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Production Filename: 13401 (In Product Library)

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Dimensions: 8.5 inch wide, 11 inch tall

Material: Paper, 92 Bright White or better, 75g/m² or heavier

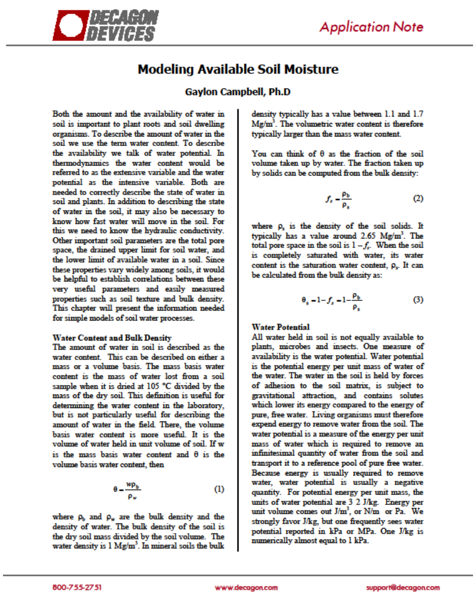
Colors: Color Print on White

Printer: HP Color LaserJet 8550-PS

Finish: None

Adhesive: None

Special Notes: Illustrations are Ref Only ** Not to Scale ** (Shown page 1 of 4)



DECAGON DEVICES Application Note

Modeling Available Soil Moisture

Gaylon Campbell, Ph.D

Both the amount and the availability of water in soil is important to plant roots and soil dwelling organisms. To describe the amount of water in the soil we use the term water content. To describe the availability we talk of water potential. In thermodynamics the water content would be referred to as the extensive variable and the water potential as the intensive variable. Both are needed to correctly describe the state of water in soil and plants. In addition to describing the state of water in the soil, it may also be necessary to know how fast water will move in the soil. For this we need to know the hydraulic conductivity. Other important soil parameters are the total pore space, the drained upper limit for soil water, and the lower limit of available water in a soil. Since these properties vary widely among soils, it would be helpful to establish correlations between these very useful parameters and easily measured properties such as soil texture and bulk density. This chapter will present the information needed for simple models of soil water processes.

Water Content and Bulk Density

The amount of water in soil is described as the water content. This can be described on either a mass or a volume basis. The mass basis water content is the mass of water lost from a soil sample when it is dried at 105 °C divided by the mass of the dry soil. This definition is useful for determining the water content in the laboratory, but is not particularly useful for describing the amount of water in the field. There, the volume basis water content is more useful. It is the volume of water held in unit volume of soil. If w is the mass basis water content and θ is the volume basis water content, then

$$\theta = \frac{w\rho_b}{\rho_w} \quad (1)$$

where ρ_b and ρ_w are the bulk density and the density of water. The bulk density of the soil is the dry soil mass divided by the soil volume. The water density is 1 Mg/m³. In mineral soils the bulk density typically has a value between 1.1 and 1.7 Mg/m³. The volumetric water content is therefore typically larger than the mass water content.

You can think of θ as the fraction of the soil volume taken up by water. The fraction taken up by solids can be computed from the bulk density:

$$f_s = \frac{\rho_b}{\rho_s} \quad (2)$$

where ρ_s is the density of the soil solids. It typically has a value around 2.65 Mg/m³. The total pore space in the soil is $1 - f_s$. When the soil is completely saturated with water, its water content is the saturation water content, ρ_s. It can be calculated from the bulk density as:

$$\theta_s = 1 - f_s = 1 - \frac{\rho_b}{\rho_s} \quad (3)$$

Water Potential

All water held in soil is not equally available to plants, microbes and insects. One measure of availability is the water potential. Water potential is the potential energy per unit mass of water of the water. The water in the soil is held by forces of adhesion to the soil matrix, is subject to gravitational attraction, and contains solutes which lower its energy compared to the energy of pure, free water. Living organisms must therefore expend energy to remove water from the soil. The water potential is a measure of the energy per unit mass of water which is required to remove an infinitesimal quantity of water from the soil and transport it to a reference pool of pure free water. Because energy is usually required to remove water, water potential is usually a negative quantity. For potential energy per unit mass, the units of water potential are 3 2 J/kg. Energy per unit volume comes out J/m³, or N/m or Pa. We strongly favor J/kg, but one frequently sees water potential reported in kPa or MPa. One J/kg is numerically almost equal to 1 kPa.

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