Anions will be attracted to positively charged soil colloids
    - Cl^-, NO_3^-, SO_4^-
  - Adsorption of exchangeable anions is not as extensive as for exchangeable cations

PROPERTIES AND TYPES OF SOIL COLLOIDS

- **Adsorption of water**
  - Colloids attract and hold large numbers of water molecules
  - ***Generally, the greater the external surface area of the soil colloid, the greater the amount of water held when the soil is air-dry***

TYPES OF SOIL COLLOIDS

- **Crystalline silicate clays**
  - Dominant in most soils
  - Mostly negatively charged
  - Crystalline structure is layered
  - Vary in intensity of charge, stickiness, plasticity, swelling
  - **Examples:** **kaolinite** (fine grained mica) and **smectite**

MINERAL ORGANIZATION OF SILICATE CLAYS

- **1:1 Silicate clays** – one tetrahedral and one octahedral sheet per layer
  - **Example: kaolinite**
  - Easy to cultivate
  - Well-suited for roadbeds and foundations
  - Good for making bricks and ceramics

MINERAL ORGANIZATION OF SILICATE CLAYS

- **Expanding 2:1 Silicate clays**
  - **Montmorillonite** is most prominent smectite
  - Undesirable for construction because of expansion and shrinkage
  - Well-suited for forming seals of low permeability
  - **Vermiculites are limited expansion clays**

TYPES OF SOIL COLLOIDS

- **Organic (humus) colloids**
  - Important in nearly all soils
  - Not minerals or crystalline
  - Consist of carbon atom chains bonded to hydrogen, oxygen, and nitrogen
  - Among the smallest soil colloids

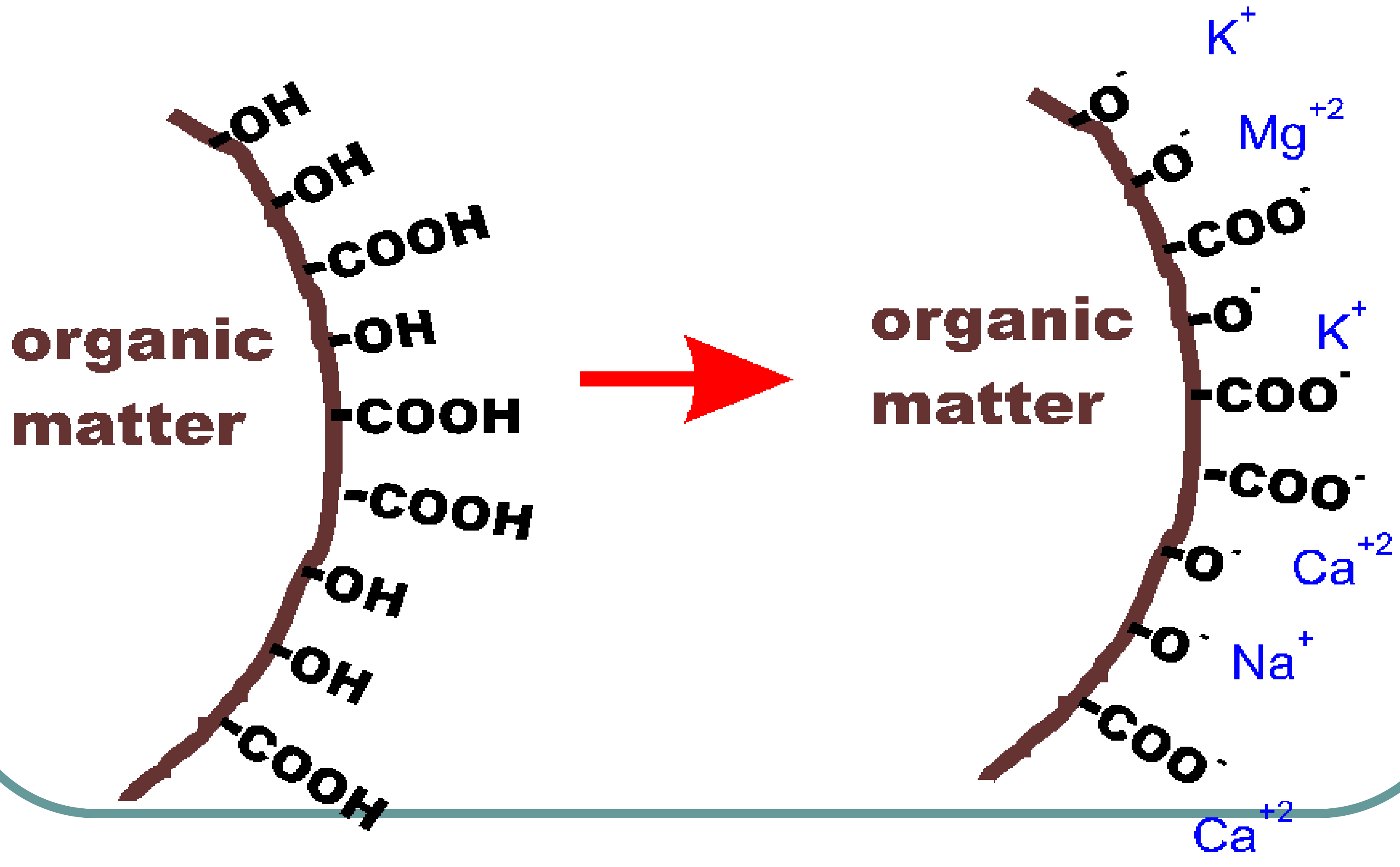
TYPES OF SOIL COLLOIDS

- **Organic (humus) colloids**
  - Very high water adsorption capacity
  - No plasticity or stickiness
  - Very little bearing strength for engineering
  - Net charge is negative and varies with soil pH

ORGANIC COLLOIDS (HUMUS)

- Non-crystalline organic substance
- Consists of very large organic molecules
  - Carbon (C) = 40-60%
  - Oxygen (O) = 30-50%
  - Hydrogen (H) = 3-7%
  - Nitrogen (N) = 1-5%
- Cations and anions are attracted to and adsorbed by humus colloids
- Possesses a large ***net*** negative charge

ORGANIC COLLOIDS



CATION EXCHANGE CAPACITY

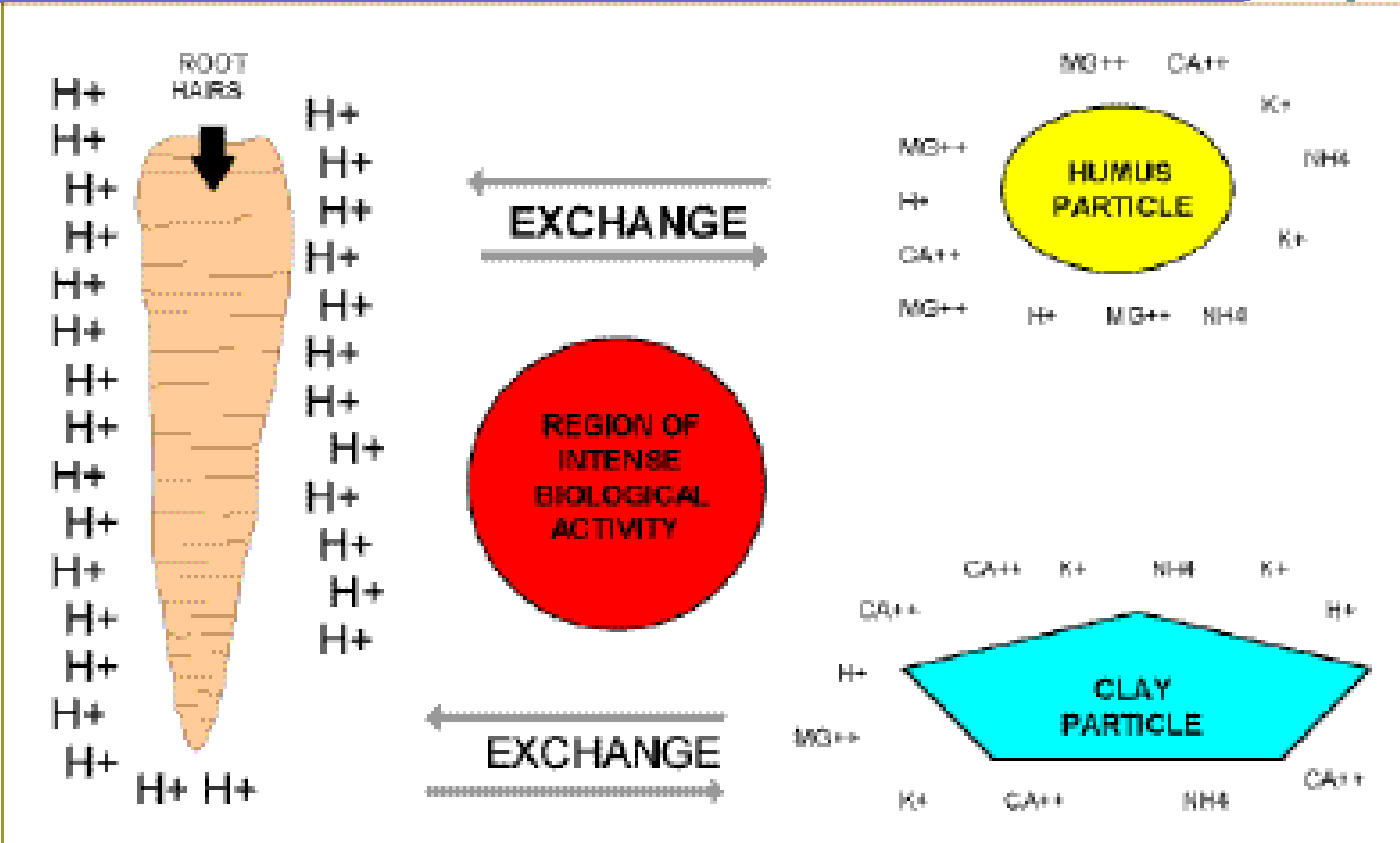
- **CEC is the sum total of the exchangeable cations that a soil can adsorb**

- **Means of expression**
  - Number of moles or positive charge adsorbed per unit mass ($cmol_c/kg$)

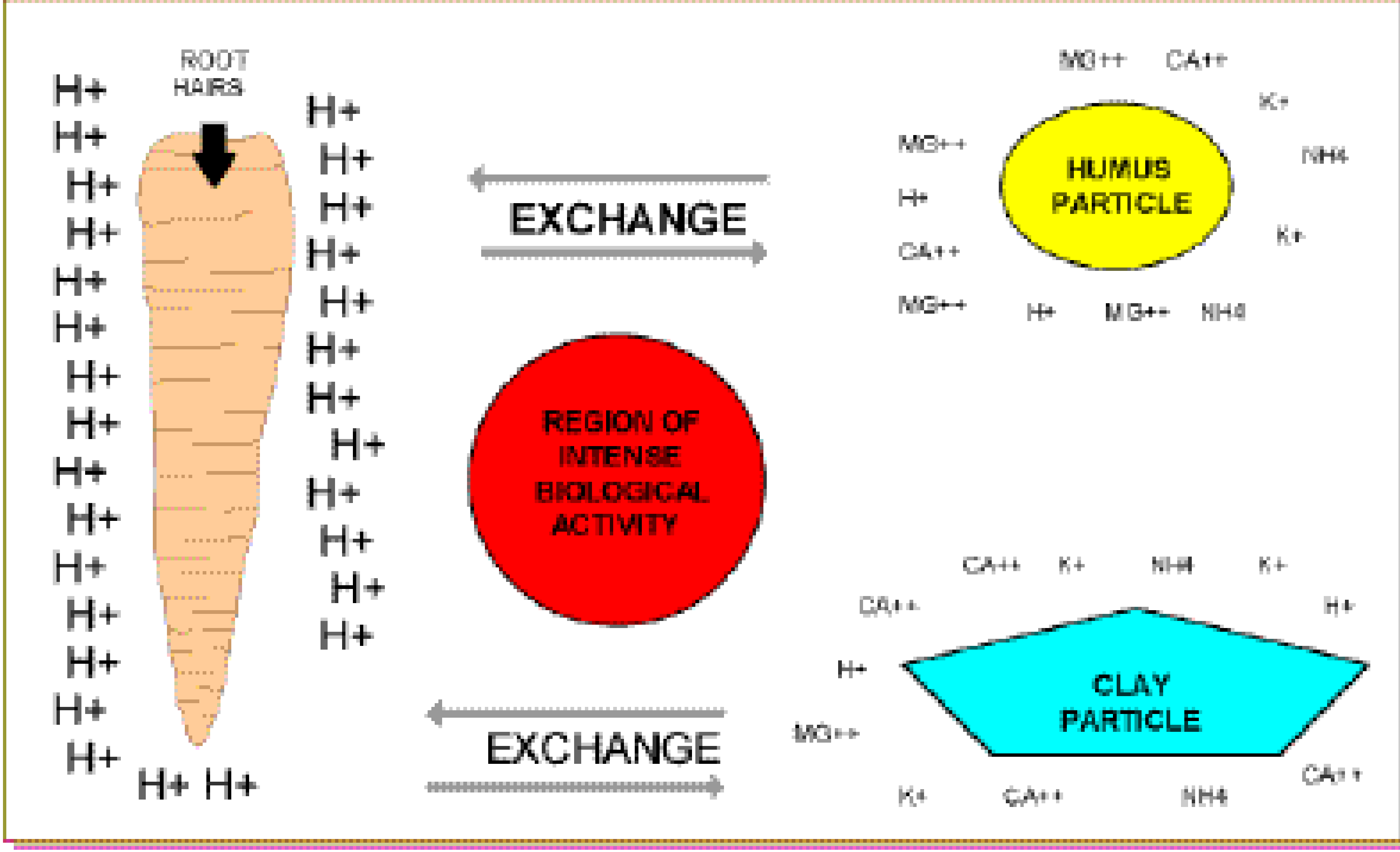
CATION EXCHANGE CAPACITY

- **CEC=15 $cmol_c$/kg means:**
  - 1 kg of soil can hold 15 $cmol_c$ of H^+ ions
  - Can exchange this number of charges from H^+ ions for the same number of charges from any other cation
  - Exchange reactions take place on a **charge-for-charge basis**

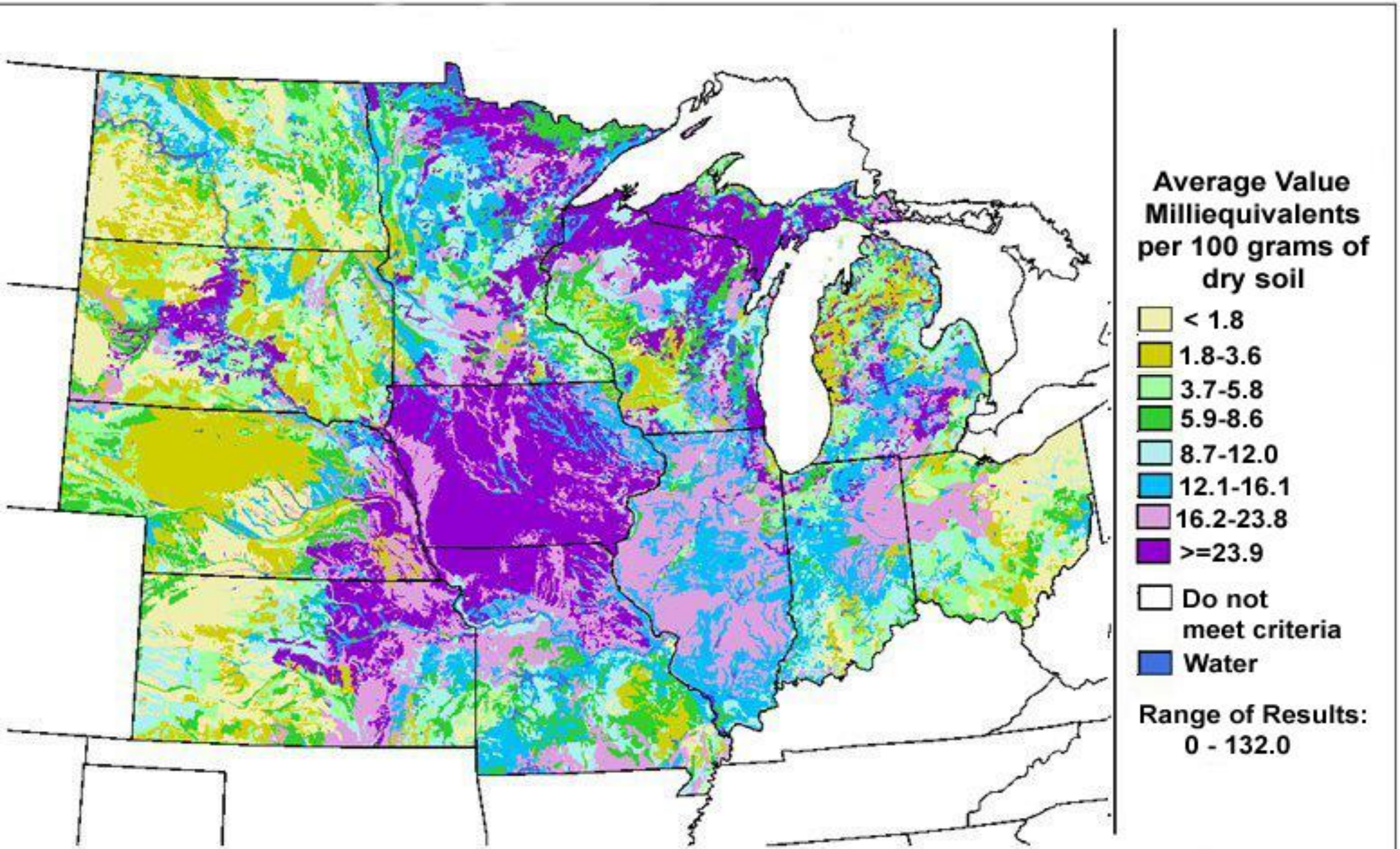
CATION EXCHANGE CAPACITY



CATION EXCHANGE CAPACITY



CATION EXCHANGE CAPACITY



CEC OF SOILS

- Determined by relative amounts of different colloids in the soil and by the CEC of each of the colloids
  - **Low CEC's**
    - Sandy soils
    - Fe and Al oxides
  - **High CEC's**
    - Silt and clay loams
    - Humus

END OF PRESENTATION