NOTA

UNIT GRADIENT IN INTERNAL DRAINAGE EXPERIMENTS FOR THE DETERMINATION OF SOIL HYDRAULIC CONDUCTIVITY

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ABSTRACT: It is theoretically shown that unit hydraulic potential gradients cannot occur in homogeneous soils undegoing internal drainage process even though this assumption has been used successfully by several authors of soil hydraulic conductivity methods.
Key Words: soil hydraulic conductivity, unit gradient, internal drainage.

GRADIENTE UNITÁRIO EM EXPERIMENTOS DE DRENAGEM INTERNA PARA DETERMINACÃO DA CONDUTIVIDADE HIDRÁULICA DO SOLO

RESUMO: É mostrado teoricamente que gradientes unitários de potencial hidráulico da água não podem ocorrer em perfís homogêneos de solo sob drenagem interna, apesar desta aproximação ter sido utilizada com sucesso em vários métodos de determinação de condutividade hidráulica do solo.
Descritores: condutividade hidráulica do solo, gradiente unitário, drenagem interna.

Many methods used for the determination of unsaturated soil hydraulic conductivity are based on experimental designs involving the drainage of previously saturated soil profiles Preventing soil surface evaporation and assuming water flow occurring only in the vertical direction, the integration of Richard's equation yields the basic equation for the estimation of unsaturated hydraulic conductivity $K_L(\Theta)$:

$$K_L(\Theta) = \frac{\int_o^L [\partial\Theta/\partial t]\, dz}{[\partial H/\partial z]_L} \qquad 1$$

where:

- Θ = volumetric soil water content (cm^3cm^{-3}).
- H = total hydraulic pressure head (cm), assumed as the sum of matric pressure head h (cm) and gravitational pressure head z (cm).
- t = time (s).
- z = vertical space coordinate (cm), L being a particular value of z at which $K(\Theta)$ is determined.

Since the integral in equation (1) strongly determines the value of $K(\Theta)$ and since many experiments indicate that the hydraulic gradient $\partial H/\partial z$ is close to 1 due to the dominance of gravity, and because of the extra efforts to be devoted to measure $\partial H/\partial z$, several authors use the so called "unit gradient assumption". This assumption was first introduced by DAVIDSON et al., (1969) and then used in several field methods (e.g. CHONG et al., 1979; LIBARDI et al., 1980, SISSON et al., 1980). The validity of this assumption is frequently questioned; one clear example has been published by AHUJA et al (1988).

Although gradients close to unit are frequently observed during internal drainage, it is my point of view that theoretically unit gradients cannot occur, even for a homogeneous soil profile. Assuming $H = h + z$, the condition $\partial H/\partial z = 1$ implies in $\partial h/\partial z = 0$, and as a consequence $h =$ constant in depth, for all t. The soil being homogeneous, there is a unique $h(\Theta)$ relation and, as a result, Θ will also be constant in depth. Figure (1) ilustrates these points. The constant Θ profiles shown in figure 1C indicate that $K(\Theta)$ calculated according equation (1) (considering $\partial H/\partial z = 1$, as assumed) must increase in depth:

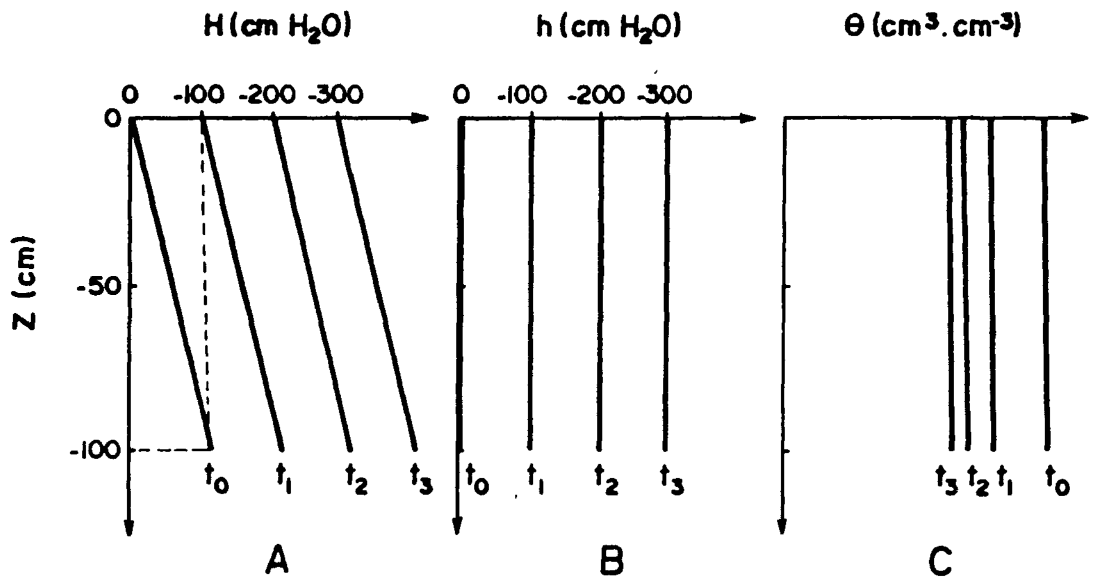

Figure 1 - Theoretical evolution of H, h and Θ profiles during the internal drainage process of an homogeneous soil, covered with plastic, starting at saturation, when unit gradient is assumed.

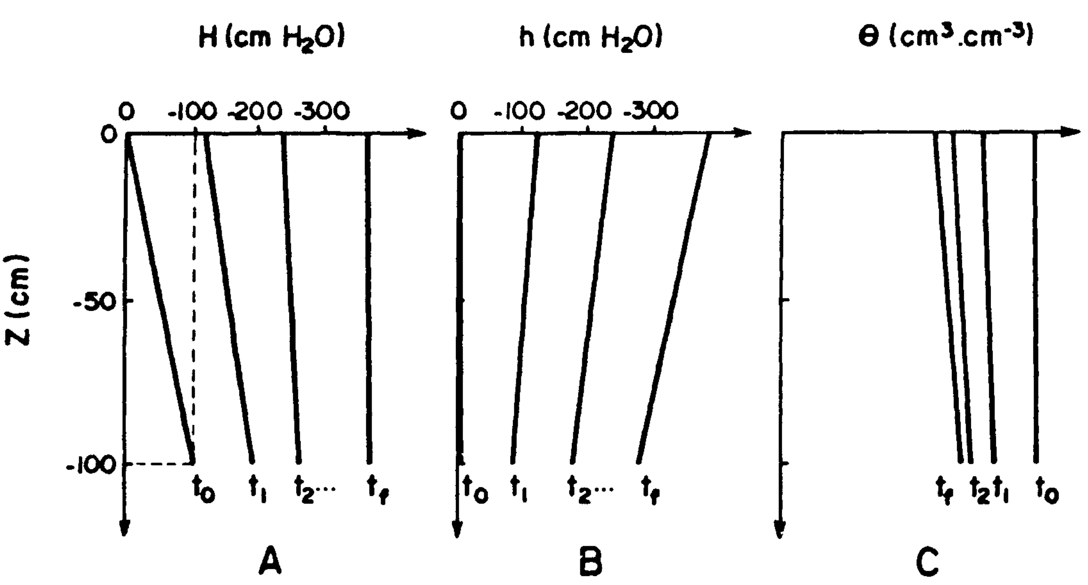

Figure 2 - Theoretical evolution of H, h and Θ profiles, as shown in figure 1, unit gradient not assumed.

$$K(\theta) = \frac{\partial\theta}{\partial t} . L \qquad 2$$

which contradicts the first assumption of an homogeneous soil. Therefore, $\partial h/\partial z$ cannot be zero, and should actually decrease during drainage time until equilibrium is reached, when $\partial H/\partial z = 0$, and water flow stops.

Figure 2 ilustrates this point. At time t_f the soil reaches the theoretical soil water equilibrium, when the Darcian flux density ($cm.s^{-1}$) becomes zero ($\partial H/\partial z = 1 - 1 = 0$) and matric forces counteract gravity. In fact q becomes very close to zero much before t_f, due to the exponential character of the $K(\Theta)$ function.

In practice, it is frequently observed that soil profiles present fairly parallel water content profiles during the evolution of the internal drainage process and, as a consequence K, values for given Θ values will increase in depth.

Does this reflect the reality or is it an artifact of our calculations? I wonder if K values would decrease in depth if those soil profiles could be inverted.

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