DRUtES

MANUAL: INFILTRATION EXPERIMENTS

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INTRODUCTION

Infiltration can be used to determine the field saturated hydraulic conductivity. The difference to the saturated conductivity measured in the laboratory is that the complete saturation of the pores space is above the groundwater table is close to never given. An important role for the value of the saturated hydraulic conductivity is the presence of secondary pores, e.g. fractures and cracks in soils with high clay content, weathered root channels, earth worm path.

Infiltration is the process of water entering the soil when water is added to the system. The infiltration behavior of a soil is influenced by the added water, the initial dryness of the soil and hydraulic conductivity of the soil. Additionally, the state of the soil as well as the presence of stagnation layers impact infiltration.

Infiltration capacity is the infiltration rate of the soil, which occurs when a bigger area of land is covered by water. This value of special interest as it allows determination of the corresponding value of surface runoff.

RING INFILTRATION

Ring infiltration is a well-established method to measure the maximal infiltration capacity of soil. The initial infiltration rate is high in a typical ring infiltration. The infiltration rate gradually drops to a constant rate given a homogeneous soil. The initial infiltration rate differs depending on soil and initial dryness and can be twice (sand) to a hundredfold (clay) of the final infiltration rate.

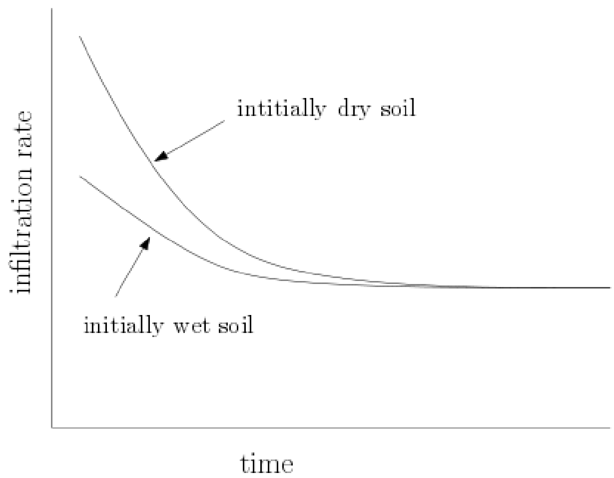

Figure 1: Schematic representation of infiltration in dry and in a wet soil.

The asymptotically established infiltration rate that is closely related to the hydraulic conductivity at field saturation. Infiltration experiments are therefore useful to estimate the saturated hydraulic conductivity K_s. For an idealized infiltrometer with an infinite radius (purely 1D vertical water movement) and neglible water overhead, we can assume that at full saturation in the wet soil the gradient of the hydraulic (or matric) head can be assumed to be:

$$\frac{dh}{dz} = 0 \tag{1}$$

Replacing this in the Darcy-Buckingham law, we obtain:

$$q = -K(\frac{dh}{dz} - 1) = -K(0 - 1) = K \tag{2}$$

The main issue with the interpretation of the results of the ring infiltration measurements is the lateral flow component of the water flow, which makes the analysis of the flow problem complicated. The lateral flow causes the stationary infiltration flow to always be higher than the infiltration capacity and the hydraulic conductivity of a soil. Stagnating layers throughout the soil affected by the infiltration also cause an overestimation of the infiltration capacity.

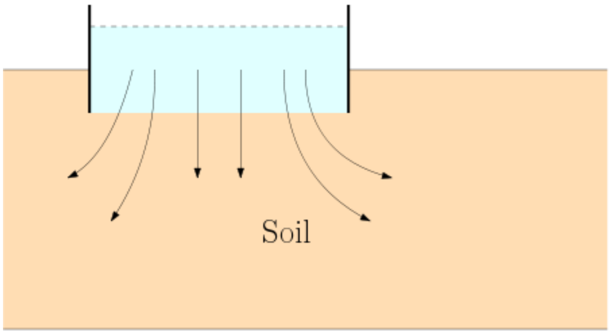

Figure 2: Schematic of ring infiltration with lateral flow.

To avoid lateral flow double ring infiltrometer can be used. However, especially in organic soils or forest soils, they can cause unnecessary preferential flow paths. Generally, it is preferable to use rings with a large radius to have a better ratio between ring and experimental area. Using a large enough ring leads to improvement in the representativeness and can compensate for small heterogeneities.

The infiltration curve against time can be described with the 2-parametric equation according to Phillips [2]:

$$\begin{aligned} I(t) &= S \cdot t^{1/2} + A \cdot t + C \\ i(t) &= S0.5 \cdot S \cdot t^{-1/2} + A. \end{aligned} \tag{3}$$

The constant C describes the initial state of $C = 0$. S is the sorptivity [cm $\mathrm{d}^{-\frac{1}{2}}$]. The infiltration rate i for t $\rightarrow \infty$ is A. The constant A [cm d^{-1}] is therefore with a small overhead $A = K_s$. Both Parameters A and S can be determined by fitting the infiltration data to Eq. 3.

To compensate for lateral flow and the overcompensation [3] identified scaling factors, so that:

$$i(t) = fK_s \tag{4}$$

where f is the appropriate scaling factor. f can be computed using

$$f = \frac{H + \phi_m / K_s}{y + r/2} + 1 \tag{5}$$

where H is the height of the water column above the soil, ϕ_m is the matric flux potential defining the influence of the water absorption through the unsaturated soil, z is the installation depth and r is the radius of the infiltration ring. Some values of f can be found in Tab.

Table 1: Values for the scaling factor f Eq. 5 [3]. The values are for z=5cm,H=5cm and an initial pressure head of pF=3.

Soil	r=10cm
Fine sand	2.6
Loam	1.9-2.1
Clay	3.2

Ring infiltration experiment

1. Installation of ring
2. Measurement of diameter of ring
3. Installation of water supply and water height regulation
4. Beginn of experiment:
   a) Read water level in the Mariotte's bottle every 30 s.
   b) The experiment end when the infiltration is stationary.

Evaluation

We measure cumulative infiltration I [cm] as the Volume entering the specific area as a function of time.

$$\Delta V = \pi r^2 \delta h \tag{6}$$

where r is the radius of the Mariotte's bottle and δh is the water height difference in regard to the initial value.

$$I(t) = \frac{\Delta V}{A} \tag{7}$$

The infiltration rate can be calculated as:

$$i = \frac{dI}{dt} \approx \frac{\Delta I}{\Delta t} \tag{8}$$

To evaluate we can plot the infiltration rate against time and fit the Phillip's equation to estimate Sorptivity S and the final infiltration rate i_f. The saturated conductivity can be estimated using the correction factor f.

GUELPH PERMEAMETER

The Guelph Permeameter can be used to estimate the near-surface hydraulic conductivity. The Guelph Permeameter creates a constant head and requires only approx. 2 Liter per experiment. Known problems occur with soils that show silting, where the K_s will be underestimated, whereas with layered soils K_s will be overestimated.

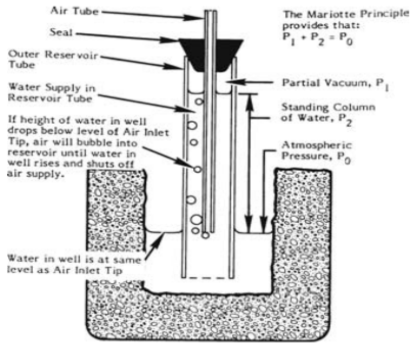

Figure 15. In-hole constant-head permeameter setup

Figure 3: Set-up of in-hole Guelph permeameter [1].

Experiment

1. Create bore hole
2. Installation of permeameter and topping up of permeameter
3. Setting of the constant head with the air entry valve
4. Begin experiment by opening air entry valve

Evaluation

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