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Soil water potential: measurement and modeling of the tensiometric curve

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The soil water potential curve or the "soil moisture characteristic curve"provides hydral status of the soil water medium for a range of water contents.It allows for modelling water movements in soils and the exchanges with other systems studied by plant, atmosphere, vegetation cover, and agronomic systems. However, the equations used to describe this characteristic curve are still empirical (like equations of Van Genuchten, Campbell, Brooks and Corey) and parameters of these equations do not represent a physical state of the soil water medium. Braudeau and Mohtar (2004) showed that the equations of Low (1) (J/J°=exp(β/W) and Voronin (2) ($h = E/(W - \sigma) - E/(W_{sat} - \sigma)$) concerning the thermodynamical properties (J) of the water layer at the surface of clay particles in the soil were comparable (β and E being soil characteristics). Braudeau and Mohtar (3) reformulated the above two equations by taking account of the soil organization as an assembly of *primary aggregates (or peds)*. Accordingly, the micropore water potential of these primary peds, $h_{mi}(W_{mi})$, and that of the inter aggregate $h_{ma}(W_{ma})$ can be written as:

$$h_{ma} = Ps_{ma} - Ps_{ma^\circ} = \rho_w E_{ma} \{1/(W_{ma} + \sigma) - 1/(W_L - W_M + \sigma)\}$$

$$h_{mi} = Ps_{mi} - Ps_{mi^\circ} = \rho_w E_{mi} \{1/(W_{mi} - W_N) - 1/(W_M - W_N)\}$$

where ρ_w is the water bulk density; Ps_{ma} and Ps_{mi} are the swelling pressure inside and outside primary peds, E_{mi} and E_{ma} are the potential energies of the solid phase resulting from the external surface charge of clay particles, inside and outside primary peds, in joules/kg of solids; σ is a part of the micropore water at the surface of primary peds which intervenes, along with the macropore water, in the control of Ps_{ma}. Both terms Ps_{ma° and Ps_{mi° represent the swelling pressure in the macro and micro

pore spaces at complete saturation when $W_{ma} = W_{masat} = W_L - W_M$; and W_{mi} = max(W_{mi}) = W_M. At equilibrium, the two types of water, W_{mi} and W_{ma}, are determined in terms of W and both parameters W_M and k_M, using two physical equations developed by Braudeau et al. (5) from the shrinkage curve characteristic of the soil (in the range of water contents between saturation to 1500 kPa).

Parameters of these equations have a physical meaning that was established in relationship with the functional and structural organization of the soil medium made of solids water and air. They are hydrostructural characteristics of the soil referred to its “Representative Structural Volume” named “Pedostructure”. Parameters W_N, W_M, k_M, W_L are organizational parameters and enter into the physical formulation of the shrinkage curve, $V(W)$, via the types of water W_{mi} and W_{ma} (5).

We have analysed tensiometric curves and shrinkage curves of soils composed of various structures and clay materials from Martinique (volcanic soils with allophanes, halloisite, kaolinite, montmo-rillonite) and from Indiana (fine-loamy and sandy soils). A method for extracting parameters from the tensiometeric curve was developed.

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