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*Shaping Lives...
Empowering Communities...*

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 density, crusting and tillage

Soil density

1. Particle density:

- Soil particle density D_p is defined as the mass per unit volume of soil *solids*
- Thus, if 1 m³ of soil solids weighs 2.6 megagrams (Mg), the particle density is 2.6 Mg/ m³ (which can also be expressed as 2.6 grams per cubic centimeter)
- Particle density is essentially the same as the specific gravity of a solid substance
- Particle densities for most mineral soils vary between the narrow limits of 2.60 and 2.75 Mg/ m³

2. Bulk density:

- Bulk density D_b , which is defined as the mass of a unit volume of dry soil. This volume includes both solids and pores
- The units are same as particle density
- But the value of bulk density is changeable unlike particle density
- Generally coring instruments are used to determine the soil bulk density

Determination of soil bulk density

Cylindrical core:

- The sampler head contains an inner cylinder and is driven into the soil with blows from a drop hammer
- The inner core containing an undisturbed soil core. Trimmed on the end with a knife. The volume can easily be calculated from its length and diameter.
- The weight of soil is calculated after drying



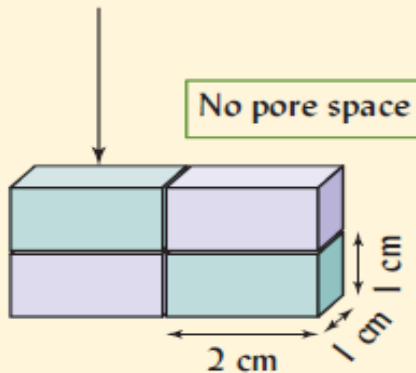
Calculations of D_p and D_b

Particle Density

Consider four blocks of solid rock
(no pore space)

- Volume = $4 \times (2 \text{ cm} \times 1 \text{ cm} \times 1 \text{ cm}) = 8 \text{ cm}^3$
- Weight = 21.6 g
- Particle density = $21.6/8 = 2.7 \text{ g/cm}^3$

A prismatic solid mass
consisting of four tightly
fitted mineral blocks

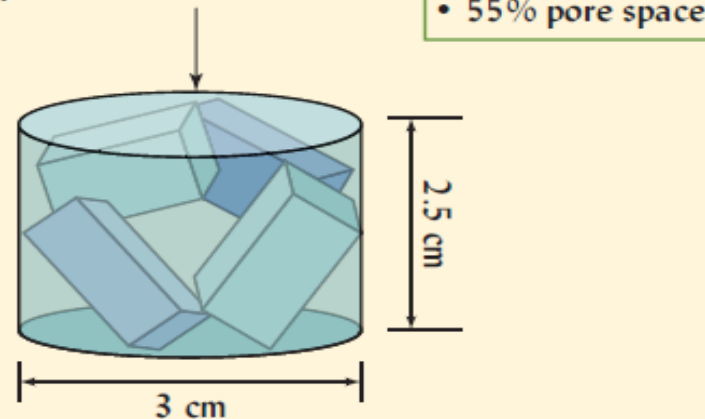


Bulk Density

Consider the same four blocks of solid rock arranged
loosely to form a cylinder of "soil" that includes the
space between the mineral blocks.

- Volume = $\pi r^2 h = 3.14 \times (1.5)^2 \times 2.5 = 17.7 \text{ cm}^3$
- Weight = 21.6 g
- Bulk density = $21.6/17.7 = 1.22 \text{ g/cm}^3$

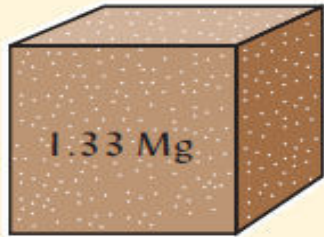
A cylindrical mass of "soil"
consisting of four loosely
packed mineral blocks



Calculations of D_p and D_b

In the field,
one cubic meter
of a certain soil
appears as...

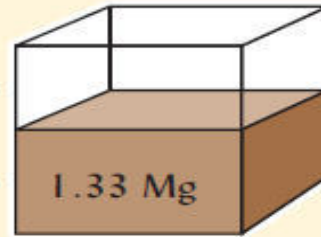
Solids and
pore spaces



If all the solids could be
compressed to
the bottom, the cube
would look like...

1/2 pore spaces

1/2 solids



To calculate bulk density of the soil:

Volume = 1 m^3 Weight = 1.33 Mg
(solids + pores) (solids only)

Bulk density = $\frac{\text{Weight of oven dry soil}}{\text{Volume of soil (solids + pores)}}$

Therefore

$$\text{Bulk density, } D_b = \frac{1.33}{1} = 1.33 \text{ Mg/m}^3$$

To calculate solid particle density:

Volume = 0.5 m^3 Weight = 1.33 Mg
(solids only) (solids only)

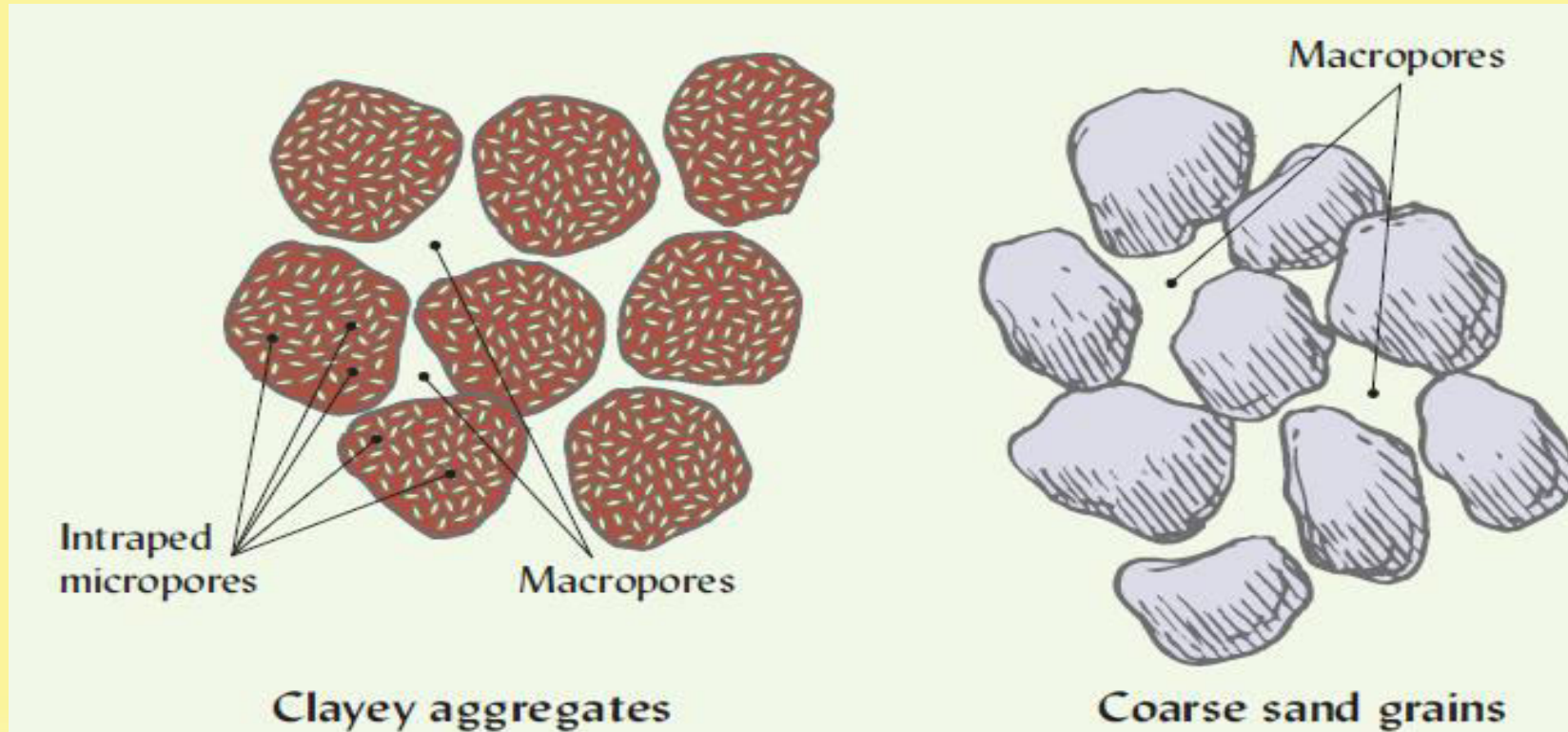
Solid particle density = $\frac{\text{Weight of solids}}{\text{Volume of solids}}$

Therefore

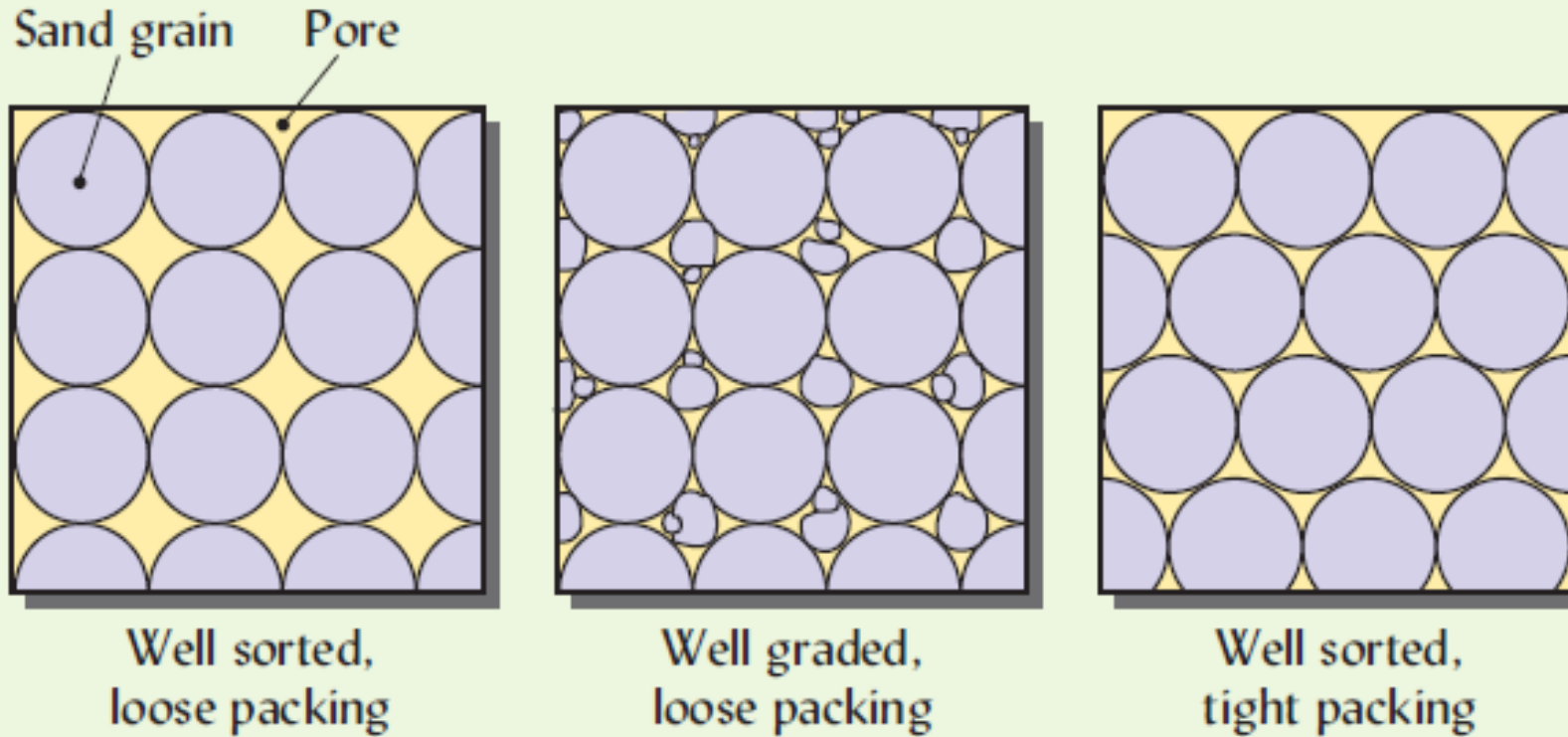
$$\text{Solid particle density, } D_p = \frac{1.33}{0.5} = 2.66 \text{ Mg/m}^3$$

Factors affecting Db

- **Effect of Soil Texture-** Fine-textured soils have lower bulk density than the coarse-textured soil



- **Effect of soil structure-** The well aggregated soils have lower Db than poorly aggregated soils.



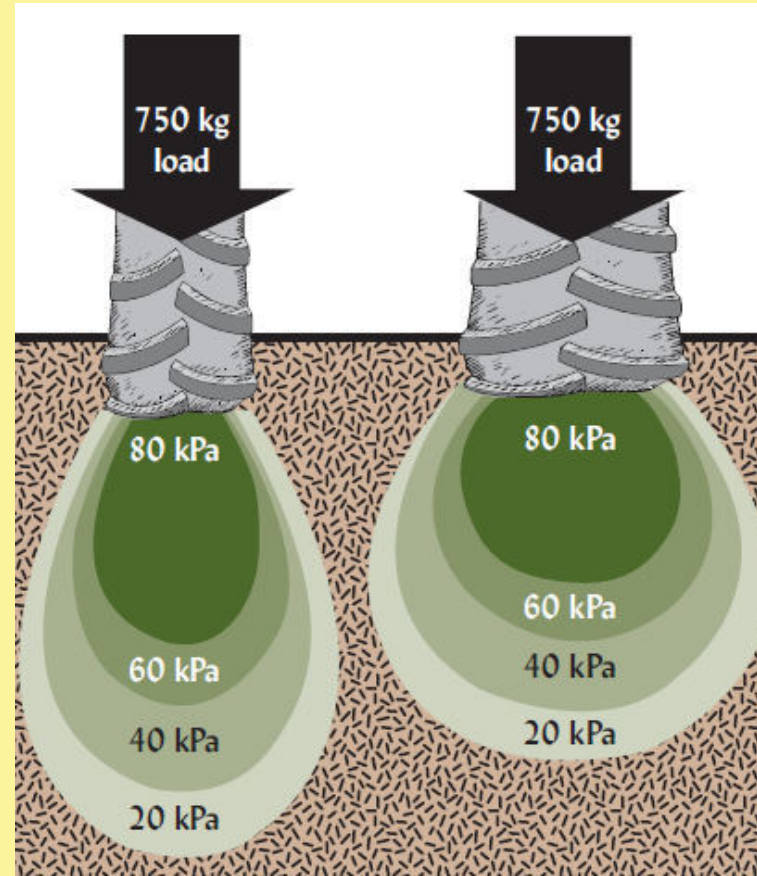
- **Effect of Organic matter-** Organic matter helps to form a good aggregation. So, it reduces the bulk density of the soil
- **Depth of Soil Profile-** Pore space reduces with the increase in soil depth. So, Db generally increased

Agricultural Land:

- **The long-term intense tillage increases soil bulk density by depleting soil organic matter and weakening soil structure**
- **In mechanized agriculture, the wheels of heavy machines used to pull implements, apply amendments, or harvest crops can create yield-limiting soil compaction (plow pans or traffic pans)**



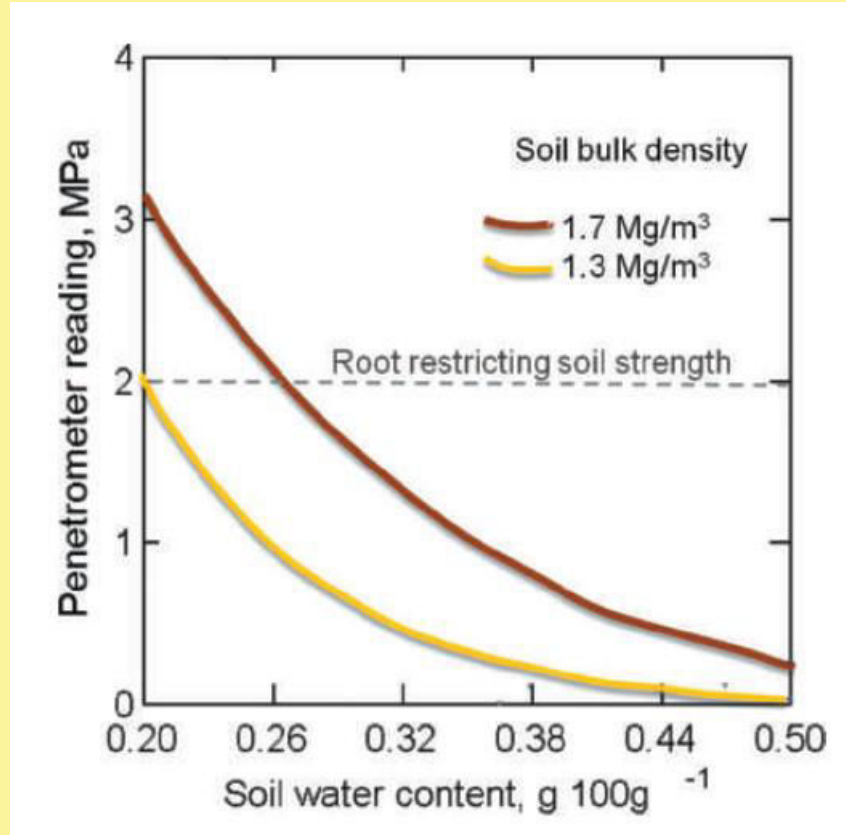
- **Vehicle tires (750 kg load per tire) compact soil to about 50 cm**
- **The more narrow the tire, the deeper it sinks and the deeper its compaction effect**



Influence of Db on soil strength and root growth

Effect of Soil Water Content:

Soil strength is increased when a soil is compacted to a higher bulk density, and also when finer-textured soils dry out and harden. So, it can easily restrict the growth of the root



- **Effect of Soil Texture:**

The more clay present in a soil, the smaller the average pore size, and the greater the resistance to penetration at a given bulk density than the sandy soil

- **Effect of Land Use and Management:**

Land uses as row crop agriculture often markedly and simultaneously affect soil bulk density and strength in ways that restrict or enhance root growth and water movement

Tillage

The preparation of soil for planting and the cultivation of soil after planting.



Tillage and soil tilth

Tilth refers to the physical condition of the soil in relation to plant growth.

It depends on-

- Aggregate formation
- Stability
- Bulk density
- Soil moisture content
- Degree of aeration
- Rate of water infiltration
- Drainage
- Capillary water capacity

Conventional tillage

Farmers use machines like a plow or disc to turn over and loosen the soil after harvest (a process called **tillage**). This can leave the soil exposed to rain and wind, which can sometimes lead to erosion of the topsoil that is needed to grow a crop



Types of conventional tillage

- **Primary tillage:** Primary tillage is the first soil tillage after the last harvest. It is normally conducted when the soil is wet enough to allow plowing and strong enough to give reasonable levels of traction. This can be immediately after the crop harvest or at the beginning of the next wet season. When there is sufficient power available some soil types are ploughed dry.
- Objectives
 1. To attain a reasonable depth (10-15 cm) of soft soil with varying clod sizes
 2. Kill weeds by burying or cutting and exposing the roots
 3. Soil aeration and water accumulation
 4. chop and incorporate crop residues



Types of conventional tillage

- **Secondary tillage:** Secondary tillage is any working completed after primary tillage and is undertaken for
 1. Reducing clod size
 2. Weed control
 3. Incorporation of fertilizers
 4. Puddling
 5. Leveling soil surface



Puddling



Conservation tillage and soil tilth

In recent decades, agricultural land-management systems have been developed that minimize the need for soil tillage and leave the soil surface largely covered by plant residues, thereby maintaining

- Soil biological habitat
- Stabilizing soil structure
- Conserving soil organic matter
- Physically protecting the soil from drying sun, scouring wind, and beating rain

These systems are called conservation tillage.

The U.S. Department of Agriculture defines *conservation tillage* as that which leaves at least 30% of the soil surface covered by residues

Conservation tillage

This is a technique for planting seed that minimizes the disruption of soil and therefore helps prevent soil erosion. Farmers use special equipment to plant seeds, leaving most of the residues (e.g. stalks) of the previous crop intact. Planting in this way allows the crop residue to break down, which adds organic matter (like composting) while protecting the soil from erosion



No till

One crop is planted in the residue of another, with virtually no tillage.



Soil crusting

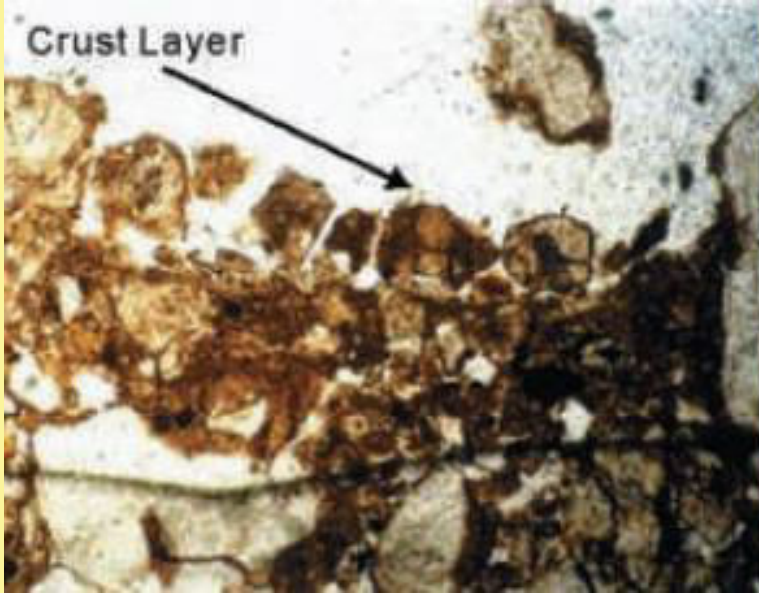
- Falling drops of water during heavy rain or sprinkler irrigation can beat apart aggregates exposed at the soil surface
- Once the aggregates become dispersed, small particles and dispersed clay tend to wash into and clog the soil pores
- Soon the soil surface is covered with a thin, partially cemented, low permeability layer material called a surface seal
- As the surface seal dries, it forms a hard crust



Integrated Crop Management - Iowa State University

Problems of soil crusting

- **Inhibits water infiltration**
- **Increases erosion losses**
- **Inhibits emergence of seedlings**
- **In arid and semiarid regions, soil sealing and crusting can have disastrous consequences because high runoff losses leave little water available to support plant growth**



Management of soil crusting

- Keeping some vegetative or mulch cover on the land to reduce the impact of raindrops.
- Once a crust has formed, it may be necessary to rescue a newly planted crop by breaking up the crust with light tillage (as with a rotary hoe), preferably while the soil is still moist.
- It can be minimized by using Soil Conditions.



FarmLink

Soil conditioners

- Improved management of soil organic matter and use of certain soil amendments can “condition” the soil and help prevent clay dispersion and crust formation.
 1. Gypsum
 2. Organic Polymers

• **Gypsum-**

1. Used for collecting the soil physical condition
2. Used in low salinity to sodium rich soil
3. Improve the flocculation of the soil

• **Organic Conditioners –**

Polyacrylamide (PAM) is effective in stabilizing surface aggregates when applied at rates as low as 1–15 mg/L of irrigation water or sprayed on at rates as low as 1–4 kg/ha.