ESTIMATION OF SOIL HYDRAULIC PARAMETERS WITH THE HELP OF ROSETTA PROGRAM

Adriana Nicoleta UNGURAŞU[1], Florentina Daniela ANEI[1], Florian STĂTESCU[1]

e-mail: ungurasuadriana@gmail.com

Abstract

Soil hydraulic parameters are necessary for many studies but, most of the time they cannot be measured because of the practice and financial restraints. A wide range of methods exists currently for measuring soil hydraulic parameters. Using mathematics models to solve problems that involves transport and flow processes it became very important. Soil hydraulic functions can be directly measured, or they can be estimated indirectly more easier using soil data, such as texture and bulk density. This methods have an important role in understanding transport processes happening in soils. Models of this kind can be named pedotransfer functions. This pedotransfer functions have been developed over time. Pedotransfer functions estimates indirectly some soil attributes and they are known from the beginning of modern soil science. By applying this we can conclude some of the soil properties based on some other properties, more easily to find and with lower costs. Rosetta program can estimate many properties as: water retention parameters according to van Genuchten(1980), saturated hydraulic conductivity and unsaturated hydraulic conductivity parameters according to van Genuchten (1980) and Mualem (1976). Rosetta have five pedotransfer functions that allows us to predict hydraulic properties. The hierarchical approach has a great importance because it permits optimal use of available input data. In this context, this paper presents some characteristics of the program. Also the program Rosetta is used to determine hydraulic properties for one type of soil. This properties were used later in a modeling program.

Key words: program, hydraulic parameters, pedotransfer functions, mathematical model, van Genuchten, Mualem

INTRODUCTION

Soil texture and soil structure influence a lot water infiltration, permeability and water retention in soil. Soil porosity refers to the space between soil particles and it consists from different amounts of air and water. Porosity depends on soil structure and also on soil texture. Water can be hold better in the smaller pores than the bigger ones, that's why sandy soils can hold bigger amounts of water than coarse soils. Water infiltration is defined as the movement of the water from the surface of soil. Texture, structure and soil slope have a great impact on the rate of water infiltration. Due to gravity, water moves soil pores and thus soil particle size and their space determines how much water can flow into the ground. Pores space from soil surface increases water infiltration rate.

The movement of air and water in soil is very important because it affect the air supply needed for the roots and the nutrients available for plant uptake.

The traditional approach to modeling phenomena that occur in soil pores (gas diffusion and water transport) was considering soil as a continuous medium. To see how porosity affects air and water regime in the soil I used Mohid Studio software. To use this software I needed soil hydraulic parameters. To determine these parameters we used Rosetta program.

Rosetta is a program that estimates unsaturated hydraulic properties, from surrogate soil data such as: soil texture and bulk density. This kind of models can be named pedotransfer functions because they can transform soil basic data in hydraulic properties. Rosetta can be used for determining the following :

- Water retention parameters according to van Genuchten (1980);
- Saturated hydraulic conductivity;
- Unsaturated hydraulic conductivity parameters according to van Genuchten (1980) and Mualem (1976).

MATERIALS AND METHODS

[1] Gheorghe Asachi" Technical University of Iasi

Rosetta is a windows 95/98/XP program. It is also based on Acces-97 database tables which allow efficient handling and lookup of small and large volumes of data. Rosetta estimates unsaturated hydraulic properties for soils. In this program are 5 pedotransfer functions that are used to predict the hydraulic properties with sets of input data. Data can be either manually entered or can be read from ASCII files. After hydraulic properties are estimated we can transfer the data in ASCII files and we can use it in other programs.

Rosetta offers a hierarchical approach and it has great practical value because it permits optimal use of available data. The models use the following hierarchical sequence of input data:

- Soil textural class;
- Sand, silt and clay percentages;
- Sand, silt and clay percentages and bulk density;
- Sand, silt and clay percentages and bulk density and a water retention point at 330 cm (33 kPa);
- Sand, silt and clay percentages, bulk density and water retention points at 330 and 15000 cm (33 and 1500 kPa).

The first model is based on a lookup table. This provide class average hydraulic parameters for each USDA soil textural class. The others models are based on neural network analyses and provide more accurate predictions when more input variables are used. (www.cals.arizona.edu/research/rosetta/download/rosetta.pdf)

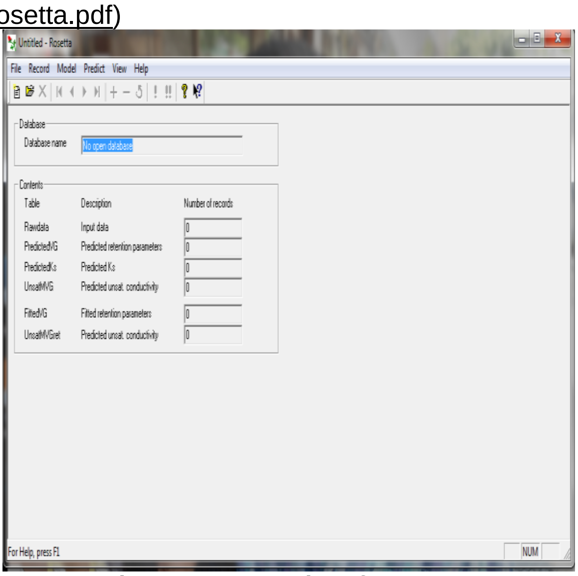

Figure 1. Rosetta interface

Rosetta hydraulic functions

Rosetta is capable to predict van genuchten (1980) unsaturated hydraulic conductivity and water retention parameters, as well as of providing estimates of the saturated hydraulic conductivity, ks. van genuchten water retention function is given by:

$$\theta(h) = \theta_r + \frac{\theta_s - \theta_r}{[1+(\alpha h)^n]^{1-1/n}} \quad (1)$$

θ(h) = water retention curve defining the water content (cm3/cm3);
h = soil water pressure head (cm);
θr,θs = residual and saturated water contents (cm3/cm3);
α, n = curve shape parameters.

If we want to obtain the relative saturation S_e we write the equation:

$$S_e = \frac{\theta(h) - \theta_r}{\theta_s - \theta_r} = [1+(\alpha h)^n]^{1/n-1} \quad (2)$$

If we use this equation and we combine with the pore-size distribution model by Mualem (1976) we can obtain the van Genuchten – Mualem (van Genuchten, 1980)

$$K(S_e) = K_o S_e^L \{1 - [1 - S_e^{\frac{n}{n-1}}]^{1-\frac{1}{n}}\}^2 \quad (3)$$

L(-) = empirical pore tortuosity/connectivity parameter (is assumed to be 0.5 by Mualem, 1976) L in most cases is negative. (Schaap and Leij, 1999).

RESULTS AND DISCUSSION

We used data from a gleyed cambic chernozem from Podu-Iloaiei , Iasi county. In general, this type of soil are more compacted especially in the fourth horizon, so the bulk density in the first 3 horizons was between 1,28 – 1,36 g/cm3, and in the fourth horizon was between 1,48 and 1,52 g/cm3. Total porosity presents higher values on surface (49-56%) and lower values in depth (43 - 46%). We also use the percentage of clay, silt and sand of this type of soil:

Tabel 1

Soil texture from Podu-Iloaiei

Sand (%)	Silt (%)	Clay (%)
29.8	27.8	42.4
36.2	24	39.8
40.1	28.3	31.6
48.6	27.6	23.8

We put soil data (texture and bulk density) in Rosetta program and the program generate the following results:

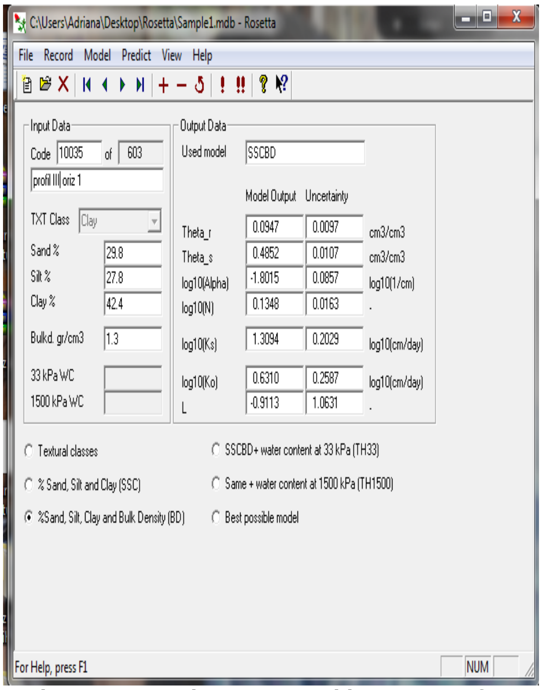

Figure 2. Results generated by Rosetta for first horizon

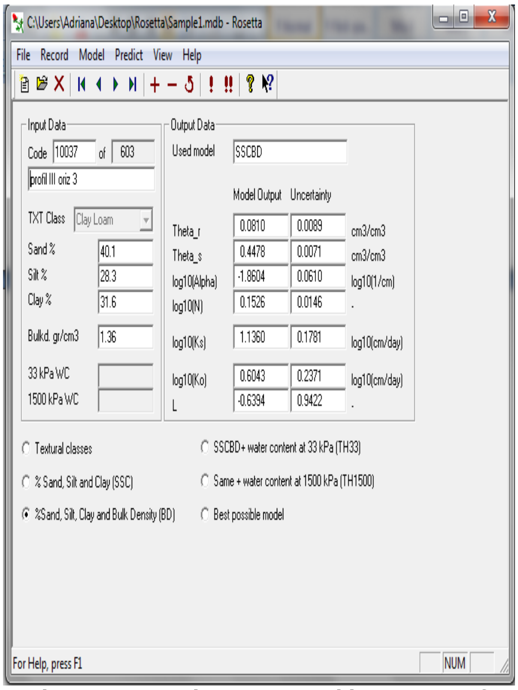

Figure 4. Results generated by Rosetta for third horizon

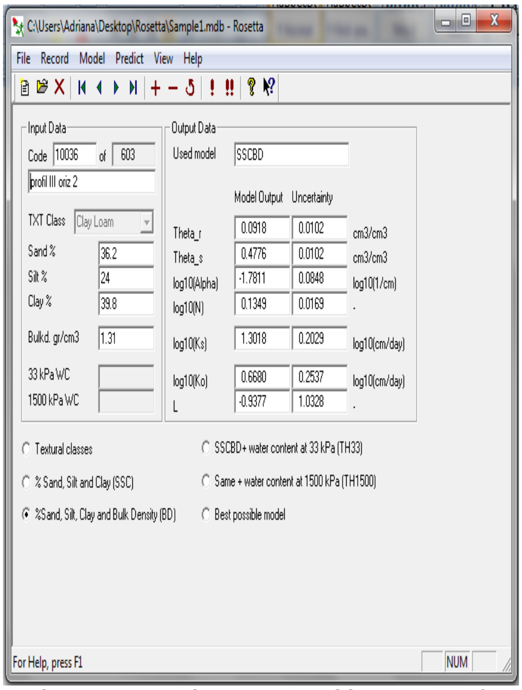

Figure 3. Results generated by Rosetta for second horizon

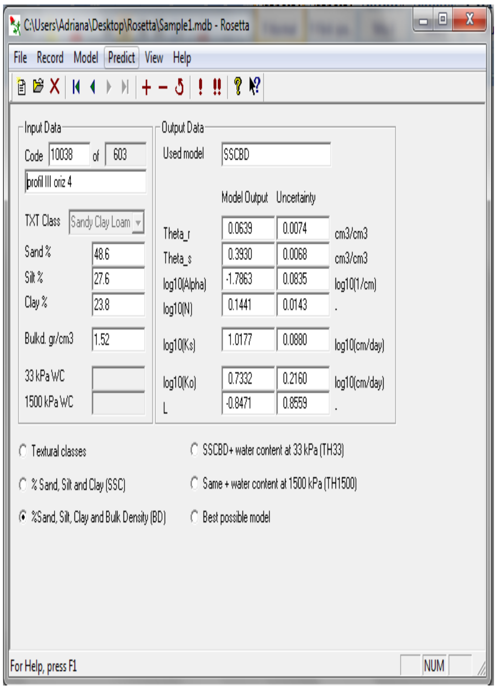

Figure 5. Results generated by Rosetta for fourth horizon

CONCLUSION

All estimated hydraulic parameters are accompanied by uncertainty estimates that permit an assessment of the reliability of Rosetta's prediction. We used Rosetta program for the 4 horizons of our type of soil and we put the results in another program that helped us to simulate how porosity influence the air and water regime in soils. The program it was easy to use and help us a lot, because we saved a lot of time and, Rosetta also can lead to better estimates of the van Genuchten parameters than the other methods presented in literature.

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