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# **ASAC 1101 : FUNDAMENTALS OF SOIL SCIENCE (2+1)**

**Level : B.Sc (Ag), I semester**

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**SOIL SCIENCE AND AGRICULTURAL CHEMISTRY**

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## **Topic**

**Soil porosity and Soil consistency**

## Concepts Covered:

- What is soil porosity
- Factors affecting soil porosity
- Soil consistence and consistency

# Porosity

- ❑ Soil porosity refers to percent of soil volume occupied by pore spaces
- ❑ Total pore space includes both air and water filled pores
- ❑ An ideal soil would have a total porosity of **50%** with equal amount of air and water filled pores

# Calculation of porosity

$$\text{Bulk density, } D_b = \frac{\text{Weight of soil solids}(W_s)}{[\text{Volume of solids}(V_s) + \text{Volume of pores}(V_p)]} \longrightarrow \textcircled{1}$$

$$\text{Particle density, } D_p = \frac{\text{Weight of soil solids}(W_s)}{\text{Volume of solids}(V_s)} \longrightarrow \textcircled{2}$$

From equations 1 and 2, equating for  $W_s$ ,

$$D_p * V_s = D_b * (V_s + V_p) \quad \text{which implies} \quad \frac{V_s}{V_s + V_p} = \frac{D_b}{D_p}$$

We know that  $\frac{V_s}{V_s + V_p} * 100 = \% \text{ of solid space}$  and

$$\% \text{pore space} + \% \text{solid space} = 100\%$$

$$\text{Hence, } \% \text{pore space} = 100\% - \left( \frac{D_b}{D_p} * 100 \right)$$



Brick = high bulk density,  
low pore space



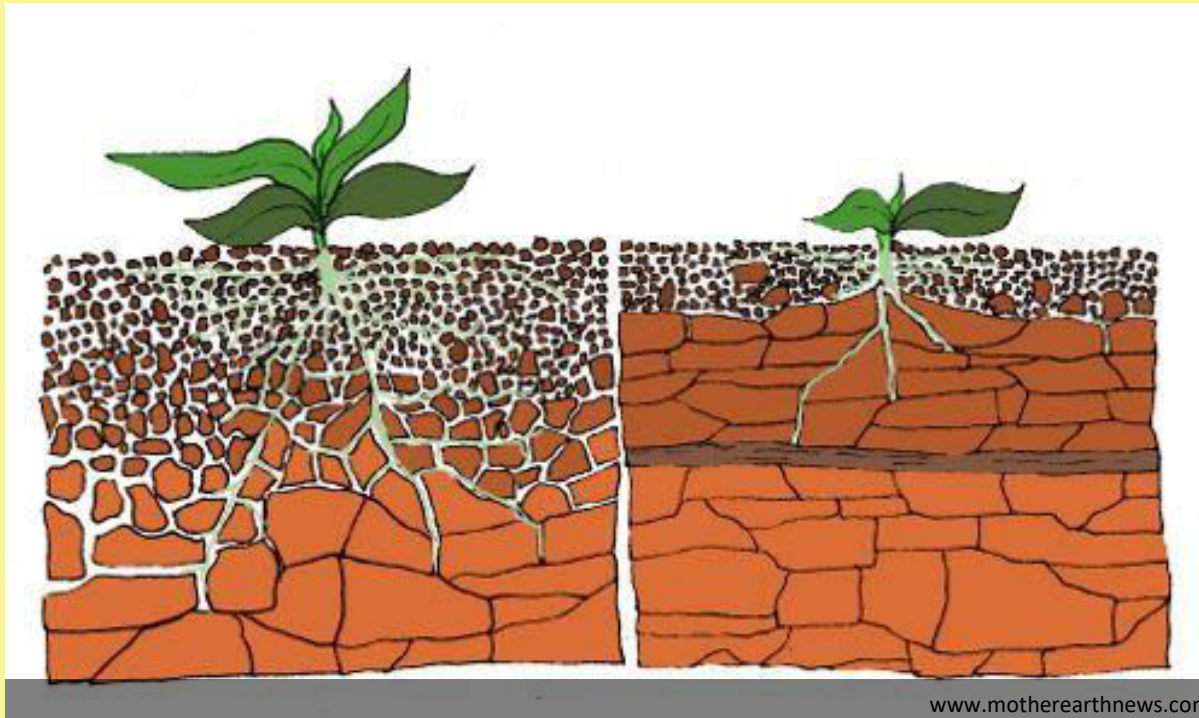
Sponge = low bulk density,  
high pore space

# Factors affecting total pore space

## 1. Management

- Highly compacted soils have less porosity
- Well granulated, organic matter rich soil have higher porosity
- Intense cultivation reduces the porosity due to reduction in organic matter content
- Organic matter content increases the porosity

# Compaction and porosity



## 2. Size of pores

- Soil pores occur in wide variety of size and shape
- This determines the role they play in the soil
- Two major types of pores are
  - Macropores
  - Micropores



# Classification and function of pores

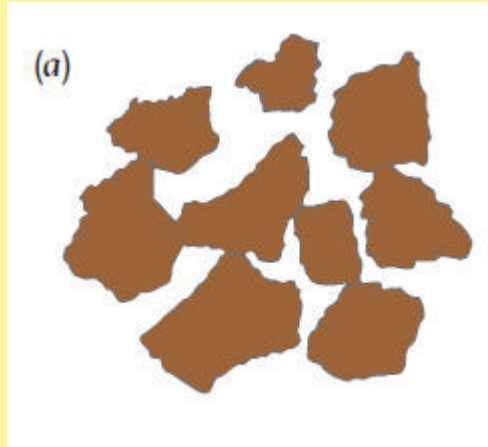
Simplified class	Class <sup>a</sup>	Effective diameter range, mm	Characteristics and functions
Macropores	Macropores	0.08–5+	Generally found between soil peds (interped); water drains by gravity; effectively transmit air; large enough to accommodate plant roots, habitat for certain soil animals.
Micropores	Mesopores	0.03–0.08	Retain water after drainage; transmit water by capillary action; accommodate fungi and root hairs.
	Micropores	0.005–0.03	Generally found within peds (intraped); retain water that plants can use; accommodate most bacteria.
	Ultramicropores	0.0001–0.005	Found largely within clay groupings; retain water that plants cannot use; exclude most microorganisms.
	Cryptopores	<0.0001	Exclude all microorganisms, too small for large molecules to enter.

<sup>a</sup>The pore size classes and boundary diameters are those cited in Soil Science Society of America (2001).

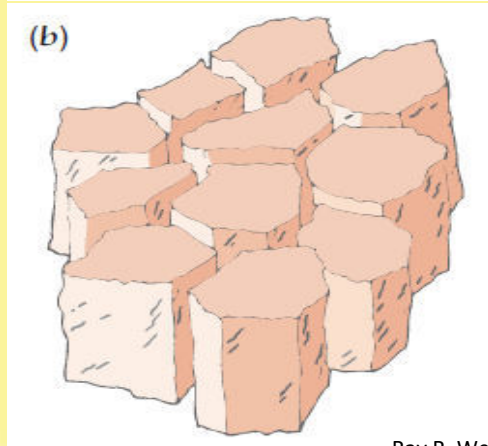
# Macropores

- **Effective diameter > 0.08 mm**
- **Macropores readily allow the movement of air and water**
- **Accommodates the plant root system and animals**

# Types of macropores

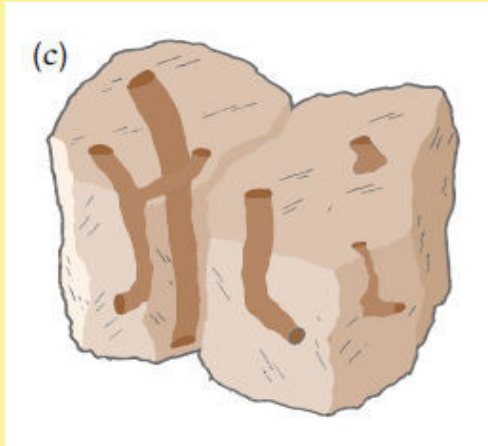


- Macropores in between individual soil grains
- Responsible for movement of air and water in sandy soils

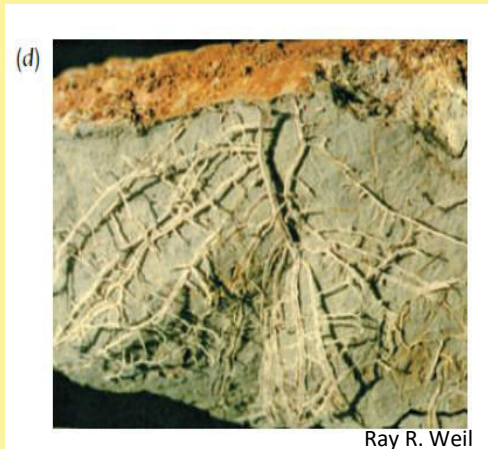


- Interped pores in well structured soils
- Occurs between tightly packed blocky peds and also prismatic peds

# Types of macropores



- Bio pores are a type of macropore created by roots, earthworms and other animals
- Tubular shaped and continuous
- In clayey soils, bio pores are major pores for facilitating plant root growth
- Both soil structure and texture influence the distribution of micro and macropores

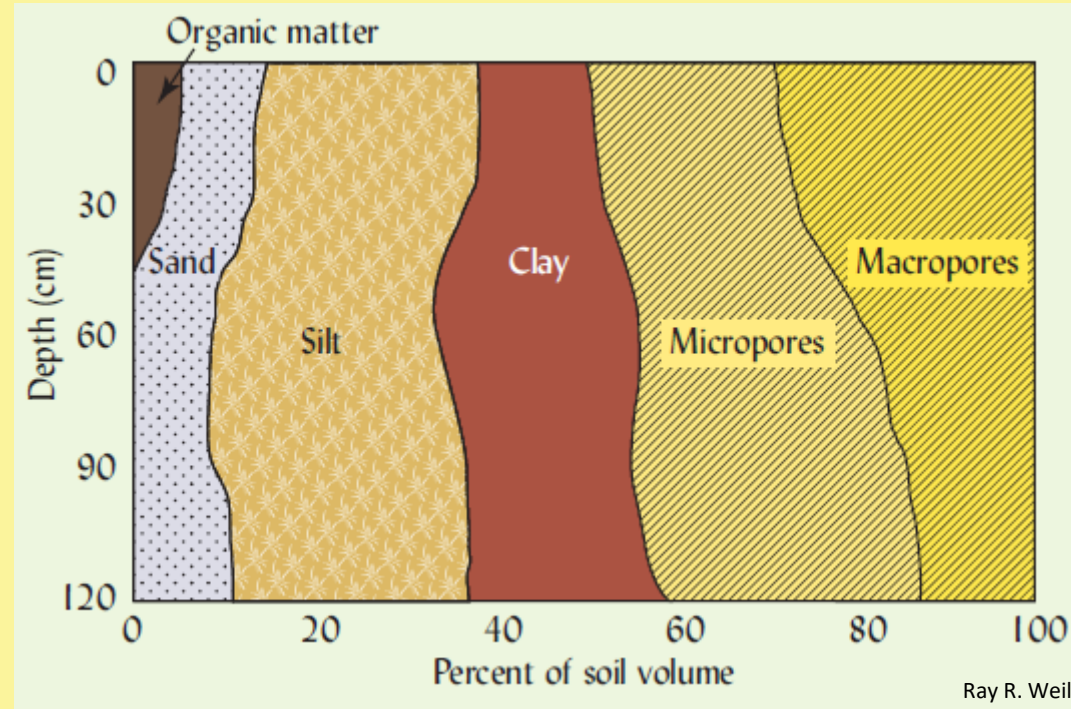


Root growing in Interped zone of a prismatic ped

# Micropores

- ❑ Effective diameter < 0.08 mm
- ❑ They retain water in field conditions but too small for air movement
- ❑ However, most of the water is not readily available for plants
- ❑ Small micropores, known as **nanopores**, act as hiding place for adsorbed pollutants and organic materials
- ❑ Size, shape and interconnection of pores is important rather than volume of pores

# Volume distribution of soil separates and pores in good structured soil



### **3. Cultivation and pore size**

- Continuous cropping reduces the soil organic matter**
- Consequently, macropore reduces**
- Conservation tillage promotes long-lived network of biopores**
- They increase the macroporosity of surface layers**



# Soil consistence

- **Consistence:** ease with which soil can be reshaped or ruptured
- Soil consistence provides a means of describing the degree and kind of cohesion and adhesion between the soil particles as related to the resistance of the soil to deform or rupture
- Since the consistence varies with moisture content, the consistence can be described as **dry consistence**, **moist consistence**, and **wet consistence**



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# Rupture resistance

- A measure of the strength of the soil to withstand an applied stress
- Moisture content is also considered
  - – Dry
  - – Moist (field capacity)

# Wet consistency

- **Stickiness**

The capacity of soil to adhere to other objects

Estimated at moisture content that displays maximum adherence between thumb and fore finger

- **Plasticity**

Degree a soil can be molded or reworked causing permanent deformation without rupturing

# Stickiness classes

- **Non-Sticky** – little or no soil adheres to fingers after release of pressure
- **Slightly Sticky** – soil adheres to both fingers after release of pressure with little stretching on separation of fingers
- **Moderately Sticky** – soil adheres to both fingers after release of pressure with some stretching on separation of fingers
- **Very Sticky** - soil adheres firmly to both fingers after release of pressure with stretches greatly on separation of fingers

# Stickiness classes



**Non-Sticky**



**Slightly Sticky**

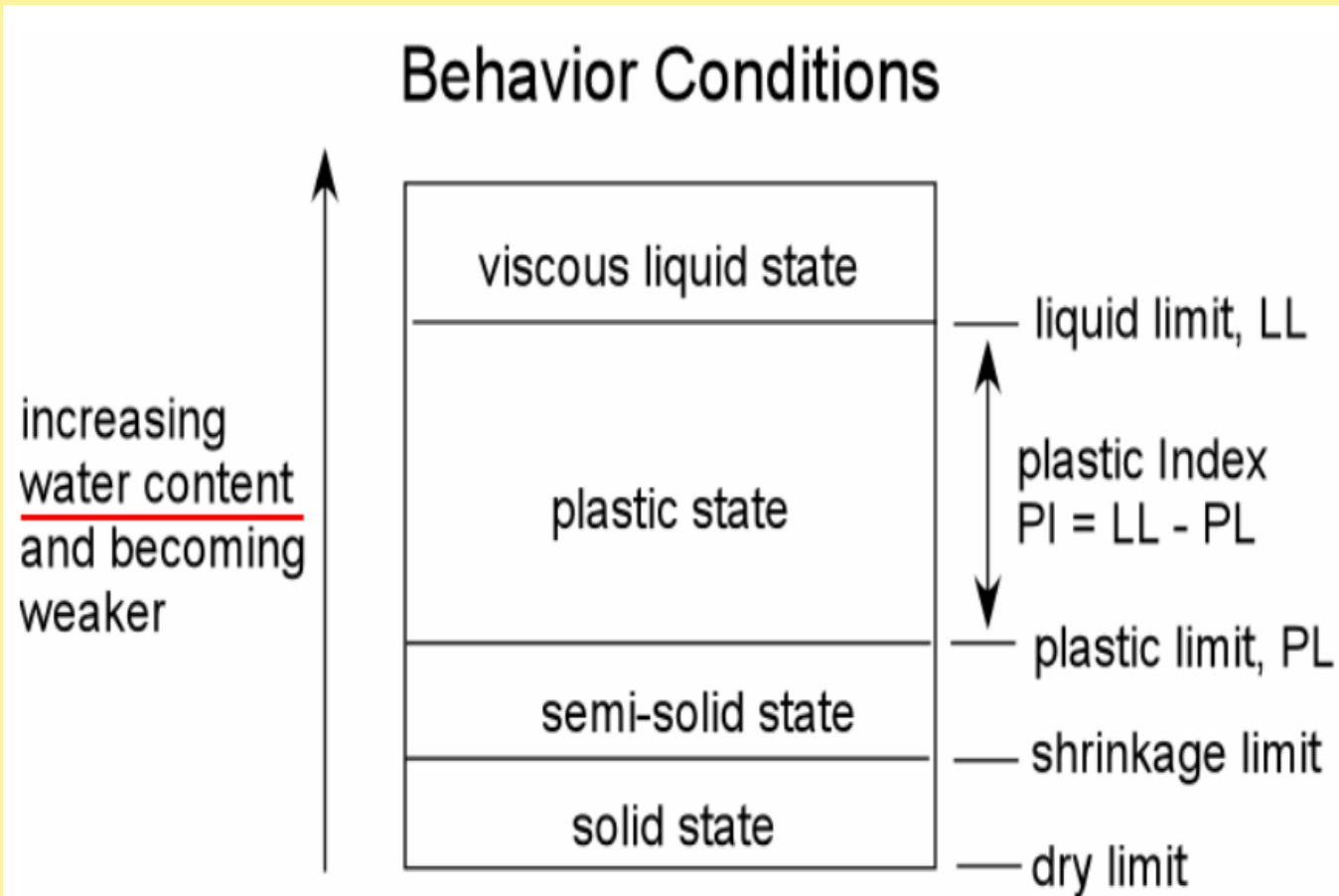


**Very Sticky**

# Plasticity

- The degree to which puddled or reworked soil can be permanently deformed without rupturing
- Evaluation done by forming a 4 cm long wire of soil at a water content where maximum plasticity is expressed

# Atterberg limits



**LL:** The lowest water content above which soil behaves like liquid, normally below 100.

**PL:** The lowest water content at which soil behaves like a plastic material, normally below 40.

**PI:** The range between LL and PL.

**Shrinkage limit:** the water content below which soils do not decrease their volume anymore as they continue dry out. – needed in producing bricks and ceramics .

# Plasticity classes

- **Non-Plastic**– will not form a 6 mm dia, 4 cm long wire, or if formed , can not support itself if held on end
- **Slightly Plastic**–6 mm dia, 4 cm long wire supports itself, 4 mm dia, 4 cm long wire does not
- **Moderately Plastic**– 4 mm dia, 4 cm long wire supports itself, 2 mm dia, 4 cm long wire does not
- **Very Plastic**– 2 mm dia, 4 cm long wire

