Soil physic

- Consistency
- Density
- Porosity
- Soil temperature
- Soil water and aeration
blocky structure

Examples of Soil Structure

Granular

Blocky
(Subangular)
(Angular)

Platy

Prismatic

Columnar

Wedge
SOIL DENSITY

Density is the mass (weight) of material contained within a given volume.

This is the idea that a given size of box may be heavy or light, depending upon what kind of material it contains. If the box were filled with wood, it would be light when compared to having it filled with lead.
The weight of water is the reference for density measurements: 1 gram of water=1 cubic centimeter (cc), and 1 cc water=1 ml.

The bulk density of a soil is the mass of dry soil per unit of "bulk" (total volume of soil or soil particles & pore space).
• Density = \frac{\text{Mass (M)}}{\text{Volume (V)}}

• 2 type of density:

  particle density and bulk density
<table>
<thead>
<tr>
<th></th>
<th>Bulk density</th>
<th>Particle density</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average</strong></td>
<td>1.30 - 1.35 Mg/m³</td>
<td>2.6 - 2.7 Mg/m³</td>
</tr>
<tr>
<td><strong>Value</strong></td>
<td>Soil volume changed according to degree of aggregate, organic matter content and tillage</td>
<td>Constant because volume of solid not change</td>
</tr>
</tbody>
</table>
NOTES:

• Right plough increase aggregate-decrease bulk density
• Wrong plough (soil wet, compact soil) – increase bulk density
• Bulk density depends on porosity volume – to determine soil porosity.
Soil Porosity and Permeability

• Water and air movement in soil is influenced by total pore space and distribution of pores size (between macro and micro pores)

• \% Pore Space = \( (1 - \frac{\text{Bulk density}}{\text{Particle density}}) \times 100 \)

• \% Pore Space depends on bulk density.
Porosity

• Between soil particles and organic matter are open spaces called pores.
• Water which fills all or parts of the pores is soil water.
• Soil porosity directly influences soil water movement.
Consistence:
Dry and moist rupture resistance, manner of failure, and stickiness/plasticity
SOIL CONSISTENCE

Soil consistence is the soil's ability to cohere or stick together. Evaluated at three moisture conditions: air dry, moist, and wet. Moist consistence is evaluated by placing the soil between the thumb and forefinger and gently applying pressure. The ease with which a ped can be crushed determines the consistency.

Terms commonly used to describe moist consistence are:
- **Loose**- Non-coherent when dry or moist; does not hold together in a mass.
- **Friable**- When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.
**Firm**- When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

**Plastic**- When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

**Sticky**- When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

**Hard**- When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

**Soft**- When dry, breaks into powder or individual grains under very slight pressure.

**Cemented**- Hard; little affected by moistening.
Soil temperature

**Definition**

The temperature of a soil at a depth of 50 cm at a given point in time.

**Rationale**

Soil temperature and the extent of temperature changes influences biological activity and productivity within a soil (e.g. plant root growth, seed germination, and decomposition of organic material). Soil temperature is also important to pedogenetical processes.
Temperature control

• 1) Mulching
• 2) Irrigation – water cooling effect
  Water specific heat = 1.0 cal/g/ °C
  Soil specific heat = 0.4 cal/g/ °C
  Iron specific heat = 0.16 cal/g/ °C
• 3). Cover crops e.g. cocoa
MULCHING
Rajah 6.2: Kesan sungkupan ke atas suhu tanah
The End - Part 1
SOIL WATER

• Water is a important natural resource and is part of the hydrology cycle. (Diagram 7.1)
• 3 sources of water:
  1. surface water: river, surface runoff, pond.
  2. ground water
  3. soil water
Rajah 7.1: KITAR AIR
Soil Water

Important factors affecting crop production.

- Water must be available to replenish that is lost by evaporation and transpiration.
- Soil water carries nutrients in solution to the growing crop.
- Has significant effect on aeration and temperature conditions of the soil.
- Water content of soil is seldom at optimum value for maximum crop production.
• **Soil Water** or soil moisture or soil solution
• Soil characteristics are important and may influences other characteristics such as:
  - plasticity
  - elasticity
  - swelling and shrinking
  - consistency
  - compaction
  - aeration and temperature
Soil Water Potential

- Soil water potential - water is held in soil by “tension” or attraction of water molecules to solid surfaces and to other water molecules.
- Water fills up the micro and macro pores in the soil.
- Saturated – is a state where both the micro and macro pores are filled up with water.
- In dry soils water is held by a stronger force making it difficult to be available to the plant.
- In damp soil water fills the macro space and is held by weak forces and easily available to the plant roots.
Porosity in different sediments.
A. A porosity of 30 percent in reasonably well-sorted sediment.
B. A porosity of 15% in a poorly sorted sediment in which fine grains fill spaces between larger grains. C. Reduction in porosity in an otherwise very porous sediment due to cement that binds grains together.

In very small spaces water is held by molecular attraction.

Water can move through larger spaces, although some is held.

Effect of molecular attraction on permeability in the intergranular spaces of a fine, silty sediment (top) and a coarse, sandy sediment (bottom) of equal porosity.
• Units used for soil water potential or moisture tension:
  - water cm
  - bars
  - pF
  - Pascal (Pa) or kilo Pascal (KPa).
- 1 bar = 1 000 water cm
  pF = log cm H₂O
  KPa = 10cm H₂O

- Water potential range

  0 cm H₂O ————> 10, 000, 000 cm H₂O
  (very wet/) (very dry)
  damp
Energy Concept of Soil Moisture

Expression in terms of energy makes it more easy to compare availability of the moisture in soils of different textures.

Most commonly accepted unit at present is bars of suction.

- Suction is negative pressure, the higher the numerical value the lower the energy status of the water.
- Soils at field capacity - 0.1-0.3 bars of suction
- When soils at wilting point - 15 bars of suction
Soil Water Classification

- 0 to -0.3 bar = Gravitational
- -0.3 to -15 bar = Field Capacity & wilt pt.
- -15 to -100 bar = stages of air dry
- -10,000 bar = oven dry
Soil Water - Adhesion Water

- held by strong electrical forces - low energy
- little movement - held tight by soil
- exists as a film
- unavailable to plants
- removed from soil by drying in an oven
Soil Water - Cohesion water

- held by hydrogen bonding
- liquid state in water film
- major source of water for plants
- greater energy than adhesion water
Gravitational Water

- exists in macro-pores
- has greatest energy (true liquid)
- moves freely due to gravitational forces.
<table>
<thead>
<tr>
<th>TYPES OF SOIL WATER</th>
<th>WATER POTENTIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cm H₂O</td>
</tr>
<tr>
<td>Saturated</td>
<td>0</td>
</tr>
<tr>
<td>Field capacity</td>
<td>333</td>
</tr>
<tr>
<td>Wilting point</td>
<td>15,000</td>
</tr>
<tr>
<td>Air dry</td>
<td>1 x 10⁶</td>
</tr>
<tr>
<td>Oven dry</td>
<td>10 x 10⁷</td>
</tr>
</tbody>
</table>
**Wilting point:** Water content of soils at which plants will not regain turgor even if the soil water content is raised.

**Field capacity:** Amount of water retained in soil after it has been saturated and allowed to drain freely.

**Water availability:** Amount of water available to the plants (between field capacity and wilting point).
Muatan Air Tanah \( \propto \) luas permukaan + ruang pori (risipada)

Teks turut

Muatan Medan TERSEDIA

Takat kelayuan
Soil-moisture availability (increasing →)

Soil particles with forms of soil moisture

- Hygroscopic H₂O*
- Capillary H₂O
- Gravitational H₂O

H₂O unavailable for plants → H₂O available → H₂O

Wilting point → Field capacity → Saturation

*Note: Some capillary water is bound to hygroscopic water on soil particle and is also unavailable.
Water Movement

1. Mass Flow (Saturated)
2. Capillary action (Unsaturated)
b) Aliran Air Taktepu
(Pergerakan Air Tegak ke Atas)
(Daya Rerambut)

Alirannya sama seperti aliran di dalam tiub rerambut.

Diagram:

\[ h = \frac{2\gamma \cos \theta}{\rho g} \]  \hspace{1cm} (1)

- \( T \): Ketegangan permukaan air (Surface tension of H2O)
- \( \theta \): Sudut sentuh (Contact & )
- \( r \): Jeijari tiub/saluran (radius)
- \( d \): Ketumpatan air
- \( g \): Angkatap graviti (gravity constant)
Depd. kajian dengan menggunakan 

terus yg di, isi dgn 

didapat graf sp. di banah

![Graph](image)

Tinggi air rerambut (cm) 50

masa (jam) →

Lengkung kenaikan air rerambut

untuk pasir, lom dan lempung

kenaikan air rerambut maksimum

pasir < lom < lempung.
Water moves from areas of high potential (wet soil: -2 or -4) to areas of low potential (dry soil -8)
Soil water determination:

• **Gravimetric:**
  • Wet soil samples are oven dried for 24 hours at 105°C and later weighed
  • % are based on weight
  • % soil water = \( \frac{\text{Weight of wet soil} - \text{Weight of oven dried soil}}{\text{weight of oven dried soil}} \times 100 \), \( q_w \% \)
• volume

\[ \theta_v \% = \theta_w \% \times \text{Bulk density} \]

\( \theta_v \% \) amount of water based on volume

\( \theta_w \% \) amount of water based on weight

Other methods

1. Neutron Scattering
2. Electrical resistance
3. Tensiometer (measures matrix potential of field soils)
Factors influencing soil water content

1. Soil texture
2. Soil structure – distribution of pore size
3. Organic matter content
Soil Air

Soil Air is important:

• for the plant roots to grow
• Living microorganisms in the soils e.g. fungus, bacteria, worms etc.
• Influence oxidation process in soil
• Influence soil water.
• At optimum growth level, soil content is half water and half air.

• Example: loam soil 50% solid
  25% water
  25% air

• Composition of soil air is same as the atmosphere. The difference is the ratio (Table 7.2)
Table 7.2: Soil Air Composition

<table>
<thead>
<tr>
<th></th>
<th>% O₂</th>
<th>% CO₂</th>
<th>% N</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATMOSPHERE</td>
<td>21.0</td>
<td>0.03</td>
<td>78.9</td>
</tr>
<tr>
<td>SOIL AIR</td>
<td>&lt;20.0</td>
<td>&gt;0.03</td>
<td>79</td>
</tr>
</tbody>
</table>
UDARA TANAH

Kandungan gas yg. terdapat dlm. ruang rongga yg. tidak dipenuhi air

UDARA

vakuol
• **O₂ -- CO₂ Equilibrium**: soil air is important because it determines the quality. Too much of CO₂ is toxic to the roots and microorganisms in soil.

This depends on:

1) Root and microorganisms respiration, where O₂ is used and CO₂ is respired. Therefore soils with planted plants has higher CO₂ than O₂.
2) Decaying of aerobic organic matter:
   O$_2$ is used and CO$_2$ respired.
   Therefore CO$_2$ content increases.

O$_2$ - CO$_2$ equilibrium can be repaired through gas exchange between soil air and atmosphere air, where O$_2$ is diffused into the soil and CO$_2$ respired to the atmosphere. This process is called aeration.
Aeration is influenced by

- **Pore space**: total and size distribution (micro and macro space)
- **Water content**

Aeration can be done by:

- **Proper ploughing and drainage of soils**
Soil factors influencing aeration:

1. Texture
2. Structure
3. Density
4. Water content
5. Depth
Effects of proper aeration

• Oxidation
  1. decaying of organic matters.
  2. Pyrite oxidation (FeS$_2$) to jarosite to form sulphate acid soil (pH < 3.2)
  3. Oxidation of ammonia to nitrate
     \[ \text{NH}_4^+ - \text{-----} \rightarrow \text{NO}_3^- \]
Effects of poorly aerated soils

- **Reduction**
  1. $\text{NO}_3^-$ changed to $\text{NO}_2$ and escapes to atmosphere. This process is called denitrification; one way of loosing N fertilizer.
  
  2. Anaerobic decaying which produces methane ($\text{CH}_4$). This happens in swamps, ponds and rubbish disposal areas and can cause fire and gas explosion.