Entrapped Air Effects on Soil Suction Measurements

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ABRIDGMENT

•THE PARTICLE interaction characteristics in a soil-water system may be measured and described in terms of soil suction (pF) or moisture potential. Of the many methods available for measurement of soil suction, the two most common techniques utilize either the Richards pressure method (1949) or the Haines tension apparatus (1930). The characteristic soil suction or moisture potential curve obtained by the pressure technique may not represent the actual condition of the soil water as determined by the Haines tension method.

Because of the possibility of air bubbles nucleating in the soil water after release of pressure from the pressure technique, the corresponding tension in the water will not be equivalent to that obtained from actual initial tension measurements. The results of study on an initially unsaturated coarse silt fraction show that at a water content of 23 percent, the tension method indicated that the moisture potential was 8 cm of mercury, whereas the pressure method gave a value of 17 cm of mercury. The discrepancy becomes less with decreasing water contents. At 13 percent water content, the moisture potential derived was 24.5 cm and 27.4 cm of mercury for the tension and pressure methods, respectively. Experiments on a fine fraction silt showed that the discrepancy between the two techniques was less at the same water contents.

A theoretical expression is derived relating moisture potential with changes in pressure which may be related directly to the volume of entrapped air.

$$\frac{\partial v}{\partial \psi} = \frac{\frac{\partial \theta}{\partial \psi}(1+k)(B + J\alpha^{-1/3}) - \alpha}{B + J\alpha^{-1/3}}$$

where

ψ = moisture potential;
v = total volumetric water content (includes volumetric entrapped air content);
α = volumetric entrapped air content;
θ = actual volumetric water content;
k = fraction of volume of water filled with entrapped air or vapor bubbles;
$J = \frac{4\sigma}{3}\left(\frac{4\pi n}{3}\right)^{1/3}$, where σ is surface tension of water, and n is number of bubbles per unit volume of soil; and
$B = \psi + p$, (p = pressure).

In the theoretical development for air entrapment, the successful use of the equation derived depends on one's ability to provide values for volumetric entrapped air content and estimation of the compression of trapped air bubbles. This development is restricted because of the difficulty in measuring the rate at which the trapped air may be increasing or decreasing.

The results show clearly that soil moisture potential measurements obtained using either the pressure or tension technique do not lend themselves to the description of equivalent tensions in the soil water. For soils in the initially unsaturated state, the

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difference between actual and assumed tensions is maximum before air entry. Following air entry, this difference becomes progressively smaller. In the case of the initially saturated samples, because of the absence of initial air content, the values for actual and assumed tension correspond exactly until air entry. Following air entry, these values begin to diverge and remain divergent even at the lower ranges of water content.

The differences in tension recorded by the two techniques lead to the conclusion that the tensiometer method would provide a more realistic picture of the tension in the soil water. However, this technique is necessarily restricted to pressure differences below one atmosphere. The energy relationship between soil and water described in terms of soil suction or soil moisture potential is, in essence, a reflection of the tension in the soil water. Unless an accurate assessment of this phenomenon is made, predictions and correlations using soil suction measurements must be made with total awareness of the air entrapment effect. As long as the technique is specified, and comparisons are made within the same technique, the error involved in correlative studies may at best be given the role of a constant.