

**KLASIFIKASI FRAKSI TANAH**

1. Sistem Internasional

LEMPUNG	DEBU	PASIR		KERIKIL	
		HALUS	KASAR		
←	0.002	0.02	0.2	2.0	→

2. Sistem USDA

LEMPUNG	DEBU	PASIR					KERIKIL	
		SANGAT HALUS	HALUS	SEDANG	KASAR	SANGAT KASAR		
←	0.002	0.05	0.1	0.25	0.5	1	2	→

**Koloid Tanah**  
*Soil Colloid*

- KOLOID TANAH adalah penyusun tanah yang berperan aktif dalam reaksi kimia tanah yang mempunyai diameter < 1 mikron.
- Sifatnya :
  - Mempunyai bidang permukaan yang luas per unit massa
  - Tersuspensi dalam air
  - Bermuatan negatif/positif

**Characteristics of Soil Colloids**

- High surface area
  - Smectites & vermiculites: 1 g = 800 m<sup>2</sup>
  - Range: 10 - 800 m<sup>2</sup> g<sup>-1</sup>
- Electrically charged surface
  - Usually net negative surface charge
  - In low pH soils dominated by sesquioxides, allophane, imogolite, surfaces may be net positive

**MACAM KOLOID TANAH :**

1. Anorganik (Koloid Mineral)
  - a. Koloid silikat (SiO<sub>2</sub>·nH<sub>2</sub>O) kristalin yang bermuatan negatif
  - b. Koloid silikat non kristalin
  - c. Hidroksida Besi [Fe(OH)<sub>3</sub>] dan hidroksida aluminium yang menimbulkan warna merah, kuning, coklat atau campurannya
2. Koloid Organik
  - Koloid Humus

### Pembentukan koloid lempung silikat (Genesis of colloid silicate clay)

- Weathering /pelapukan
- Physical and chemical *alteration*
- **Alteration:**
  - Perubahan ukuran partikel, patahan mineral
  - .Changes of particle size, and broken edges.
  - Weathered 2:1
- Chemical *decomposition-recrystallization*
- **Recrystallization:**
  - Pembentukan struktur baru (rekristalisasi) dr struktur mineral yang telah hancur sempurna. 1;1 from 2:1

### Silicate Clay Minerals

- Aluminosilicates have a definite crystalline structure. Formed by the alteration of existing minerals or by synthesis from elements.
- < .002 mm in size (only seen with aid of electron microscope)
- Two basic kinds of clay minerals  
**1 : 1 and 2 : 1**

### Basic Building Blocks for Clay Minerals

Silicon - Oxygen Tetrahedron ( $Si_2O_5^{-2}$ )

### Basic Building Blocks - 2

Aluminum Octahedral (Gibbsite Sheet)  
 $Al(OH)_6^{-3}$

### Types of Clay Minerals

1) **Kaolinite** a 1: 1 clay mineral  
1 silica sheet and 1 gibbsite sheet  
.0072 cm thick

Properties:  
1) **LARGE PARTICLES** LOW CEC - 3-15 MEQ/100G  
2) **RIGIDLY FIXED-** LOW SHRINK SWELL

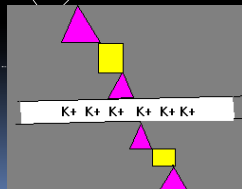
### kaolinite

- silicate example: **kaolinite:**  $Al_2Si_2O_5(OH)_4$
- composed of sequences of T (silica) and O (gibbsite) sheets
- thus called a 1:1 clay mineral

## 2 : 1 CLAY MINERALS

### 1. Hydrous Mica or Illite

replacement of  $Si^{4+}$  with  $Al^{3+}$  in 25% of tetrahedrals, each substitution leaves 1 neg charge site also  $K^+$  ions are a bridge between layers and hold them tightly together

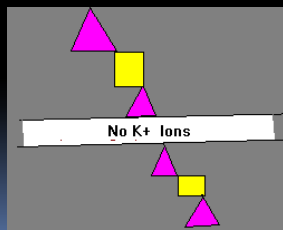


Properties  
 1) non-expanding  
 2) Low CEC 30 meq/100



### 2. Vermiculite

Same as Illite with all the  $K$  ions removed

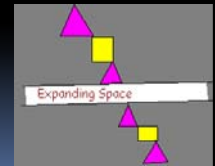


Properties  
 1) expanding - large shrink swell  
 2) High CEC=150meq/100g

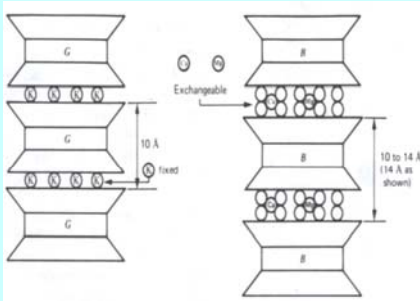
### 3. Smectite or Montmorillonite

$Mg^{++}$  replaces  $Al^{+++}$  in Octahedral layer  
 Properties: 1) expanding (common clay found in Minnesota's soils.

2) CEC = 80-150 meq/100g



## 2:1 Minerals(Illite-Vermiculite)



- The octahedral sheet is brucite.
- The basal spacing is from 10 Å to 14 Å.
- It contains exchangeable cations such as  $Ca^{2+}$  and  $Mg^{2+}$  and two layers of water within interlayers.
- It can be an excellent insulation material after dehydrated.

Illite

Vermiculite

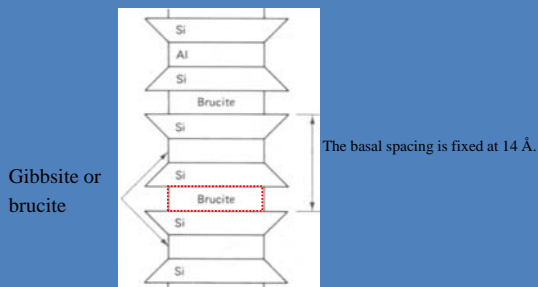
Mitchell, 1993

### ANGGOTA TERPENTING ADALAH KLORIT

- ✓ TERDIRI DARI 2 LEMBAR TETRAHEDRAL SILIKA DAN 2 LEMBAR OKTAHEDRAL MAGNESIUM
- ✓ LEMPENG MAGNESIUM DISEBUT **BRUSIT**  $[Mg(OH)_2]$
- ✓ SUBSTITUSI ISOMORFIK TERJADI DALAM  
 ✓ LAPISAN TETRAHEDRAL MAUPUN OKTAHEDRAL
- ✓ DITEMUKAN DALAM TANAH : **ARIDISOL, MOLLISOL, ULTISOL**

### TIBE MINERAL 2:2

## 2:1:1 Minerals-Chlorite



## KOLOID NONSILIKAT (NON SILICATE COLLOIDS)

- Modifikasi dr structure kristal, umumnya tdk mempunyai lapisan tetrahedral atau octahedral dalam komposisinya.
- Substitusi isomorfik sedikit.
- Muatan berasal dari pengurangan/penambahan ion  $H^+$  ke permukaan kelompok oxy-hydroxyl

## MINERAL NON SILIKAT AMORPHOUS

- **Iron and Aluminum Oxides**
  - Gibbsite  $[Al(OH)_3]$  Oxisols and Ultisols
  - Goethite  $(FeOOH)$  yellow brown soils
  - Hematite  $(Fe_2O_3)$  red soils
- Allophane and Imogolite – Volcanic
  - $Si(OH)_x$  and  $Al(OH)_x$

## Sesquioxides - Al and Fe Oxides

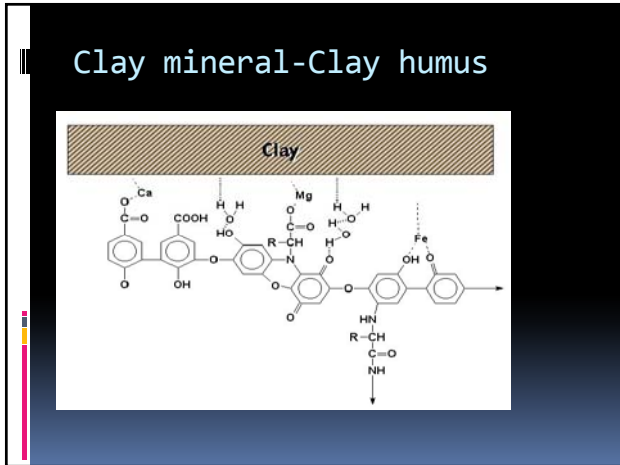
- **Sesquioxides**
  - **Gibbsite**  $[Al(OH)_3]$ : ubiquitous in soils, particularly those that are highly weathered (Oxisols & Ultisols) and in Al-rich soils (Andisols)
  - **Goethite**  $[FeOOH]$ : the most common hydrous Fe oxide (found in all soils), particularly in cool, moist climates
  - **Hematite**  $[Fe_2O_3]$ : found in almost all soils, favored in warm, dry climates and in the tropics and subtropics

## Allophane and Imogolite

- Mixtures of silica and alumina that are poorly-crystalline to microcrystalline
- Allophane:  $Al_2O_3 \cdot (SiO_4)_{1-2} \cdot 2.5-3H_2O$
- Imogolite:  $Al_2SiO_3(OH)_4$
- Common in young volcanic (andic) materials
  - Insufficient weathering
  - High soluble silica concentrations
- pH dependent charge
- Exchange capacity
  - CEC: 10 to 40  $cmol_c kg^{-1}$  at pH 7
  - AEC: 5 to 30  $cmol_c kg^{-1}$  at pH 4

## Organic Colloids – Humic Substances

- Stable organic matter left after decomposition of plant and animal detritus
- Dark brown to black, solubility in water is variable (fulvates are soluble; humins and humates not so much)
- Very high reactivity, mostly negative charge
  - pH dependent
  - CEC = 60 to 300  $cmol_c kg^{-1}$  SOM at pH 7; may account for 25 % to 90 % of the CEC of mineral soils
- High water holding capacity
- Very important relative to clays (can mask properties of clays)



### Sources of negative charge on Organic Colloid

1. Soil Humus

$$R-CO + \rightleftharpoons R-CO-O^- + H^+$$

$$R-C(=O)OH \rightleftharpoons R-C(=O)O^- + H^+$$

This charge is pH dependent or as the pH increases more OH<sup>-</sup> is available and therefore more CEC and conversely acid soils have a lower CEC from OM.

### Charge on Humic Substances

- Negative charge from carboxylic acid and phenolic groups; positive from amino groups

Acidic Soil                      Neutral to Alkaline Soil

### source of negative charge on Clay

1) broken bonds at edge of clay mineral

Each tetrahedron counts as 1 Si and 3 O ions

2) internal charge not satisfied because of ionic substitution - called *Isomorphous Substitution*

No substitution                      Zn<sup>2+</sup> for Al<sup>3+</sup>

Al<sup>3+</sup> for Si<sup>4+</sup> or Mg<sup>2+</sup> for Al<sup>3+</sup> or Zn<sup>2+</sup> for Al<sup>3+</sup>

Neutral                      -1 charge

### Isomorphous substitution in 2:1 mineral clay crystal

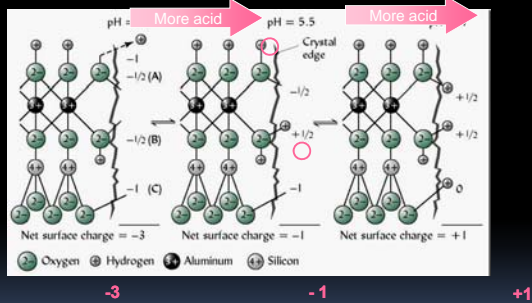
Dioctahedral (2 cations)                      Dioctahedral with isomorphous substitution

Net = 0                      Net = -1

Aluminum (3+)                      Magnesium or iron (2+)

No substitution                      With isomorphous substitution

Sources of pH-dependent charges on silicate clay (kaolinite)



Cation Exchange

- Soil colloids have negative charge
  - pH dependent = variable charge
  - Isomorphous substitution = permanent charge
- Cations from the soil solution must satisfy this charge so that mineral and organic surfaces *appear* to be charge neutral

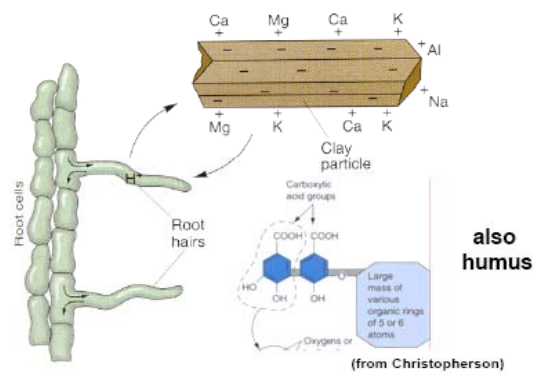
Basic Concepts

- **Cations** (→ *metals*)
  - Positively charged ions
  - $Al^{3+}$ ,  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $K^+$ ,  $Na^+$ ,  $NH_4^+$ ,  $H^+$ , etc.
- **Anions** (→ *ligands*)
  - Negatively charged ions
  - $SO_4^{2-}$ ,  $NO_3^-$ ,  $H_2PO_4^-$ ,  $HPO_4^{2-}$ ,  $Cl^-$ ,  $OH^-$ , etc.
- Cation exchange sites
  - Negatively charged sites on clay and humic colloids
  - Cations are retained at these sites by electrostatic forces

Basic Cation Exchange Concepts

- Adsorbed cations can be replaced by other, competing cations
- Law of Mass Action and Le Châtelier's principle are obeyed (large quantity of one cation can displace different cations from sites)
- Exchange reactions are reversible, rapid, and stoichiometric with respect to charge
 
$$2\{K^+-Soil\} + Ca^{2+} \rightarrow 2K^+ + Ca^{2+}-\{Soil\}_2$$
- Ease of cation displacement is a function of cation size and charge

Exchange of nutrient cations between clay and organic matter and roots



Distribution of Ions Around a Charged Surface

- Typically, high concentrations of cations and a deficit of anions are found in the proximity of clay particles.
- The region with anomalous distributions of ions is known as the "double layer".
- The region outside the influence of the charged particle is the "soil solution".
- Cations can be exchanged between the soil solution and the double layer.

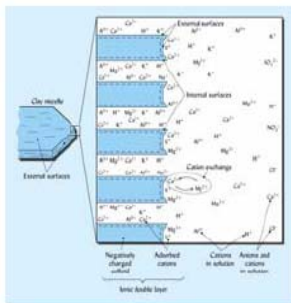


Figure 8.1 Simplified representation of a silicate clay crystal (micelle), its complement of adsorbed cations, and ions in the surrounding soil solution. The enlarged view (right) shows that the clay comprises sheetlike layers with both external and internal negatively charged surfaces. The negatively charged micelle acts as a huge anion and a swarm of positively charged cations is adsorbed to the micelle because of attraction between charges of opposite sign. Cation concentration decreases with distance from the clay. Anions (such as  $\text{Cl}^-$ ,  $\text{NO}_3^-$ , and  $\text{SO}_4^{2-}$ ), which are repelled by the negative charges, can be found in the bulk soil solution farthest from the clay (far right). Some clays (not shown) also exhibit positive charges that can attract anions.

TERIMA  
KASIH