Performance of the Arya and Paris water retention model with the UNSODA database

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Introduction

- Determination of soil water retention data (h vs θ) is time consuming
- Models to estimate h vs θ from simple taxonomic data:
  - Pedotransfer functions – PTF
  - Artificial Neural Network
  - Similarity between particle size distribution (PSD) and SWRC (ex: Arya & Paris model)

Objectives

- Develop a software for determination of soil water retention data from particle size distribution using the Arya and Paris (A&P) model.
- Apply the A&P model for the UNSODA database. Compare water content values predicted with the A&P model with measured values (laboratory and field data).
- Determine an scaling factor α for the A&P model for the UNSODA database

Materials and Methods

Unsoda database

Table 1. Limits and average values of some selected soil parameters of UNSODA database

	minimum	maximum	average	SD
ρ_{bulk} (Mgm^3)	0.170	2.10	1.50	0.20
$\rho_{particle}$ (Mgm^3)	1.98	2.87	2.65	0.08
Clay (%)	0	65.0	18.2	14.5
Silt (%)	0	87.0	30.5	22.3
Sand (%)	0.50	100	50.3	29.9
Porosity (m^3 m^{-3})	0.175	0.915	0.473	0.108

Arya and Paris Model

$$h_i = \frac{2\sigma\cos\theta}{\rho_w g r_i}$$

σ (N m^{-1}) : surface tension
θ : contact angle
ρ_w (kg m^{-3}) :water density
g (m s^{-2}) acceleration of gravity
r_i (m) : porous radius.

$$\theta_i = \left(\frac{\rho_p - \rho_s}{\rho_p}\right)\sum_{j=1}^{j=i} w_j$$

i : fraction
ρ_p (kg m^{-3}) : soil particle density
ρ_p (kg m^{-3}) : soil density
w : soil mass fraction.

Arya and Paris Model - continuation

$$r_i = R_i\sqrt{4en_i^{1-\alpha}/6}$$

$$n_i = \frac{3w_i}{4\pi R_i^3 \rho_p}$$

$$e = \frac{\rho_p - \rho_s}{\rho_p}$$

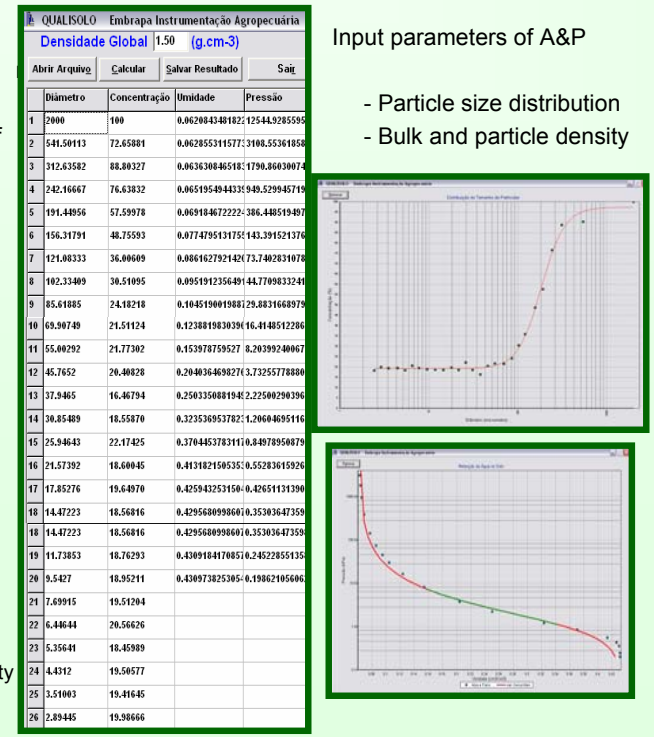
R_i : particle radius
n_i : number of particles
e : void ratio
α : fitting parameter

$$h = \frac{2\sigma\cos\theta}{\rho_w g R_i\left[\frac{4}{6}\left(\frac{\rho_p-\rho}{\rho_p}\right)\left(\frac{3w_i}{4\pi R_i^3\rho_p}\right)^{1-\alpha}\right]^{\frac{1}{2}}}$$

$$\theta_i = \left(\frac{\rho_p - \rho_s}{\rho_p}\right)\sum_{j=1}^{j=i} w_j$$

Results

- Software for prediction of SWR data from PSD (A&P model)



Input parameters of A&P

- Particle size distribution
- Bulk and particle density

Results

- Performance of A&P model with the UNSODA database

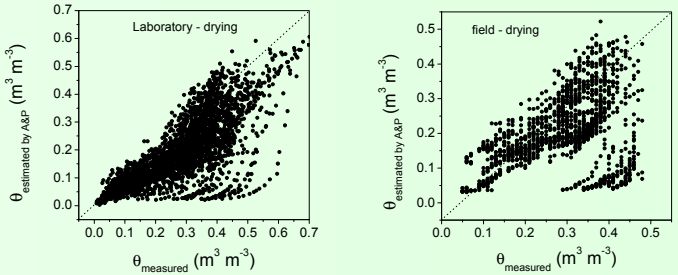


Figure 1. Soil water content predicted by A&P model and measured in the soil water retention data presented in UNSODA database.

RMSD of predicted θ (m³m⁻³)

- laboratory data (n=411): 0.100
- field data (n=107): 0.094

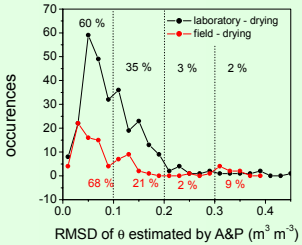


Figure 2. Frequency distribution of θ RMSD obtained with the A&P model in the UNSODA database. Percentages indicate amount of soils within that RMSD range

- Determination of α scaling factor for UNSODA database

Data set	type	α_{mode}	number of soils
Brazilian	laboratory-drying	1.02	110
UNSODA	laboratory-drying	1.17	411
	laboratory wetting	1.11	11
	Field-wetting	1.03	107
all		1.12	639

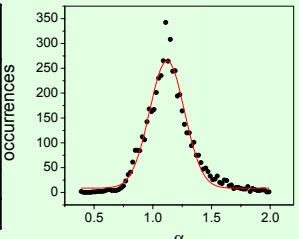


Figure 3. Frequency distribution of α values obtained with 639 soil from Brazilian and UNSODA database.

Conclusions

There was an average θ RMSD of 10 % in the determination of the retention data with the A&P model in the UNSODA database. However for a group of 247 soils (60%) the RMSD was 0.059 m³ m⁻³, that vas very close the data obtained by Vaz et al. 2005 SSSAJ v. 69, n. 3, 577-583 (RMSD of 0.062 m³m⁻³).

A group of 164 soils (40%) presented θ RMSD from 0.1 to 0.4 m³ m⁻³ indicating problems with the A&P model for some specific group of soils or inconsistencies in the PSD and/or SWR data.