

Abstract:

Determining the air permeability of a soil column as a function of water content is typically a tedious task because each measurement of permeability requires a constant water content in space and time. Between each individual measurement of permeability, the water content of the sample must be modified and allowed to equilibrate. A dynamic air permeability test is proposed that measures airflow rate, water content, and air pressure, while continually modifying the water content.

Background:

The movement of the drying front through the sample is tracked by gamma ray attenuation. Attenuation is proportional to the density of the sample and the distance through the sample, as defined in the Beer – Lambert equation (Eq. 1). The term x_w is computed by Eq. 2.

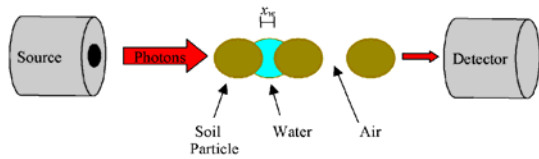


Figure 1: Schematic of photons passing through sample

$$I = I_o \exp(-\mu_w \Delta x_w \rho_w) \quad \text{Eq. 1}$$

where: I = photon count with saturated sample in place

I_o = photon count after air flow has begun

μ_w = mass attenuation coefficient (cm^2/g)

x_w = length of water in pore space (cm)

ρ_w = density of water (g/cm^3)

$$\left(\Delta \theta = \frac{\Delta x_w}{d} \right) \quad \text{Eq. 2}$$

where: $\Delta \theta$ = change in volumetric water content

Δx_w = change in length of water in pore space (cm)

d = diameter of soil column

Methods:

Dry air is pumped into the inlet of an initially wet soil column, which dries the soil over a 24 – 48 hour period. A computer controlled gamma ray attenuation system measures and records the water content, along the length of the soil column. Hypodermic needles are inserted into the soil column and are connected to pressure transducers, which measure the air pressure at multiple locations. An electronic air flow meter logs the airflow rate. The system is computer controlled and operated (Fig. 2).

Using Darcy’s Law along with air density and viscosity, the air permeability constant can be calculated from the collected data (Eq. 3).

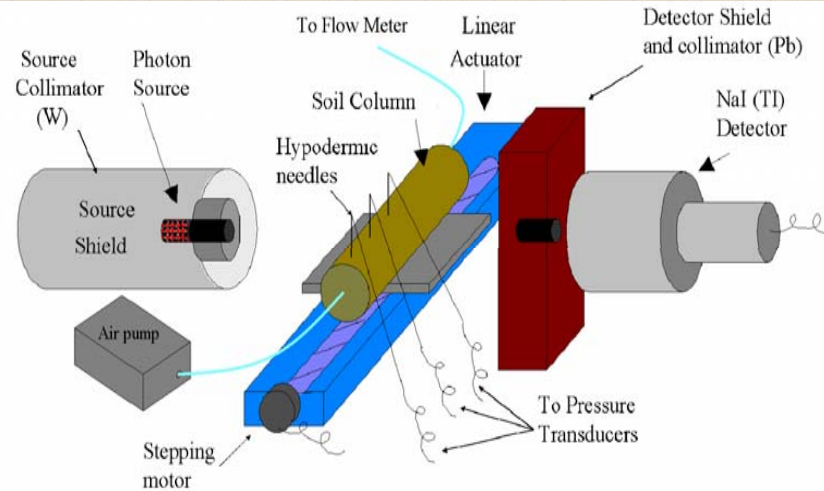


Figure 2: Gamma ray attenuation system

$$Q = KA \frac{dh}{dL} \quad \text{Eq. 3}$$

where: Q = air flow rate through the soil column (cm^3/s)

K = hydraulic conductivity (cm/s)

dh = differential pressure (cm)

dL = distance between hypodermic needles (cm)

A = cross sectional area (cm^2)

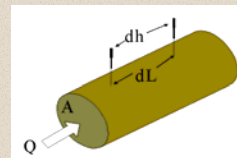
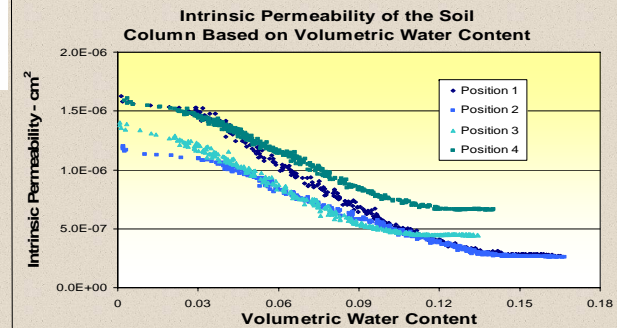
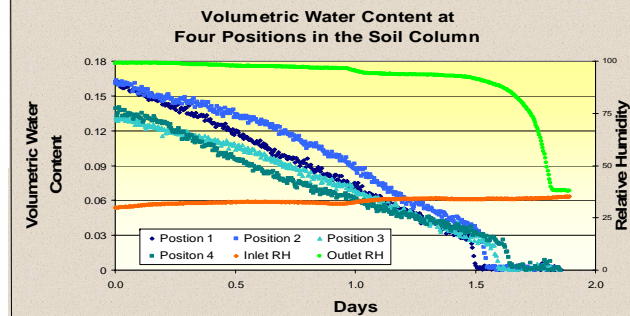
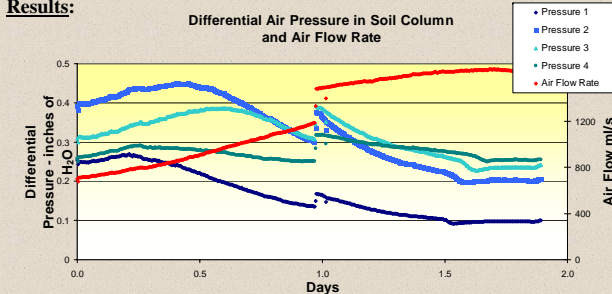


Figure 3: Diagram of Darcy’s Law

Results:



Conclusions:

- The system can measure the full range of air permeability versus water content, without human intervention
- The system can simultaneously measure the air permeability of multiple layers within a sample
- The system can measure field collected samples. Hand packing is not required.

Acknowledgements:

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