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OPTIMIZING THE INPUT OF "ROSETTA"PROGRAM TO PREDICT THE HYDRAULIC PARAMETERS OF SOME SOILS IN EGYPT.

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ABSTRACT

Rosetta program follows a hierarchical approach to estimate the hydraulic parameters of soils using five levels of input data. The first level consists of a look up table containing the average hydraulic parameters for each soil textural class, but this level is avoided because its low accuracy. The other four levels are based on neural network analysis. These levels were used to predict soil hydraulic parameters and water retention of different soil samples.

Generally, the sensitivity analysis (MSE) showed that soil particle size distribution had a major influence on the shape of water retention curve, while bulk density, soil water content at both 33kPa and 1500 kPa had increased the accuracy of the program. These increments of accuracy were differ from soil sample to another. In some cases, particle size distribution was enough to significantly predict soil water retention and more precise than in the case of adding the other parameters, such as soil bulk density or soil water contents at both 33 kPa and 1500 kPa pressure head to the used program as input parameters.

Keywords : Rosetta program , Hydraulic parameter , Soil water retention

INTRODUCTION

Predicting some soil hydraulic parameters and water retention values from information embedded in basic soil physical properties has attracted considerable attention. Tietje and Tapkenhinrichs (1993), classified predictive models into “point regression methods”, “functional parameter regression methods” and “physical model methods”. Point regression methods are the most empirical and predict water contents at fixed points in water retention curve using multiple linear regression, Rawls *et al.* (1991). Functional parameter regression methods which predict the parameters of water retention curve, were proposed by Brooks and Corey (1964), Campbell (1974), and van Genuchten (1980), and used in the works of Vereecken *et al.,* (1992), and Wosten *et al.,*(1995). Physical model methods are often referred to as semiphysical models because, they use the shape similarity between pore-size and particle size distributions, and also because they require empirical parameters, Haverkamp and Parlange (1986) and Rieu and Sposits (1991). “Rasetta”program implements pedotransfer functions that use the widely available basic soil data, e.g., texture, particle size distribution, bulk density, etc as input. Generally, the use of more input data often leads to better predictions, Schaap *et al.,* (1998). “Rosetta” program follows a hierarchical approach to estimate water retention values using limited or more extended sets of input data**.** The hierarchical approach is reflected in five models, the simplest one consists of a look up table for average hydraulic parameters for each soil textural class while , the other four models are based on neural network analysis**,** Schaap *et al.,* (1998).

The objective of this work is to define the proper model based on neural network analysis for predicting water retention curve and hydraulic parameters using easily measured soil properties of some soils in Egypt. This work aims also to estimate van Genuchten parameters using hierarchical approach for the abovementioned soil samples.

MATERIAL AND METHODS

Eight soil samples differ in their physical and chemical properties were selected to represent some soils in Egypt. Soil chemical and physical properties were determined according to the standard methods, Page (1982), and Klute (1986), Table (1). Water retention curves of the studied samples were obtained by subjecting the saturated soil samples to different pressure values,i.e., 10, 60, 100, 330, 500, 1000, 3000, 5000, 10000 and 15000 cm. Water retention data for each soil sample were fitted to the van Genuchten (1980), equation ; $\theta (h)= \theta r + [(\theta s - \theta r) / \{1 + (\alpha h)^{n}\}^{m}]$, using four levels of "Rosetta" program where, θs and θr are the saturated and residual water contents, respectively; α (cm^{-1}), m and n are the curve shape parameters, according van Genuchten Model (1980), where m = 1 - (1 / n). Fitting was carried out with the simplex or amoebae algorithm (Press *et al.,* 1988), with the following constraints: $0.0 \leq \theta r \leq 0.3$ $cm^3. cm^{-3}$, $0.6\ \Phi \leq \theta s \leq \Phi$ $cm^3. cm^{-3}$ (where Φ is the total porosity), $0.0001 \leq \alpha \leq 1$ cm^{-1}, and $1.001 \leq n \leq 10$. The parameters α and n were then log – transformed to obtain approximately normal distribution. The obtained parameters, using different levels of Rosetta program, for the studied soil samples are presented in Table (2).

To evaluate the use of the selected four levels of Rosetta program in predicting soil hydraulic parameters and water retention curve, the predicted values under each level of Rosetta were compared with the observed ones using mean-squared error (MSE). The MSE was obtained by converting the predicted parameters to water contents at the appropriate pressure heads and calculate the value of MSE as follow:

$$\mathbf{MSE = 1/n \sum_{j=i} (x_i - y_i)^2}$$

Where:

n…………number of the obtained points.
$\mathbf{x_i}$ ………..observed value.
$\mathbf{y_i}$ ………..estimated value.

RESULTS AND DISCUSSION

Table (2) shows the output parameters at four levels of Rosetta program of the studied soil samples. Generally, the noticeable variations between the values of Rosetta output parameters were negligible between

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the first, second and third levels, while these variations are relatively high between the aforementioned levels and the fourth one. Figs (1 up to 8) show the water retention curves which estimated by using different levels of “Rosetta program”and the observed ones. All predicted data were fitted well with the observed data of soil water retention, especially at the third and fourth levels of “Rosetta “ program . Table (3) shows the mean – squared error (MSE) among the observed data of water retention and the estimated ones at different levels of “Rosetta program”.

Table (3) confirms that, the use of more input parameters often leads to better prediction .Because, in general, MSE values took a descending order with the increase of input parameters except for Menof soil sample especially from 10 through 1000 cm pressure head , Fig (8). This may be due to the deviation in water behaviour under low values of pressure head in the soils of high swelling index . So, soil water content at both 33 and 1500 kPa cause a slight change in the shape of water retention curve which increases the value of mean–squared error. This suppose is confirmed by noting that “ Tortuosity / connectivity “ parameter tooks a lowest value by adding soil water content at 33 kPa and / or 1500 kPa pressure head to the input parameters in the case of Menof soil samples , Table (2) .

The decreament of “ Tortuosity / connectivity “ parameter means an increament in length and curvatures of water passway through the soil . Table (2) shows also that , the values of α (1/cm) – which equal the inverse of air entry suction - become low one when the values of soi water content at 33 and / or 1500 k Pa pressure head were added to the input of Rosetta program in the case of Menof soil sample.This findings indicate to notciable changes in water behaviour and shape of water retention curve under this conditions, Fig. (8) .

Finally Table (3) indicates that, particle size distribution may be individually used in “Rosetta” program to predict the hydraulic parameters through the obtained water retention curves of the studied soil samples. Adding another input parameters e.g. bulk density, theta at 33 kPa and theta at 1500 kPa pressure heads generally leads to increase the efficiency of prediction. So, “Rosetta” program can be used to obtain the hydraulic parameters with particle size distribution data as a sole input with a sufficient precesion.

Generally , all of the values of mean – squared residual error are unsignificant which means,that all of Rosetta levels are quite enough to predict the values of hydraulic parameters and water retention in these soil samples.

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fig 1+2

fig 3+4

fig 5+6

fig 7+8

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تحديـد أمثـل المـدخلات لبرنــامج "روزيتــا" للتنبـؤ بالمعـايير الـهيدروليكيــة لــبعض الأراضى فى مصر

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برنـامج روزيتـا يتبـع التسلسل الهرمـى فـى تقـدير المعـايير الهيدروليكيـة مسـتخدما خمـس مستويات من المدخلات. يستخدم المستوى الأول جدول يمثل متوسط قيم المعـايير الهيدروليكيـة فـى كـل قـوام تربـة وذلـك لإستنتاج المعـايير الهيدروليكيـة للتربـة بإسـتعمال رتبـة القـوام كمـدخل وحيـد للبرنامج. وهذا المستوى لم يتبع فى الدراسة لإنخفاض دقته. تم إختبار إستعمال neural network analysis للتنبـؤ بإحتجـاز الميـاه فـى التربـة و منحنـى الشـد الرطـوبى تحـت المسـتويات الأربعـة الأخرى من "روزيتا" لثمانى عينات مختلفة من الأراضـى.

أظهر تحليل حساسية النتائج أن للتوزيع الحجمى لحبيبات التربة التأثير الكبير على شكل منحنى الشد الرطوبى بينما أدت إضافة بيانات الكثافة الظاهرية أو نسبة الرطوبة عند كل من 33 و 1500 كيلـو باسكال إلـى زيـادة دقـة البرنـامج فـى إستنتاج المعـايير الهيدروليكيـة للتربـة. ولكـن هـذه الزيادة فى الدقة إختلفت من تربـة إلـى أخرى. وفـى بعض الحـالات كـان التوزيـع الحجمـى لحبيبـات التربة كافيا ومعنويا للتنبؤ بإحتجـاز المـاء بالتربـة و منحنـى الشد الرطـوبى وأكثـر دقـة ممـا فـى حالـة إضافة عامل أخر مثل نسبة الرطوبة عند 33 أو 1500 كيلو باسكال للبرنامج كمـدخلات. وبالتـالى يمكـن الإعتمـاد علـى نتـائج التوزيـع الحجمـى لحبيبـات التربـة كمـدخل وحيـد لبرنـامج روزيتـا للتنبـؤ بالمعـايير الهيدروليكيـة للتربـة ومـن ثـم منحنـى الشـد الرطـوبى تحـت ظـروف عينـات التربـة تحـت الدراسة.