Determination of bulk density of soil

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Bulk density of soil – Definition

- Bulk density of soil is the ratio between a mass of soil and its volume:

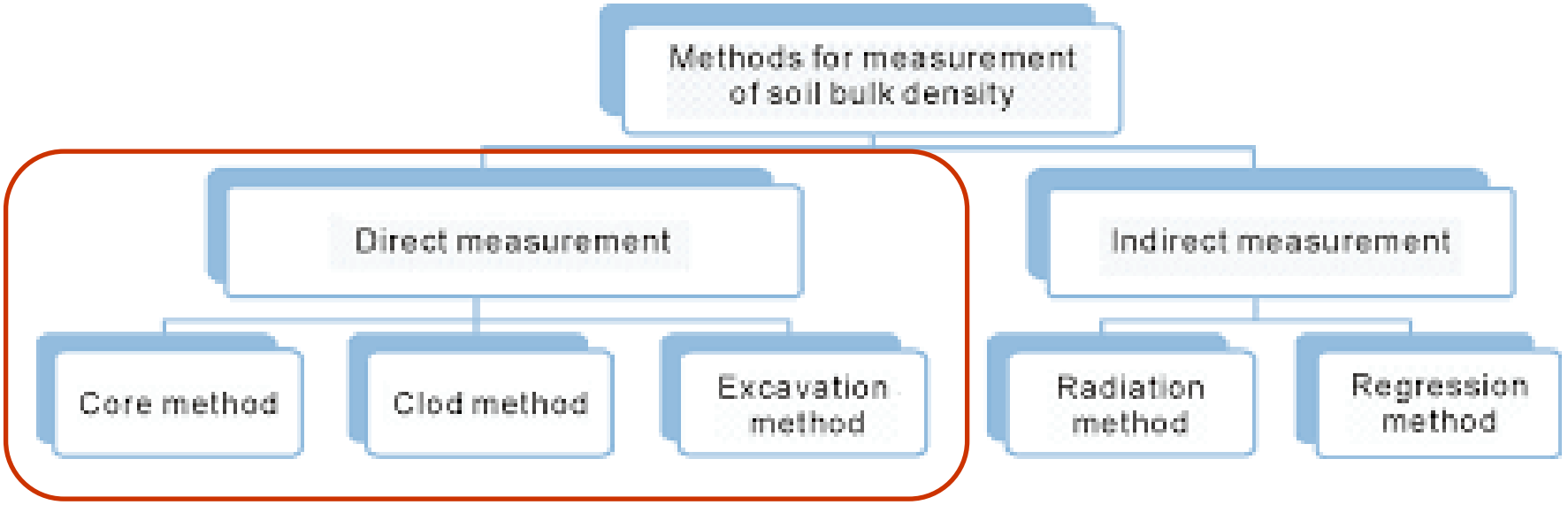
$$\rho_b = \frac{M}{V}$$

where ρ_b is bulk density (g cm^{-3}), M is mass of oven-dry soil (g) and V is volume of soil (cm^3)

Several methods (direct, indirect) can be used to estimate bulk density. We will use direct methods:

1. Coated clod method
2. Cylindrical cutter technique (core method)
3. Excavation method

Bulk density of soil – Available methods



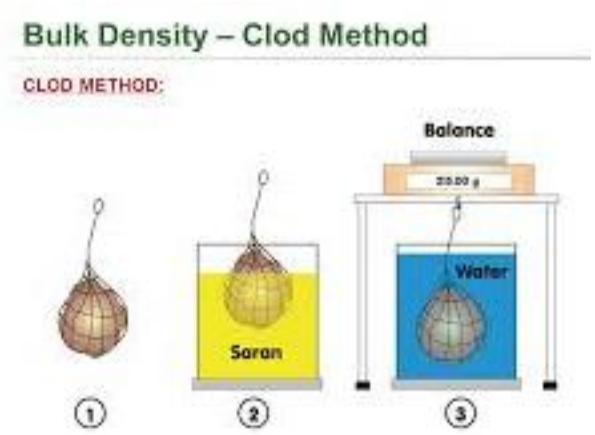
This presentation will focus on direct methods. A description of indirect methods can be found in *Pedosphere 28*(4): 581-596 [Open].

Bulk density of soil – Method 1

Procedure

A mass of air- or oven-dry soil, extracted without changing its natural structure is:

1. Weighted,
2. Coated with a sealer,
3. Weighted again, and
4. Then weighted in water.



Theory

Archimedes Principle states that an object placed in a liquid is buoyed up by a force equal to the weight of the displaced liquid. Since the displaced liquid equals the volume of the object and water has a density of 1 (g/cm^3), the increase in weight when the clod is suspended in water is equal to the clod volume.

Usefulness of this method

Particularly useful where stones make the cutter technique infeasible.

Bulk density of soil – Method 2

Procedure

1. A brass cylinder (previously weighed) is placed on a leveled soil surface and pushed into the soil using a core sampling tool or by placing a board on the ring and stepping on it.
2. The sample should fill the cylinder to the top, but care should be exercised not to compress the soil inside the cylinder.
3. The cylinder is then excavated out of the soil and the top and bottom flashed to the volume of the ring.
4. The cylinder and the soil inside are weighed to determine 'fresh' weight and placed in the oven at 105 degrees for 48-72 hs.
5. The cylinder and now dry soil are taken out of the oven and re-weighed.

Calculations

$$\rho_b\left(\frac{g}{cm^3}\right) = \frac{(Wcyl + dry\ soil) - (Wcyl)}{(Vol\ of\ cylinder)}$$

$$Moisture\ content\ \left(\%, \frac{w}{w}\right) = \frac{W\ fresh\ soil - W\ ovendry\ soil}{W\ ovendry\ soil} \times 100$$

Bulk density of soil – Method 3

Procedure

1. The excavation method was developed as a method suitable for use in gravelly soil, that is when the coarse fragment content exceeds 25% by volume.
2. The excavation method involves digging out a small hole, then oven drying (at 105°C) and weighing the excavated soil.
3. The volume of the excavation is determined by lining the hole with plastic film and filling it completely with a measured volume of water.
4. Coarse fragments (diameter >2 mm) are sieved out and bulk density is calculated as the mass of dry, coarse fragment-free soil per volume of the excavated soil, where volume is also calculated on a coarse fragment-free basis.

Calculations

- Determine bulk density and soil moisture content as described for method 2.

Useful equations

- **Bulk density of soil (ρ_b):** mass of dry soil (M) divided by volume of soil (V) and expressed in grams per cubic cm

$$\rho_b \left(\frac{g}{cm^3}\right) = \frac{M}{V}$$

- **Moisture content of soil (MC):** mass of soil-water divided by mass of dry soil and expressed in percentage

$$MC(\%, w/w) = \frac{Mass\ field\ fresh\ soil - Mass\ ovendry\ soil}{Mass\ ovendry\ soil} \times 100$$

- **Total porosity of soil (η):** pore space in soil expressed as percentage of total volume of soil. It is calculated from density properties (for particle density use 2.65 g/cm^3):

$$\eta\ (\%, v/v) = \left(1 - \frac{Bulk\ density}{Particle\ density}\right) \times 100$$

Useful bibliographic sources

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Thank You

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