THE GLOBE PROGRAM
A Worldwide Science and Education Program

Introduction to Soil (Pedosphere)

DI4A – University of Udine (I)

CREA Council for Agricultural Research and Economics (I)

Drought

by Marco Contin & Gilberto Bragato

Drought

A **drought** is an event of prolonged shortages in the water supply, whether atmospheric (below-average precipitation), surface water or ground water.

Drought depend on both: 1. Low water inputs

2. High water outputs

Water Balance: $\boxed{= \text{Inputs - Outputs}}$

Inputs: Rainfall + Water table + Irrigation + Soil water retention

Outputs: Percolation + Runoff + Evapotranspiration

Evapotranspiration: Evaporation (from soil) + Transpiration (from plants

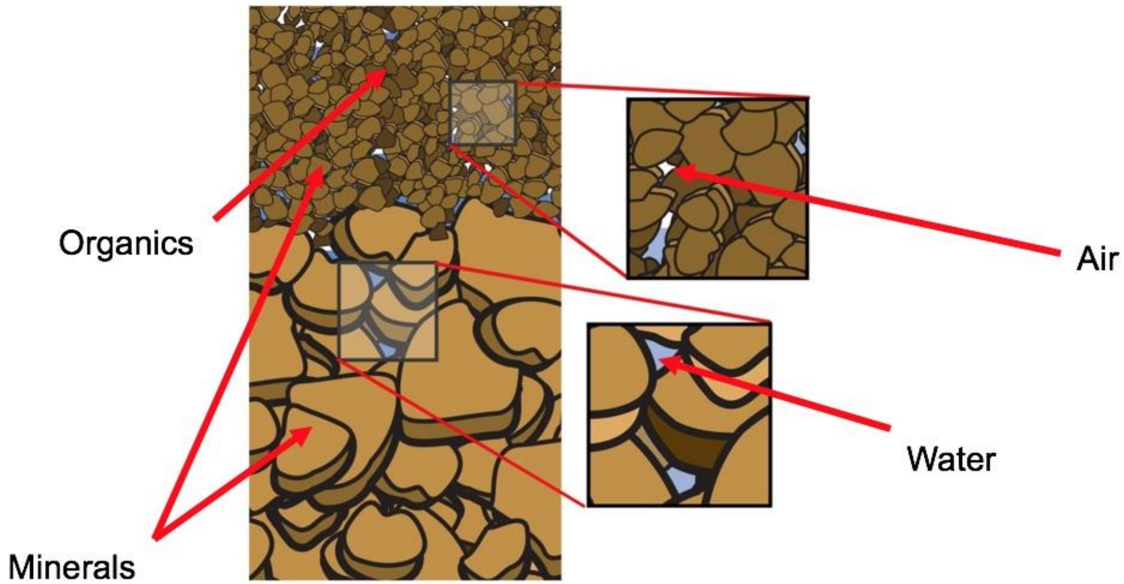
Evapotranspiration: depends on climate, crop, management, soil moisture.

It is possible to assess “drought” by soil moisture monitoring

The Role of Soil Moisture in the Environment

- Soil acts like a sponge spread across the land surface. It absorbs rain and snowmelt, slows run-off and helps to control flooding.
- The absorbed water is held on soil particle surfaces and in pore spaces between particles. This water is available for use by plants.
- Some of this water evaporates back into the air; some of this water is transpired by plants; some drains through the soil into groundwater.
- The infiltration rate of water into soil changes depending upon the level of soil saturation. Water that is not stored in the ground evaporates or becomes runoff and may pool on the surface for a time. It is possible to determine how flood-prone an area is, based on the infiltration rate of the soil.

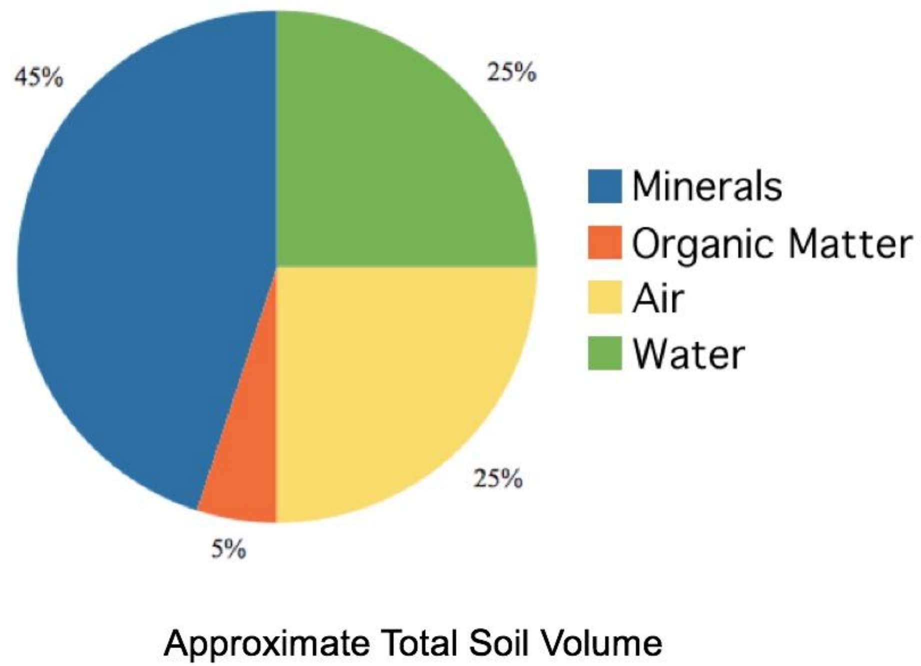
Sample Soil Components



Sample Soil Components in Horizons

If soil pore space increases and density decreases, water moves through soil more quickly. If the pore space decreases and soil's density increases, water moves through the soil more slowly.

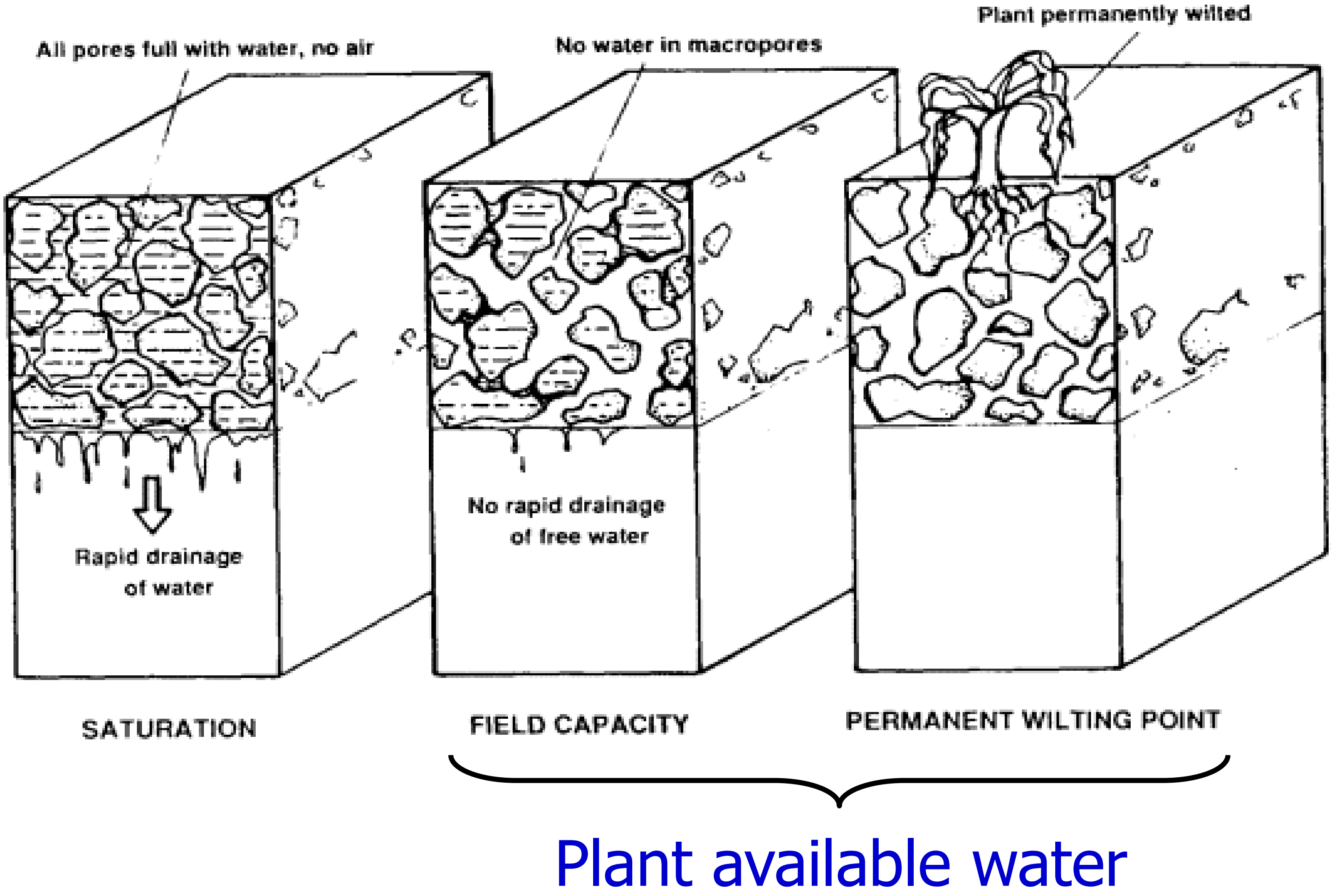
Average Soil Composition



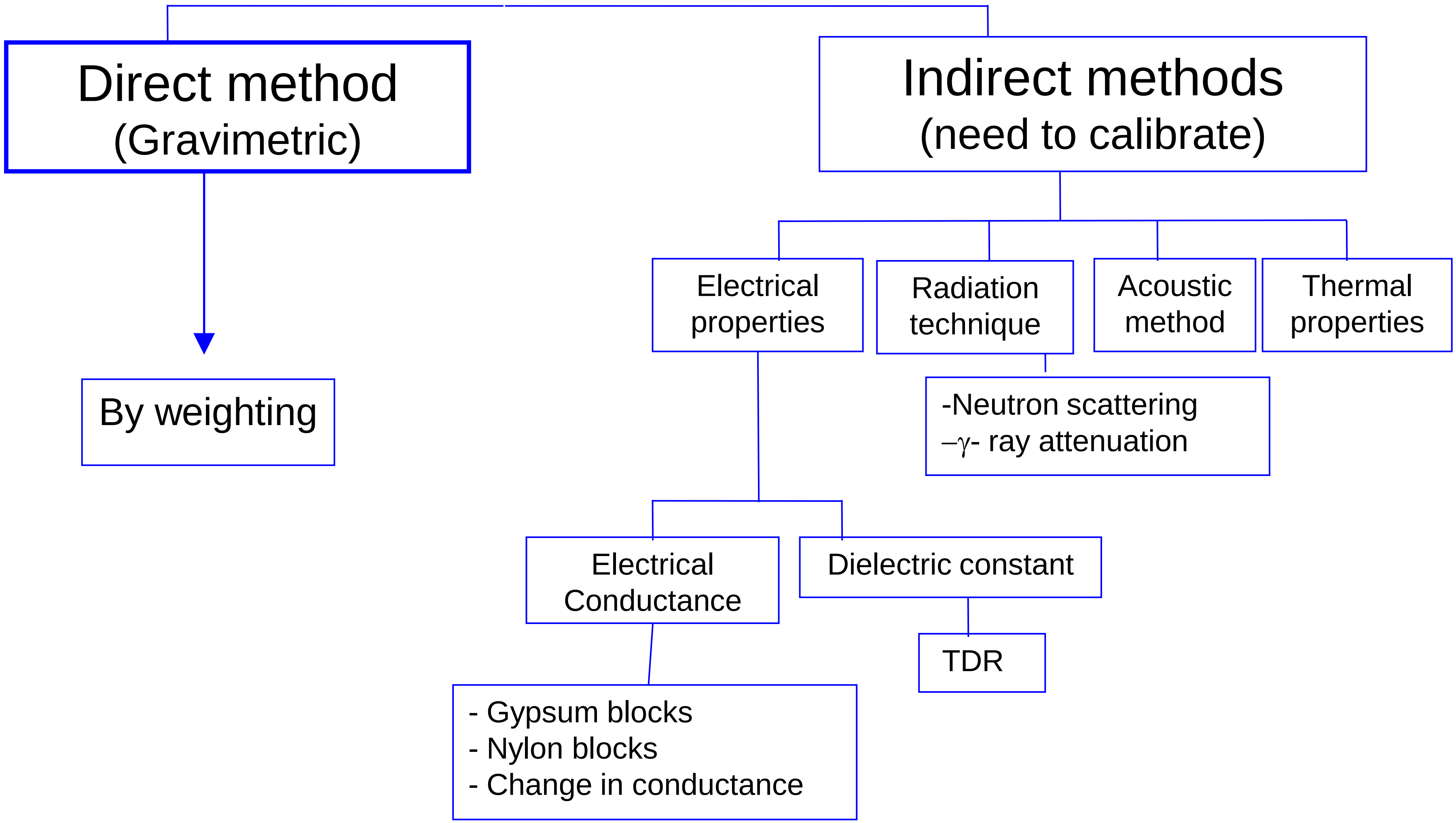
The air and water in soil represent the soil's pore space. Volumetrically, they should comprise approximately 50% of the soil's volume.

The pore space allows for movement of air, water, and organisms through the soil.

How water is retained by soil?



Methods for measuring soil water content



Gravimetric Soil Moisture Protocols

Logic steps:

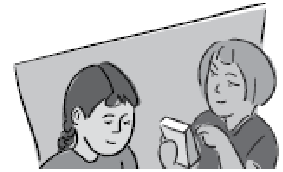
1. Soil sampling
2. Weight moist/wet soil
3. Soil Drying
4. Weight dried soil
5. Calculate soil moisture
6. Compare with SMAP or BIdriCo

Gravimetric Soil Moisture Protocols

Sampling:

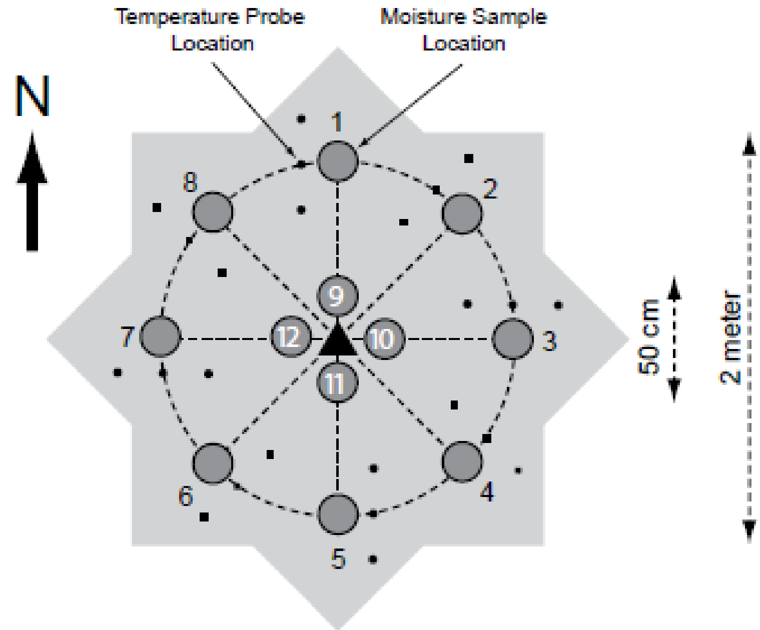
1. Site
2. Pattern or protocol
3. Depth
4. Period or frequency
5. Equipments

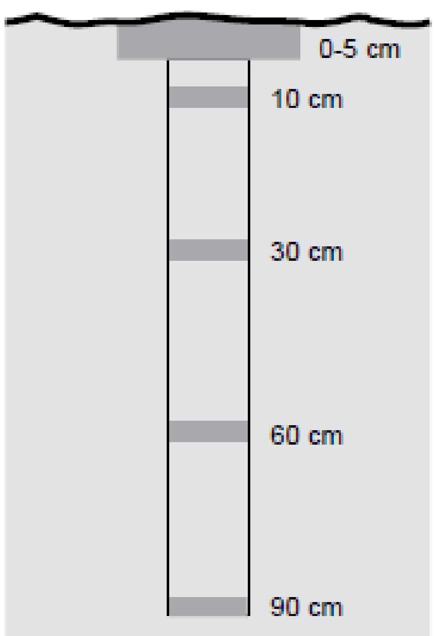
Gravimetric Soil Moisture Protocols

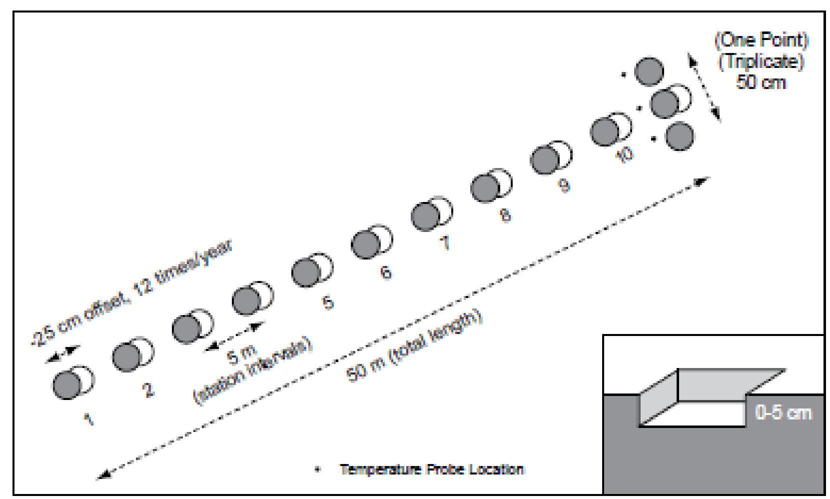


Sampling pattern:

1. The Star Pattern
2. The Transect Pattern
3. The Depth Profile







Gravimetric Soil Moisture Protocols

Sampling equipments:

Gravimetric Soil Moisture Protocols

Weighting

Drying

Figure 2, drying soil under heating lamp

Gravimetric Soil Moisture Protocols

Soil Water Content ⟺ Soil Moisture Content

Water that may be evaporated from soil by heating at 105^{0}C to a constant weight

$$\text{Gravimetric moisture content } (w) = \frac{\text{mass of water evaporated (g)}}{\text{mass of dry soil (g)}}$$

$$\text{Volumetric moisture content } (\theta) = \frac{\text{volume of water evaporated (cm}^3\text{)}}{\text{volume of soil (cm}^3\text{)}}$$

Gravimetric Soil Moisture Protocols

Calculating dry soil weight basis of samples for analysis

Weigh drying pan, moist soil *sample* + pan,

Oven dry the sample at 105°C for 24 hr,

Weigh the dried soil + pan.

Calculate the moisture content (w):

w = (g moist soil – g dry soil)/(g dry soil – pan)

Rearrange the equation to solve for dry soil wt.

Dry soil wt = g moist soil / (1 + w)

Gravimetric Soil Moisture Protocols

How to express soil moisture?

Over dry soil: $$\frac{\text{g moist soil} - \text{g dry soil}}{\text{g dry soil}} \bullet 100 \quad \%$$

Over moist soil: $$\frac{\text{g moist soil} - \text{g dry soil}}{\text{g moist soil}} \bullet 100 \quad \%$$

Dry matter: $$\frac{\text{g moist soil}}{\text{g dry soil}} \bullet 100 \quad \%$$

Other Suggestions:

BIdriCo

E' un **servizio irriguo per gli agricoltori del Friuli Venezia Giulia**. Bidrico è in grado di stimare l'umidità del suolo e di prevedere **il momento ideale per l'irrigazione**.
E' un progetto sviluppato da OSMER e dall'Università di Udine. Il servizio è attivo nei mesi di giugno, luglio e agosto.

https://www.osmer.fvg.it/agro.php?ln=

FAO web site

https://www.youtube.com/watch?v=3TFY6jhArRg

Bulk Density Protocol

Bulk density is the weight of soil mass per unit volume. It is directly related soil compactness and inversely related to the pore volume.

Bulk density gives useful indications on:
- the hydrological behavior of the soil,
- soil structure,
- erosion potential,
- soil workability,
- soil suitability for some plant species or crops.

Bulk Density Protocol

Materials and tools

- Metal or PVC* rings;
- Permanent marker;
- Wood block;
- Hammer;
- Small shovel, knife or some type of cutting edge,

* PVC rings are much less expensive. They can be obtained by cutting a 60mm rigid PVC pipe into 50-60mm high rings and sharping their bottom edge.

Bulk Density Protocol

Procedure

1. Select an appropriate location.
2. Remove the top layer of grass and roots and/or the plant litter to expose the soil below.
3. Carefully push the ring into the soil by hand or, more often, using a hammer and a piece of wood.
4. Remove the soil from around the soil ring, carefully remove the soil ring with a shovel/knife and even out the bottom surface with a sharp edge.

Bulk Density Protocol

Calculations

$$\text{bulk Density} = \frac{\text{dry soil mass}}{\text{volume of soil}}$$

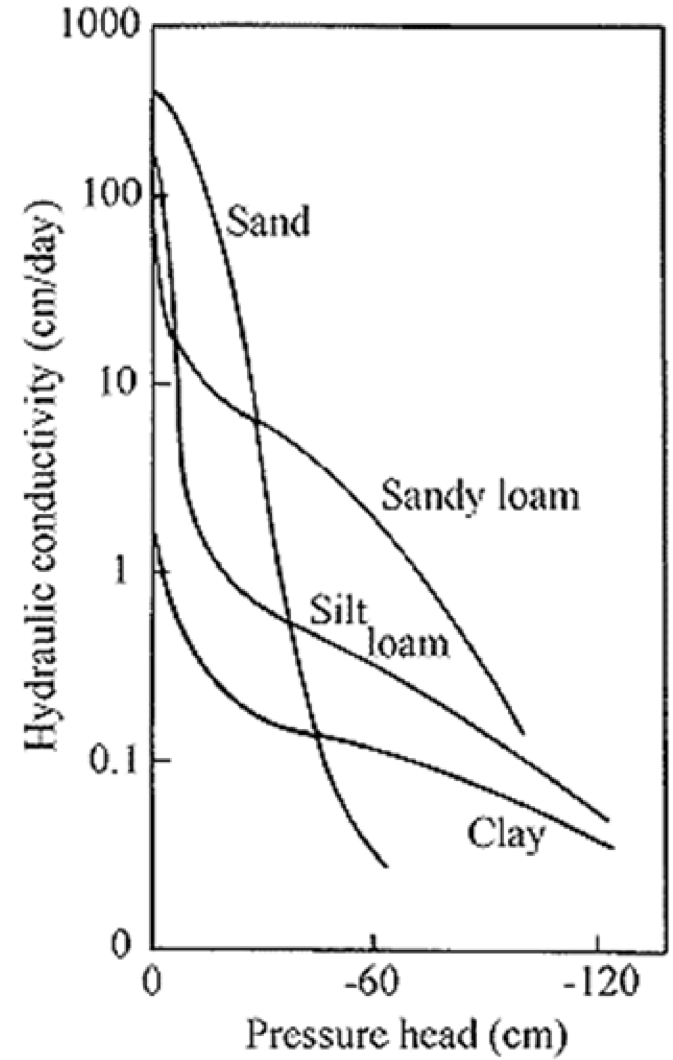
where the volume is obtained from the geometry of the cylinder.

$$\text{total porosity} = 100 * \left(1 - \frac{\text{Bulk density}}{\text{Particle density}}\right)$$

where Particle density is assumed to be 2,65 kg/L.

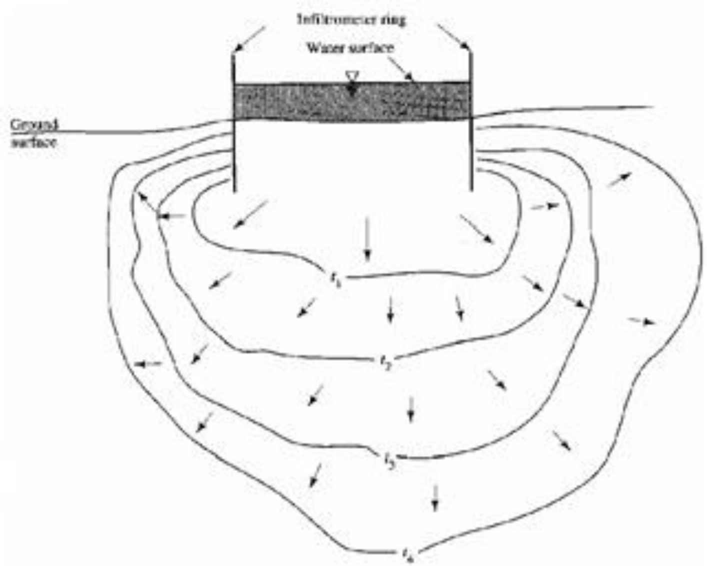
Infiltration Protocol

The infiltration rate at saturation is a parameter that assess the hydrological behavior of a soil.
It is useful to predict the erosion potential of a soil and plan the irrigation of crops.
Its measurement is usually characterized by a decrease with time to a steady-state value.



Infiltration Protocol

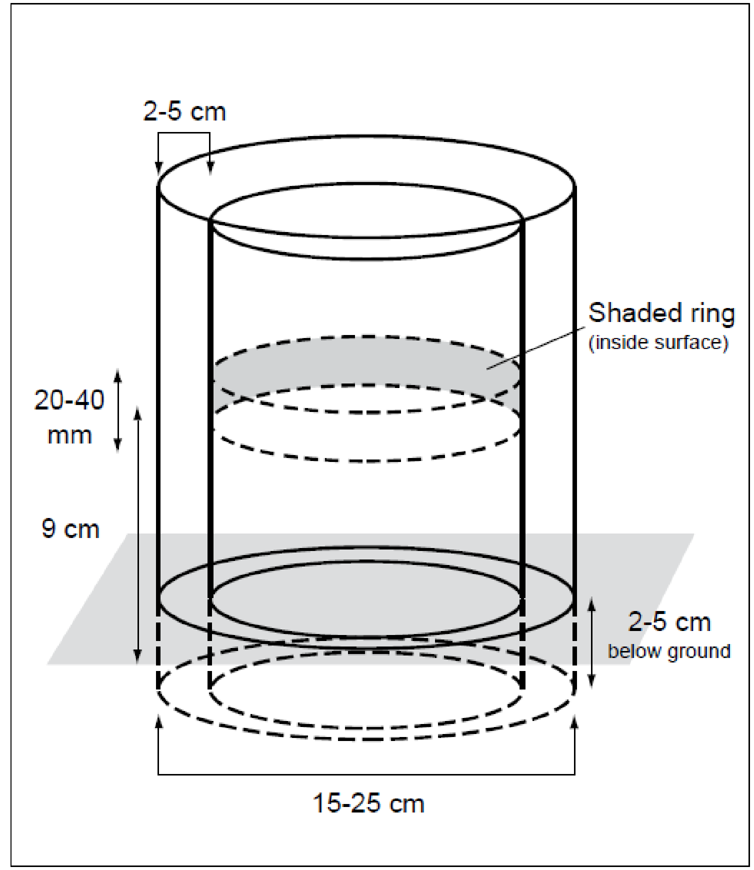
In the field, the simplest measurements are done with single/double ring infiltrometers.



Infiltration Protocol

Infiltration rings of 13-15cm height can be obtained by cutting two rigid PVC pipes of 100mm and 160-180mm diameter, respectively.

Once their bottom edge has been sharpened, the depth of insertion (3-5cm) will be marked on the bottom part of the outer surface and two reference lines will be drawn in the inner surface of the smaller ring, the lower one at about 9cm from the bottom end.



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$$\frac{q_s}{K_{fs}} = [\frac{H}{(C_1 d + C_2 a)} + \frac{1}{\alpha * (C_1 d + C_2 a)} + 1]$$

q_s, steady-state infiltration rate;
H, pressure head;
d, depth of insertion of the cylinders;
a, range of in inner cylinder;
$\alpha*$, macroscopic capillary length (0.12 for the most part of soils);
$C_1 = 0.361\pi$;
$C_2 = 0.184\pi$.

Table 8.2. Hydraulic conductivity in soils with different textures

Textural Class	Bulk Density (Mg/m^3)	Porosity (%)	Hydraulic Conductivity (cm/s)
Sand	1.55	42	1.2×10^{-1} to 2.0×10^{-3}
Loam	1.20	55	1.7×10^{-4} to 1.7×10^{-7}
Clay	1.05	60	2.5×10^{-9} to 1.0×10^{-9}