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Measurement of soil water, use of neutron probe and tensiometers 1

Klaus Reichardt
University of Sao Paulo
Brazil

Measurement of soil water content, use of neutron probes and tensiometers

O.O.S. Bacchi; K. Reichardt; M. Calvache; L.C. Timm

Laboratory of Soil Physics, Center for nuclear Energy in Agriculture (CENA), University of São Paulo, Brazil.

Estimating the Water Retention Shape Parameter from Sand and Clay Content

Budiman Minasny*
Alex B. McBratney
Faculty of Agriculture
Food & Natural Resources, A05
The Univ. of Sydney
Sydney, NSW 2006
Australia

This study developed an alternative way of estimating the van Genuchten water retention shape parameter n from a soil's sand and clay content. This estimation can be used to complement an infiltration experiment called the Beerkan method, which has been proposed for estimating the van Genuchten water retention function and Brooks–Corey hydraulic conductivity characteristic. To estimate the water retention shape parameter, the Beerkan method requires a distribution function fitted to particle-size distribution data (more than five fractions) and a measurement of bulk density. Using three published databases, we were able to derive a neural network model that predicts the shape parameter and its uncertainty from sand and clay content. Its accuracy ranges from 0.2 to 0.4. This method is comparable to prediction using parameterized particle-size distribution data. The response surface of n as a function of sand and clay content shows an increasing value of n with increasing sand content in a nonlinear way. We also show that using simpler methods for predicting shape parameter n does not influence the accuracy of the Beerkan method in estimating the soil hydraulic properties.

THEORY

The analysis of the Beerkan infiltration experiment is based on an analytical solution of three-dimensional infiltration with defined hydraulic characteristic functions (Braud et al., 2005). The water-retention function is modeled following the van Genuchten (1980) equation:

$$\frac{\theta(h)}{\theta_s} = \left[1+\left(\frac{h}{h_g}\right)^n\right]^{-m}, \text{ with } m = 1-\frac{2}{n} \qquad [1]$$

where θ is water content [$L^3 L^{-3}$], θ_s is saturated water content [$L^3 L^{-3}$], h_g is a scale parameter [L], and n is a dimensionless shape factor with condition $n > 2$. This function has a residual water content θ_r fixed at 0. Hydraulic conductivity is modeled based on the Brooks and Corey (1964) equation:

$$\frac{K(\theta)}{K_s} = \left(\frac{\theta}{\theta_s}\right)^{\eta} \qquad [2]$$

where K is hydraulic conductivity [$L\,T^{-1}$], K_s is saturated hydraulic conductivity [$L\,T^{-1}$], and η is a conductivity shape factor that can be related to n by

$$\eta = \frac{2}{\lambda} + 2 + p, \text{ with } \lambda = mn \qquad [3]$$

where p is a tortuosity parameter that depends on soil type. A value of 1 is used here following Burdine's condition (Burdine, 1953; Braud et al., 2005).

The Beerkan method measures cumulative infiltration with time; in addition, it requires measurement of bulk density, initial and saturated water content θ_s, and the PSD of the soil. Saturated hydraulic conductivity K_s is estimated from the infiltration data. The soil-water retention shape parameter n is estimated from the soil's particle size distribution function and porosity. Parameter h_g is estimated from sorptivity, K_s, and the shape parameter n (Lassabatère et al., 2006).

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Definitions of u, θ, d_b

$$\theta = u.d_b$$

$$S = \int_{z_1}^{z_2} \theta dz = \sum_{i=1}^{n} \theta_i \Delta_z = \overline{\theta}.(z_2 - z_1)$$

Measuremntes of θ

Neutron probes

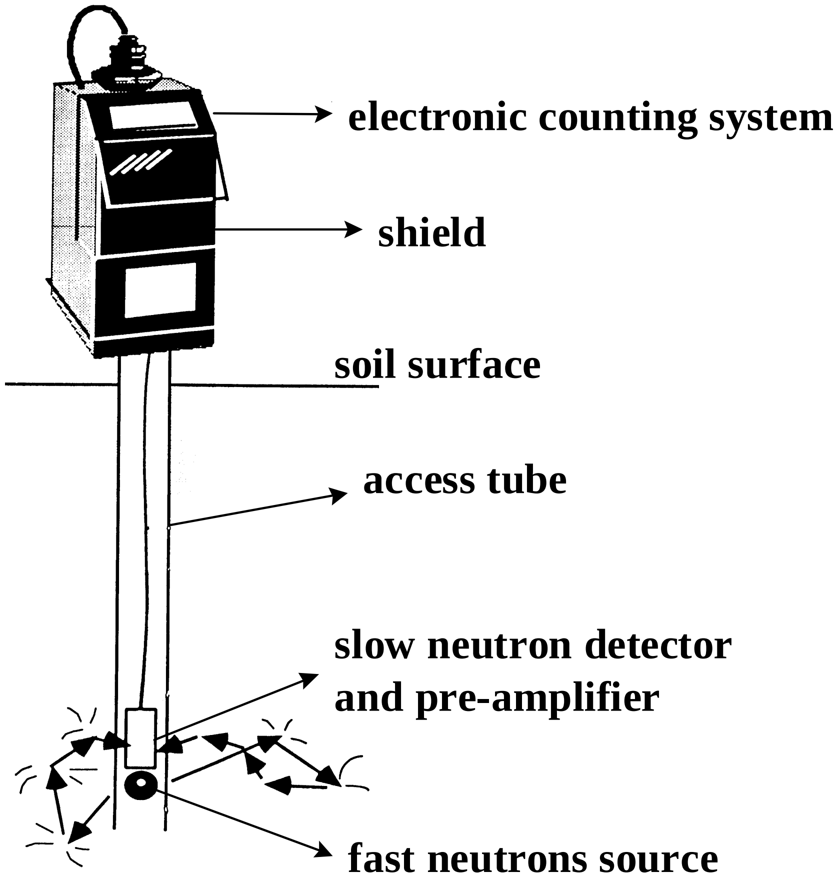
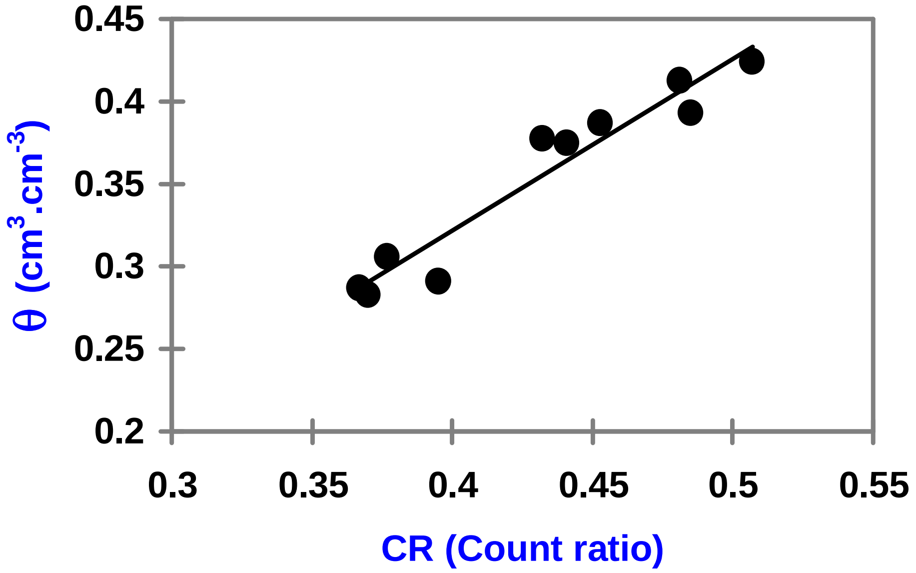
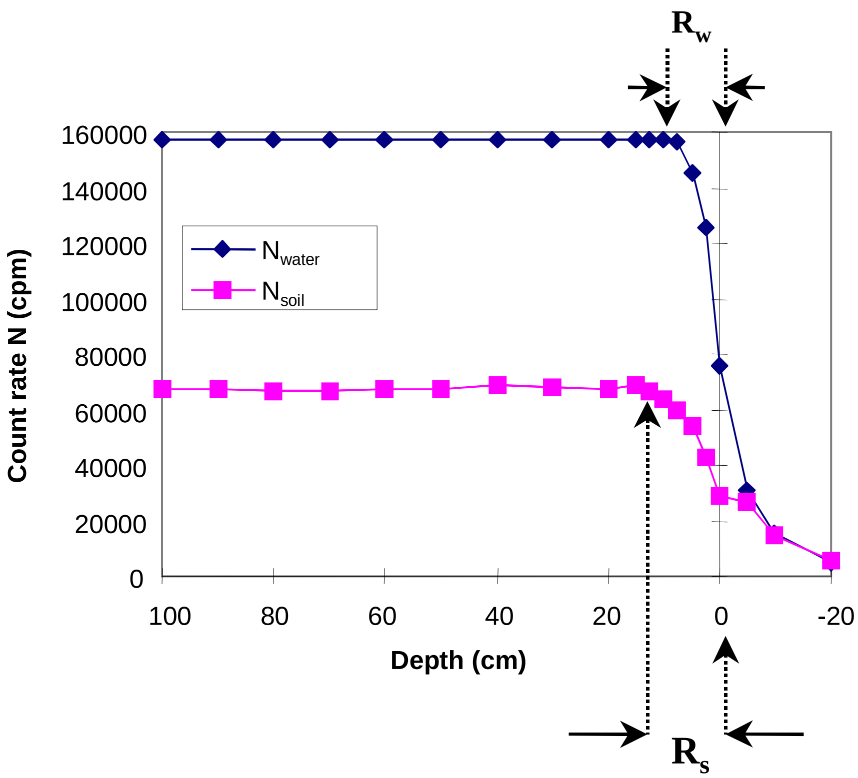

electronic counting system
shield
soil surface
access tube
slow neutron detector
and pre-amplifier
fast neutrons source

Table 1
Number of elastic collisions necessary to reduce the energy of a neutron from 2 MeV to 0.025 eV

Target Isotope	Number of Collisions
^{1}H	18
^{2}H	25
^{4}He	43
^{7}Li	68
^{12}C	115
^{16}O	152
^{238}U	2172



Calibration equation obtained with Table 3 data.

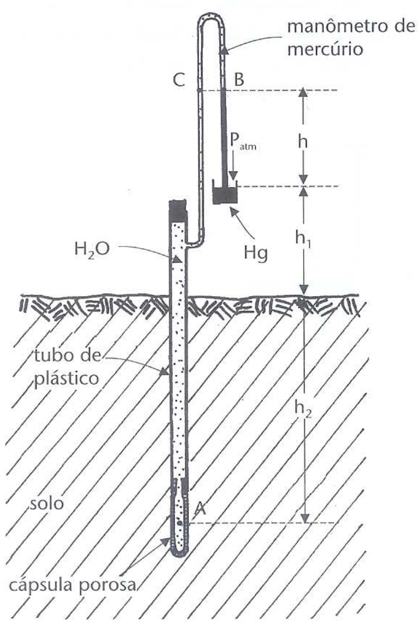


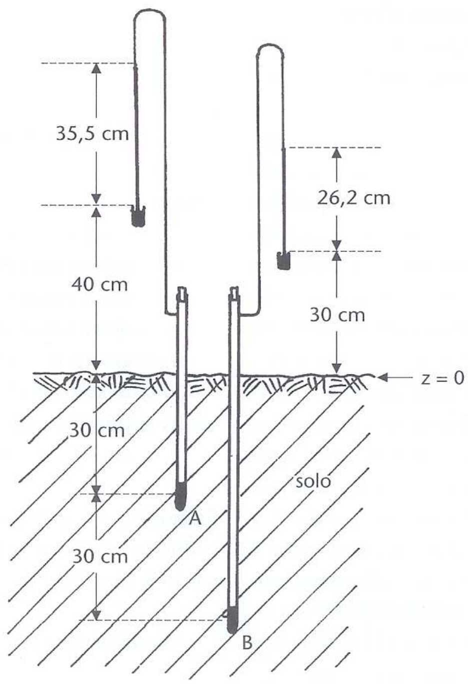
Spheres of influence in soil and water.

Matric soil water potential

Soil water retention curve

Tensiometers




35,5 cm
26,2 cm
40 cm
30 cm
z = 0
30 cm
solo
A
30 cm
B