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USING ROSETTA PROGRAM IN DETERMINING HYDRAULIC PROPERTIES OF THREE DIFFERENT MOUNTAINOUS TEXTURED SOILS UNDER SEMIARID CONDITIONS OF DUHOK IRAQI – KURDISTAN

AKRAM ABBAS KHALAF
Dept. of Soil & Water Sciences, College of Agricultural Engineering Sciences, University of Dohuk, Kurdistan Region-Iraq

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ABSTRACT

This study was carried out in three mountainous different soil textures and two depths. Field measurements of soil texture and bulk density, and laboratory measurements of soil water retention at field capacity (–33 kPa) and permanent wilting point (–1500 kPa), were taken to implement Rosetta. Calculated values of van Genuchten parameters were then compared to measured values. Results showed that Rosetta could be used to obtain values of van Genuchten parameters for a field with different soil textures. The determination coefficient (R^2) of It showsthat 50% of determination coefficients(R^2) gave more than 0.99 and 30% gave more than 0.98 and the others gave between (0.91-0.97) at applying the (PTFs) at two depths for the studied soils. The Root Mean Square Difference (RMSD) indicated that the lowest values of RMSE were exhibit by all soils (Zawita, Swaratoka and Koradare) and two depths D1 and D2 except D1 of Swaratoka Clay loam soil and at different textures.NSE elevation indicator revealed that the maximum values more than (0.99) were found in Zawita loamy soil and at depth two, D2 whereas the minimum values were noticed in Koradare Silty Loam and at depth two,D2. We conclude that Rosetta is a tool that can be used to calculate van Genuchten parameters the absence of measured values, for the studied soils(Zawita, Swaratoka and Koradare) Rosetta Levels yielded the best results as following: Level 5 gave highest (R^2) at applying in (Zawita,D1-Swaratuka and KoradareD2), lowest RMSE and maximum in (Koradare,D2) using the measured input data and thus calculated values ofvan Genuchten parameters can be used as input in simulation models.

***KEYWORDS*:** Rosetta; van Genuchten parameter; Pedotransfer Function

INTRODUCTION

Soil hydraulic properties play an important role in modeling water and solute movement within the vadose zone of soils. Direct measurement of hydraulic parameters at a wide range of scales involves considerable time, labor, and money. Pedotransfer functions (PTF) may provide an alternative way of estimating these parameters indirectly from easy-to-measure soil properties. (YunqiangWang, et al ,2012)

Soil saturated hydraulic conductivity (K_S) is one of the most important hydraulic parameters for simulating water movement and solute transportation across soil profile, which is a highly variable in space. The changes in soil and vegetation properties induced by vegetation restoration (converting the steep farmland to woodland, shrub land, or grassland via artificial vegetation or natural succession) likely affect K_S greatly(Pingzong Zhu et al,2022)

The soil water characteristic curve is an important soil hydraulic property that governs soil water storage, availability, and has potential influences of hydrological and ecological processes in whole ecosystems. (Springer Nature Switzerland AG. 2021)

In arid regions, the rational management of available scare water resources depends mainly on soil hydraulic properties (i.e., water retentionand hydraulic conductivity). knowledge of soil water content at field capacity (FC) and permanent wilting point (PWP) are very important parameters in biophysical modelling. However, direct measurement of these parameters are time consuming and expensive Soil moisture plays a key role in the Earth’s hydrological cycle and meteorological and climatic processes. The information on soil moisture content is required for irrigation scheduling, crop yield prediction, studies on weather and climate change, monitoring and forecasting extreme weather events like floods

akram.khalaf@uod.ac

and drought, and estimation of runoff and soil erosion
(ABDELHAFID, Youcef,2021)

The soil water retention curve (SWRC) is one of the principal soil hydraulic properties that is needed as input data in modeling water and solute transport through unsaturated soils. Field or laboratory measurement of SWRC is labor-intensive, expensive and time-consuming. Pedotransfer functions (PTFs) have been developed as an indirect method to predict soil hydraulic properties (*e.g.* SWRC) from more easily measured soil data (M. Rastgou et al,2021)

Current pedotransfer functions (PTFs) for estimating soil hydraulic curves are mostly developed to predict parameters of the Mualem-van Genuchten hydraulic functions. The Mualem-van Genuchten functions are recognised to be inadequate in representing soil water retention hydraulic conductivity curves at low pressure head ranges (Rudiyanto et al,2021)

Simulation models are tools that can be used to explore, for example, effects of cultural practices on soil erosion and irrigation on crop yield. However, often these models require many soils related input data of which are van Genuchten parameters which are (θs, θr,α, n and m). These data are usually not available and experimental determination is both expensive and time consuming. Therefore, pedotransfer functions are often used, which make use of simple and often readily available soil information to calculate required input values for models, such as soil hydraulic values. Our objective was to evaluate the Rosetta pedotransfer function to calculate van Genuchten parameter which are (θs, θr,α, n and m)

The forests soils of Iraqi- Kurdistan region is included different types of immature soils which could be represented partially bythe following studied soils which are Zaweta, Swaratoka and Koradare.

Hydraulic properties are the key parameters in any quantitative description of water flow into and through the unsaturated soil layers. Van Genuchten etal. (1992) used the theoretical methods for predicting unsaturated soil hydraulic conductivity in which the more easily measured soil properties and water retention data. These methods are, based on statistical pore size distribution, Mualem (1976).

Rosetta is a computer program used for analyzing soil retention functions of unsaturated soils (van Genuchten et al.1992).

The purpose of this work is to estimate the soil hydraulic parameters of the studied soils from easily measured soil properties by using high precision computer program.

Materials and Methods:

Surface and subsurface of three different mountains soils which are Zaweta, Swaratoka and Koradare were selected to represent three texture classes in Duhok semiarid of Iraqi-Kurdistan region.

Some physical properties of the investigated soils samples were determined according to standard method described by Klute (1986) and presented in Table (1).

Study Area:

The study area is in the region known as Iraqi Kurdistan Region (IKR) at Duhok governorate and the locations of investigated soils hold names of three small villages Zawita, Swaratoka and Koradare. The coordinates are 36°54 237 N; 43 8 29 E; and an elevation of 878 m above sea level for Zawita; 37 0 44N; 43 13 49 E and elevation of 1343m for Swaratoka; 36 52 21N; 43 10 42E and elevation 666m for Koradare with a semi-arid climate. The soils of investigation region lying on mountains with different steep slopes as cleared in Fig. (1) and has an average slope of 5-10%, although parts of the field have slopes more than 5%. In this region, the Sampling sites in Geographic coordinates systems are demonstrated in table (1).

akram.khalaf@uod.ac

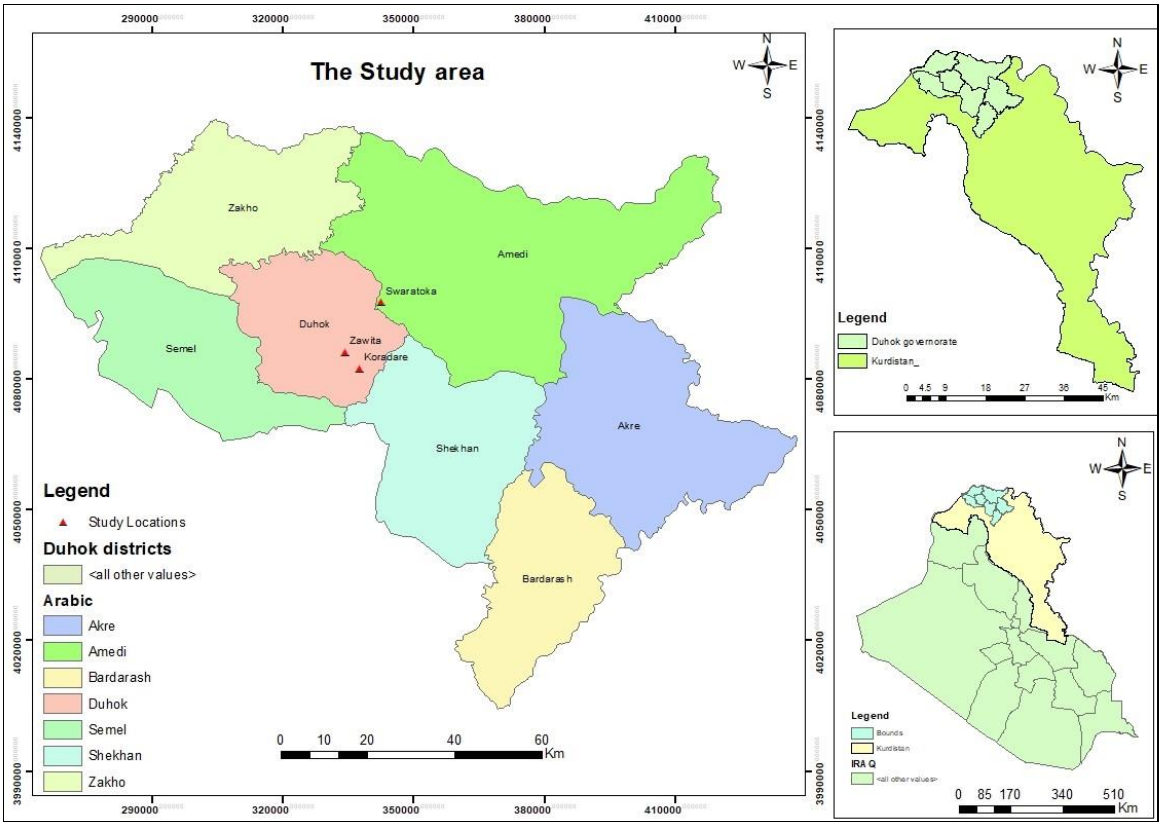


Fig.(1) :-Locations of study area of mountainous forest soils

Table (1):- Sampling sites in Geographic coordinate system

Location	Geographic system		Elevation	Slope
Soil	Latitude	Longitude	m	%
Zawita	36°54 237	43° 8 29	878	5-10
Swaratoka	37° 0 44	43° 13 49	1343	5-10
Koradare	36° 52 21	43° 10 42	666	5-10

Using hierarchical PTFs based on five levels of input dat. It is of great practical use, allowing flexibility for the user towards the required input data The first level (H1) consists of a lookup table that provides average parameters for each of the USDA textural classes.

The second level (H2) uses values from H1 plus sand, silt, and clay fractions as inputs, and provides a hydraulic parameter that varies continuously with texture. The third level (H3) includes the predictors used in level H2 and the soil dry-bulk density (ρd). The fourth level (H4) uses H3 and soil volumetric water content (θm) at a water suction of −33 kPa. The last level (H5) consists of all the other parameters, H4, plus the (€m) at a water suction of –1500 kPa.

While H1 is a simple table with average hydraulic parameters for each textural class, all other models involve a combination of neural networks and thebootstrap method The first model is based on a lookup table. This provides 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 the first model is based on a lookup table.

This provides class average hydraulic parameters for each USDA soil textural class. The other 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)

Soil Sampling

To determine the water retention curve, (6) disturbed soil samples were collected using a gouge auger; from two different depths depend on the nature of certain mountainously soils from the surface and subsurface the locations shown in Figure 2. Sampling was done on 15

akram.khalaf@uod.ac

July 2019. representative samples were taken at each depth of the three locations; to determine the textural classes, of taken samples were done by using hydrometer method for studied locations which were geo-referenced using a Global Positioning System (Model 4700 Dual Channel RTK system).

Rosetta Description

Rosetta is an algorithm that calculates soil water retention parameters, VG parameter (h), i.e., water retention [θ (h)], as well as the saturated and unsaturated hydraulic conductivity, are described with the well-known Mualem-Van Genuchten equation (Mualem,1976) and (van Genuchten,1980) and is given by:

$$\theta(h) = \theta_r + \frac{(\theta_s - \theta_r)}{\left[1+(\alpha \times h)^n\right]^m} \qquad (1)$$

where θ (h) is the soil volumetric water content ($m^3 \cdot m{-}3$) at suction h (cm).θs and θr are the saturated and the residual water content ($m^3 \cdot m^{-3}$) at h = 0 cm and −15,000 cm, respectively; α (> 0 in cm−1) is related to the inverse of the air entry suction; and n (> 1) is a measure of the pore-size distribution and m = 1 – 1/n.(In summary, the parameters calculated with the Rosetta PTF (Equations (1)-(4)) are: θr, θs, α,n and m.

Model Performance Evaluation

Calculated values of van Genuchten parameters obtained with Rosetta were compared to corresponding measured values and evaluated using two statistical parameters. The first parameter was Root Mean Squared Difference (RMSD) and the secondparameter was the Nash Sutcliffe Efficiency (NSE). The RMSD gives the mean difference between measured and calculated values ofparameters and is calculated as (Kobayashi, et al.,2000).

$$\text{RMSD} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - y_i)^2}$$

where xi is the measured value of VG1 parameter and yi is the corresponding calculated value of VG1 parameter obtained with Rosetta.

The NSE compares measured and calculated values of VG1 parameter and is given by (Moriasi, etal,2007).

$$\text{NSE} = 1 - \left[\frac{\sum_{i=1}^{n}(Y_i^m - Y_i^c)^2}{\sum_{i=1}^{n}(Y_i^m - Y_i^{\text{mean}})^2}\right] \qquad (3)$$

where

$yi^m$is measured value of VG parameters and $yi^c$is the corresponding calculated value of VGparameters, is the average of measured values of VG parameters and *n* is number of measurements. Values of NSE may range from −0 to 1. A value of NSE = 1, corresponds to a perfect match of calculated compared to the measured values of *K*. Conversely, an efficiency of 0 (NSE =0) indicates that the Rosetta calculations of a VG1 parameter are as accurate as the mean of the measured data; whereas, an efficiency <0 (NSE < 0) occurs when the measured mean is a better predictor than the model or, in other words, when the residual variance, described by the nominator in Equation (3), is larger than the data variance, described by the denominator (Moriasi, et al,2007).

Measurements

Textural Analysis. Clay, silt and sand fraction of all6-soil samples were determined using the hydrometermethod (Bouyoucos, 1962). This method uses the Navier-Stokes equationto

akram.khalaf@uod.ac

calculate soil particles in suspension in an infinitesoil column and is adequate for textural class identification but cannot be used to accurately define the particlesize (Klut,1986). Nevertheless, it provides a reasonable input to Rosetta (Schaap, et al,2001).

In Water Retention Determination,the relation betweensoil volumetric water content (θ) and water suction (h) atsaturation (h = 0) and field capacity (h = −33 kPa) wasmeasured using a sand/kaolin box (pF-Determination, Eijkelkamp, Giesbeek, The Netherlands).

RESULTS AND DISCUSSION

Measurements

There were five textural classes corresponding to the (6) layers where disturbed soil samples were taken (Table 2) and these are:2 clay loam, loam, clay, silty clay and silty loam. The total number of soil samples was six.

Table (2) :-some physical properties of two depths of studied soils

Soil Property	Zawita		Swaratoka		Koradare	
	L1	**L2**	**L1**	**L2**	**L1**	**L2**
Sand %	21.30	44.98	24.7	21.23	20.27	33.28
Silt %	42.80	34.3	35.3	36.53	39.5	52.34
Clay %	35.90	20.72	39.5	42.24	40.23	14.38
TXT Class	**clay loam**	**loam**	**clay loam**	**clay**	**silty clay**	**silty loam**
Bulk density(g/cc)	1.34	1.43	1.32	1.30	1.23	1.41
θ33 kpa (cm^3/cm^3)	0.373	0.277	0.382	0.40	0.395	0.277
θ1500 kpa(cm^3/cm^3)	0.222	0.137	0.279	0.25	0.243	0.104

"Rosetta program" was used to obtain the closed expressions of van Genuchten parameters from the values of particle size distribution, soil bulk density and soil water content on volume basis at 33 kpa and 1500 kpa, Schaap, et al (1998).

Table (3):- contains the output data of Rosetta program of surface and subsurface for each location soil samples.

Table (3):- the output data of Rosetta program of surface and sub-surface for each location soil samples.

Soil Property	Zaweta		Swaratoka		Koradare	
	l1	**l2**	**l1**	**l2**	**l1**	**l2**
Theta-r (θr)	0.0759	0.0474	0.0906	0.0592	0.1125	**0.0369**
Theta-s (θs)	0.4155	0.3449	0.4384	0.4078	0.4115	**0.3559**
log10 (Alpha)	-1.8280	-1.5676	-1.5116	-2.1977	-1.3177	**-2.3152**
log10(N)	**0.0788**	**0.1151**	0.0705	**0.0763**	**0.0797**	**0.1888**
log10(ks)	0.5466	1.0982	**0.6876**	-0.147	0.6383	**0.8579**
log10 (ko)	0.5568	1.0021	0.8294	0.1807	0.9157	**0.2619**
L	-2.1208	-1.6147	-4.0662	-1.0387	-4.1632	**0.345**

akram.khalaf@uod.ac

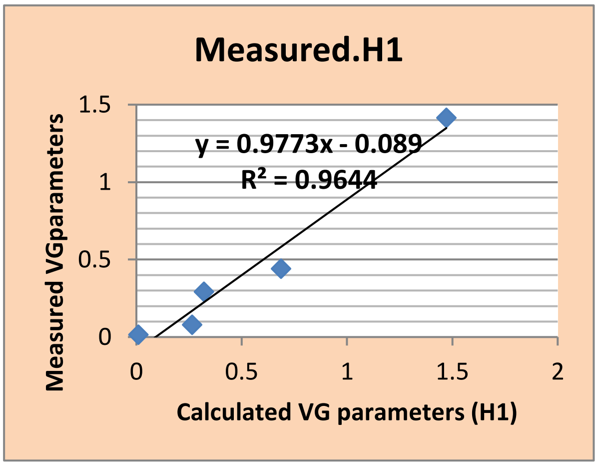
Table (4):- shows some hydraulic properties of studied soils.

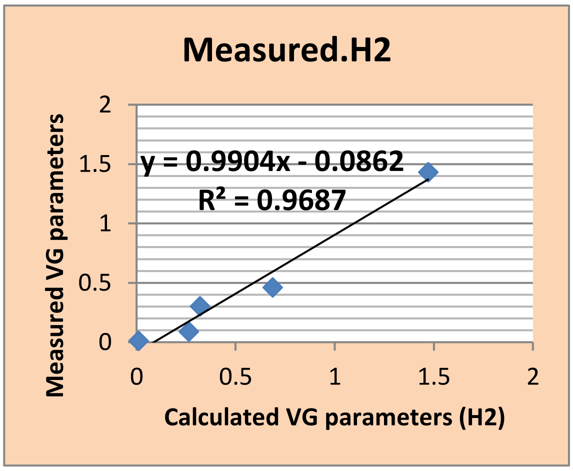
Location	Soil Depth (cm)	Hydraulic Properties 0	-33	-1500
Zawita		(kilopascal)kpa		
CL	L1	0.686	0.373	0.264
L	L2	0.376	0.277	0.123
Swaratoka				
CL	L1	0.6004	0.382	0.271
C	L2	0.6004	0.400	0.081
Koradare				
SiC	L1	0.6725	0.395	0.276
SiL	L2	0.7004	0.277	0.280

Table(5):- shows the calculated and measured values of VG parameters by using PTFs based on five levels of input data for Zawita Clay Loam soil,D1.

Zawita	Depth 1 Clay Loam					
Soil Property	H1 T.C	H2 % S,Si.C	H3 % + BD g/cc	H4 % + BD+ 33kpa	H5 % + BD + 33kpa +1500kpa	Measured
Theta-r (θr)	0.0792	0.0884	0.0892	0.088	0.0786	**0.2640**
Theta-s (θs)	0.4418	0.4619	0.4648	0.4673	0.4737	**0.6860**
Alpha (□)	0.0158	0.0105	0.0105	0.0075	0.0095	**0.0101**
(n)	1.4145	1.4318	1.4575	1.4162	1.3114	**1.4714**
(m)	0.2930	0.3015	0.3138	0.2938	0.2374	**0.3204**

- **Marks**:
  VG= van Genuchten model.
  H1= Soil catalog for initial estimate.
  H2= Neural network prediction.
  H3= H2+Bulk density in g/cc.
  H4=H3+Bulk density in g/cc.+ θm at 33 kpa.
  H5=H3+ Bulk density in g/cc.+ θm at 33 kpa.+θm at 1500 kpa.





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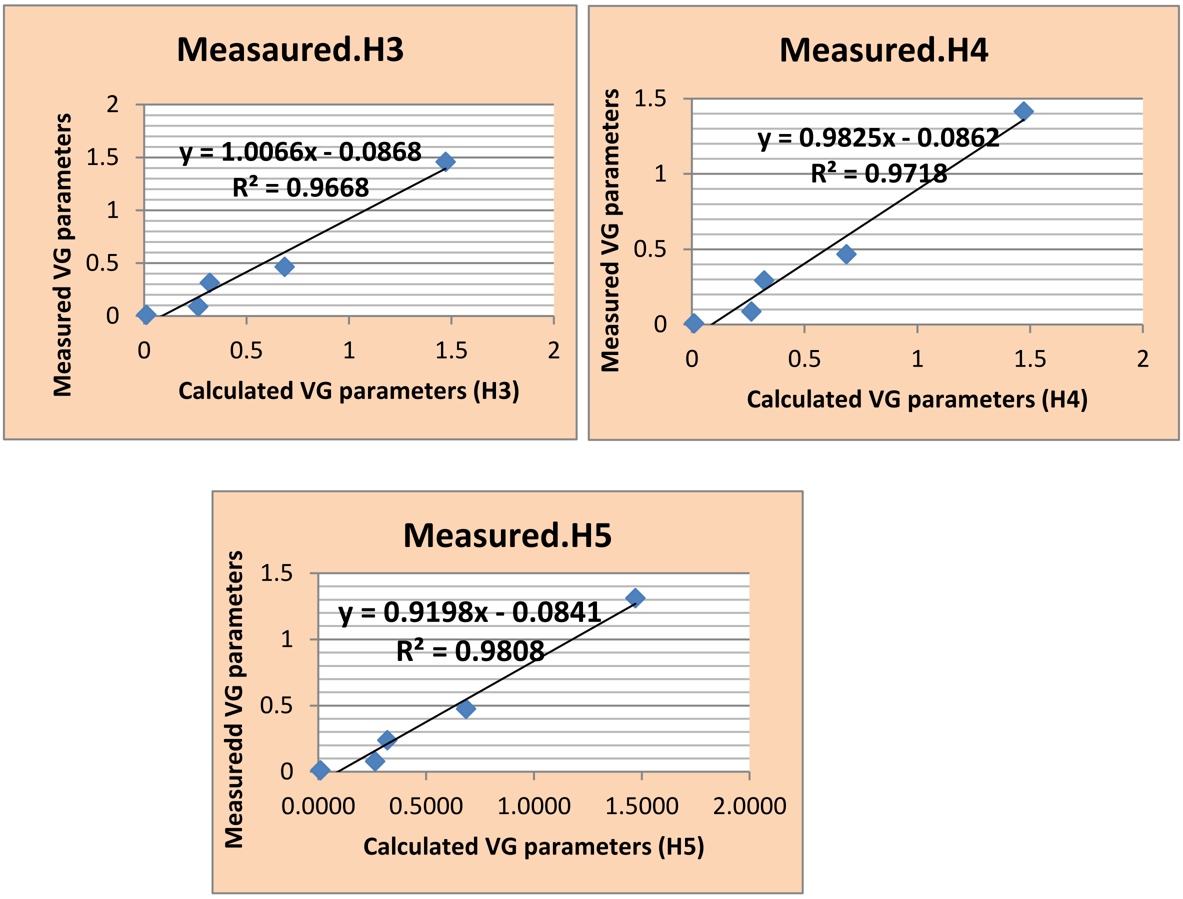


Fig. (2):- The relationships between measured and calculated VG parameters by using five pedotransfer for **Zawita, D1** soil

Fig.(2) illustrates the relationships between measured and calculated values by using hierarchical PTFs based on five levels of input data for Zawita,D1soil,that the all hierarchical PTFs performance very well for prediction through using coefficient of determination (R^2) as indicator for comparison, and also the five PETs gave high coefficient of determination for depth one, D1ofZawita Clay Loam soil and ranged between (0.9644,0.9687,0.9668,0.9718 and 0.9808) for PTFs (H1,H2,H3,H4 and H5) respectively and the best performance was for H5 and the others gave (R^2) more than 0.96.(Table 5).

Table (6):- van Genuchten parameter values depth two, D2 for Zawita loamy soil.

Zawita	Depth 2 Loam					
Soil Property	**H1**	**H2 %**	**H3 % +**	**H4 % +**	**H5 % + BD +**	**Measured**
	T.C	**S,Si.C**	**BD g/cc**	**BD+ 33kpa**	**33kpa +1500kpa**	
Theta-r (θr)	0.0609	0.0633	0.0626	0.0583	0.0497	**0.1230**
Theta-s (θs)	0.3971	0.4026	0.407	0.4186	0.4108	**0.3760**
Alpha (□)	0.0111	0.0136	0.0118	0.0123	0.0128	**0.0070**
(n)	1.4737	1.4423	1.4653	1.4096	1.3578	**1.4845**
(m)	0.3214	0.3066	0.3267	0.2905	0.2635	**0.3264**

The above table demonstrate the calculated VG parameters values applying by using five PTFs to measured values for depth two of Zawita loamy soil and best calculation were for(θs, n and m) compared to the measured values.

akram.khalaf@uod.ac

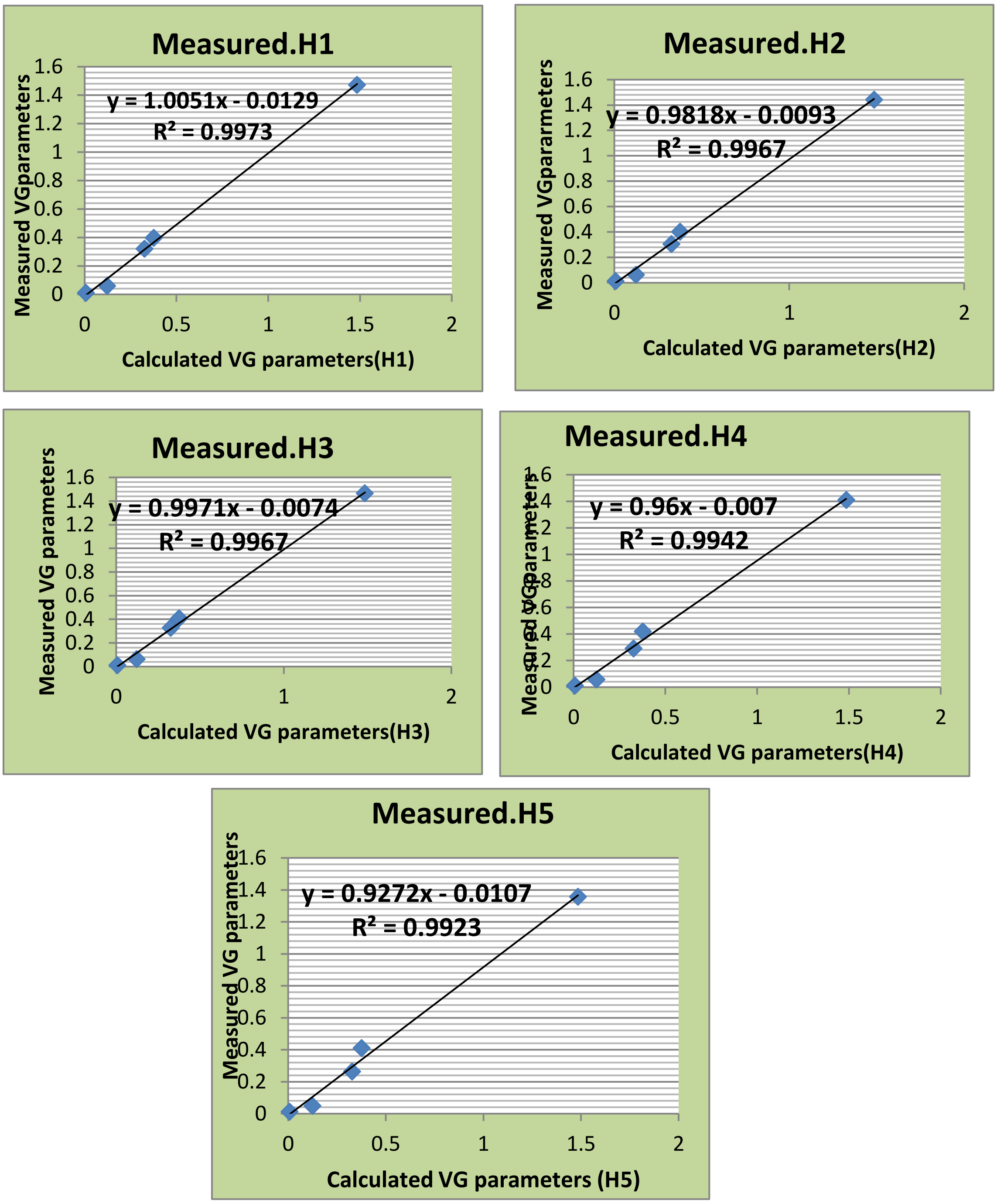


Fig. (3):- The relationships between measured and calculated VG parameters by using five pedotransfer for **Zawita, D2** soil

Fig.(3) revealed the relationships between measured and calculated values by using hierarchical PTFs based on five levels of input data for Zawita,D2 soil, that the all hierarchical PTFs performance were very well for prediction through using coefficient of determination (R^2) as indicator for comparison, and also the five PETs gave high coefficient of determination for depth one, D2 of Zawita Loamy soil and ranged between **(0.9973,0.9967,0.9967,0.9942 and 0.9923)** for PTFs (H1,H2,H3,H4 and H5) respectively and the best performance was for H1(0.9973)and the others gave (R^2) more than 0.99(Table 6).

Table (7):- shows van Genuchten parameter values depth one,D1 for Swaratoka Clay loam soil.

akram.khalaf@uod.ac

Swaratoka	Depth 1 Clay Loam					
Soil Property	**H1**	**H2 %**	**H3 % +**	**H4 % +**	**H5 % + BD +**	**Measured**
	T.C	**S,Si.C**	**BD g/cc**	**BD+ 33kpa**	**33kpa +1500kpa**	
Theta-r (θr)	0.0792	0.0892	0.0923	0.0895	0.081	**0.2760**
Theta-s (θs)	0.4418	0.4588	0.4757	0.4784	0.485	**0.6725**
Alpha (□)	0.0158	0.0133	0.0128	0.0095	0.0117	**0.0171**
(n)	1.4145	1.3652	1.4073	1.3462	1.2747	**2.1530**
(m)	0.2930	0.2675	0.2894	0.2571	0.2155	**0.3485**

The above table shows the VG parameters values calculated by using five PTFs and measured values for depth one, D1for Swaratoka Clay Loam soil and best calculation were for(α and m) compared to the measured values.

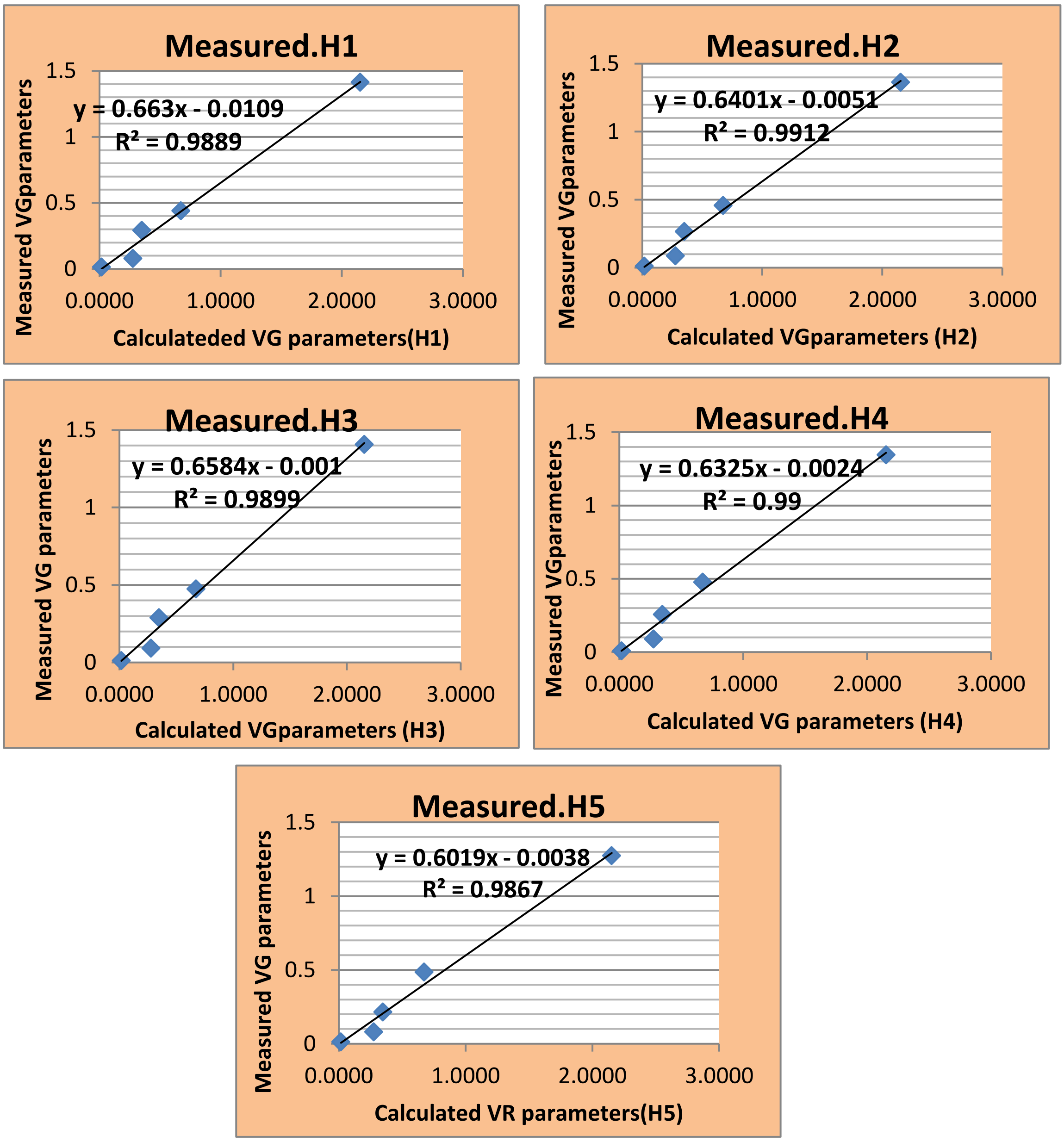


Fig. (4):- the relationships between measured and calculated VG parameters by using five pedotransfer for **Swaratoka, D1** soil

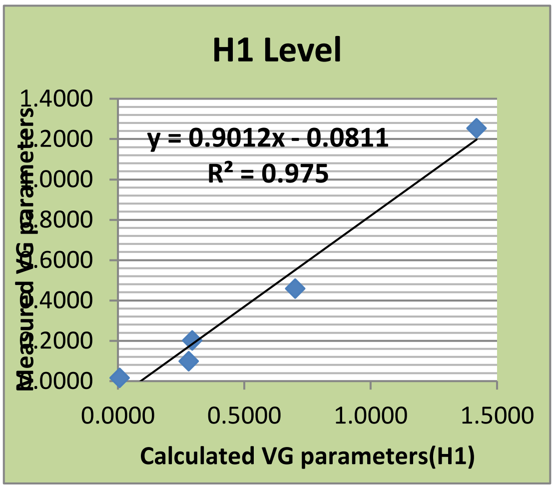
akram.khalaf@uod.ac

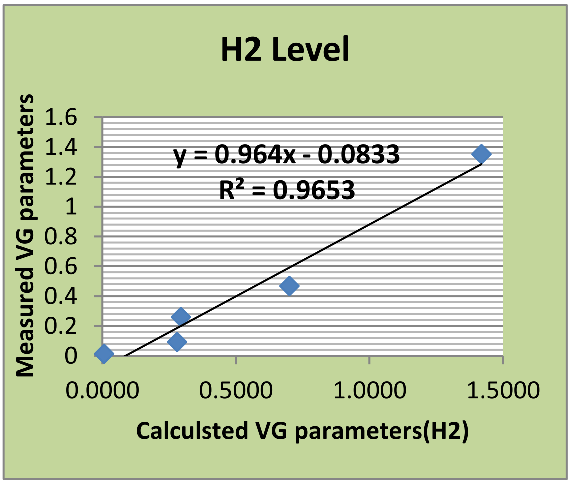
Fig.(4) revealed the relationships between measured and calculated values by using hierarchical PTFs based on five levels of input data for Swaratoka,D1soil,that the all hierarchical PTFs performance very well for prediction through using coefficient of determination (R^2) as indicator for comparison, and also the five PETs gave high coefficient of determination for depth one, D1 of Swaratoka Clay Loam soil and ranged between(0.9889,0.9912,0.9899,0.99 and 0.9867) for PTFs (H1,H2,H3,H4 and H5) respectively and the best performance was for H2(0.9912) and the others gave (R^2) more than 0.98(Table 7).

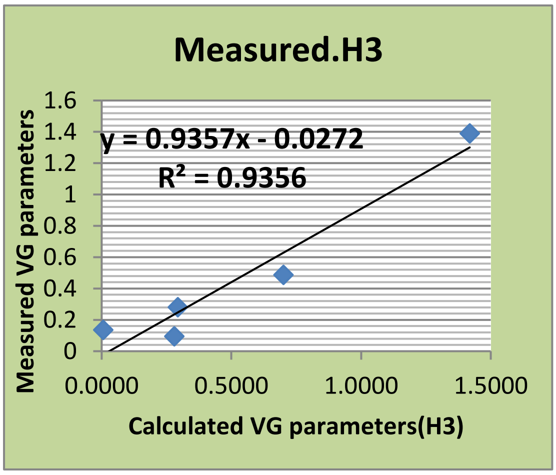
Table (8):- shows van Genuchten parameter values depthtwo,D2 for Swaratoka Clay soil.

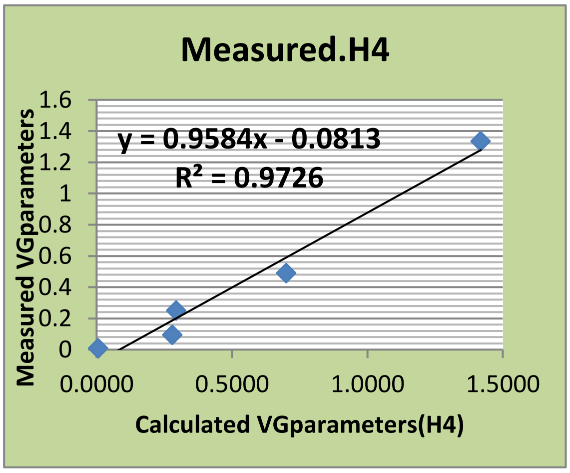
Swaratoka	Depth 2 Clay					
Soil Property	**H1**	**H2 %**	**H3 % +**	**H4 % +**	H5 % + BD +	**Measured**
	T.C	**S,Si.C**	**BD g/cc**	**BD+ 33kpa**	**33kpa +1500kpa**	
Theta-r (θr)	0.0982	0.0922	0.0954	0.094	0.0839	**0.2800**
Theta-s (θs)	0.4588	0.4687	0.4878	0.4912	0.4979	**0.7004**
Alpha (□)	0.0150	0.0135	0.136	0.0094	0.011	**0.0061**
(n)	1.2529	1.3513	1.3899	1.335	1.2675	**1.4190**
(m)	0.2018	0.2599	0.2805	0.2509	0.211	**0.2935**

The table (8) demonstrates the VG parameters values calculated by using five PTFs and measured vales for depth one,D1 for Swaratoka Clay soil and best calculation were for (n and m) compared to the measured values.









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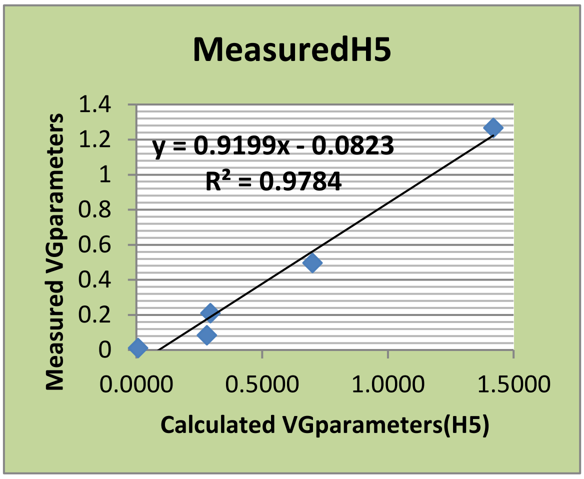


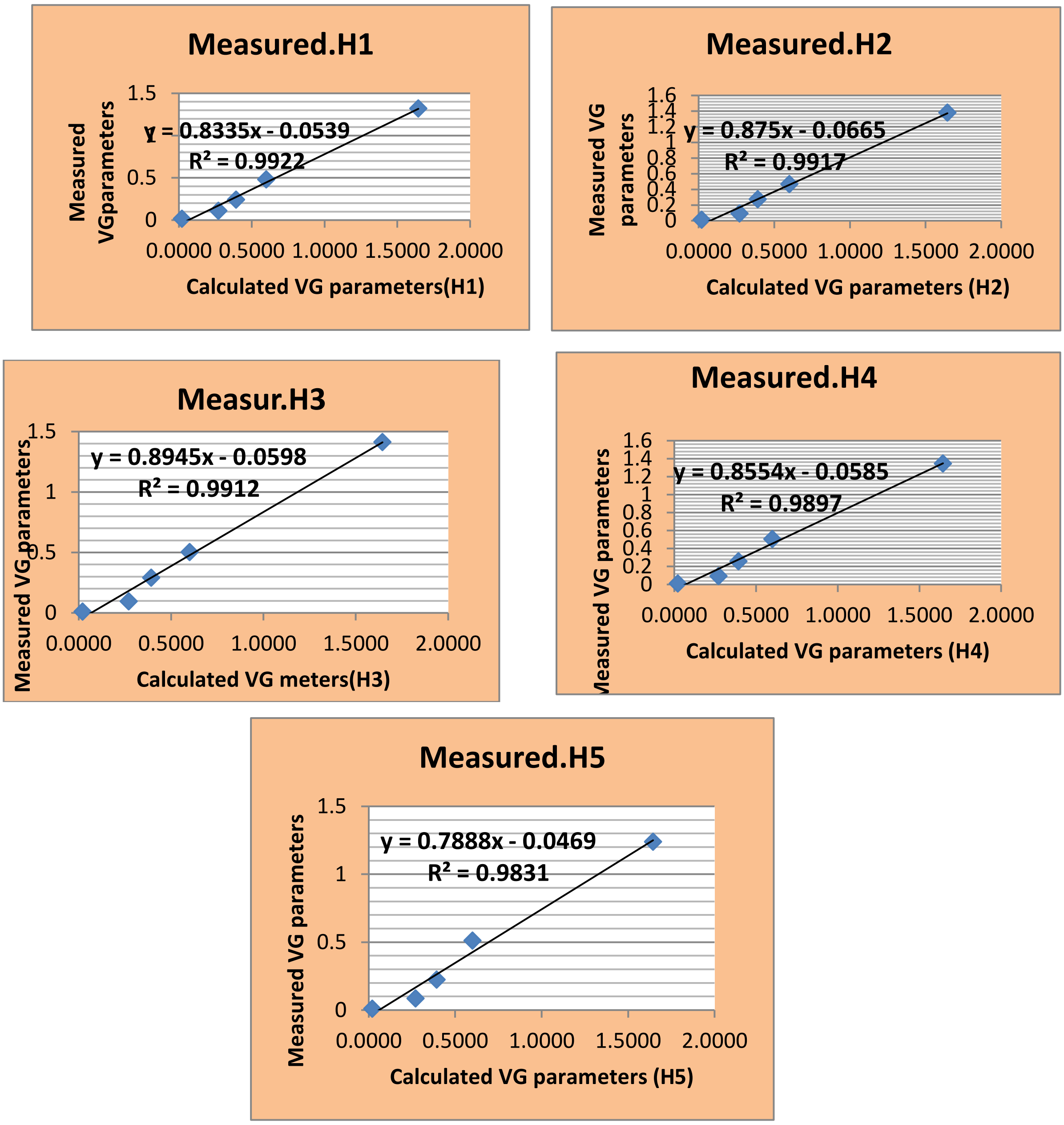
Fig. (5):- the relationships between measured and calculated VG parameters by using five pedotransfer for **Swaratoka, D2** soil

Fig.(5) illustrates the relationships between measured and calculated values by using hierarchical PTFs based on five levels of input data for Swaratoka,D2 soil ,that the all hierarchical PTFs performance very well for prediction through using coefficient of determination (R^2) as indicator for comparison, and also the five PETs gave high coefficient of determination for depth one, D1 of Swaratoka Clay soil and ranged between (0.975,0.9653,0.9356,0.9726 and 0.9784) for PTFs (H1,H2,H3,H4 and H5) respectively and the best performance was for H1 H5 (0.97845) and the others gave (R^2) more than 0.93(Table8).

Table (9) :-shows calculated and measured van Genuchten parameter values for Koradare Silty Clay soil depth one, D1.

Koradare	Depth 1 Silty Clay					
Soil Property	**H1**	**H2 %**	**H3 % +**	**H4 % +**	**H5 % + BD +**	**Measured**
	T.C	**S,Si.C**	**BD g/cc**	**BD+ 33kpa**	**33kpa +1500kpa**	
Theta-r (θr)	0.1108	0.0917	0.0959	0.0926	0.0867	**0.2710**
Theta-s (θs)	0.4808	0.469	0.5047	0.5053	0.5116	**0.6004**
Alpha (□)	0.0162	0.0123	0.0127	0.0098	0.0113	**0.0207**
(n)	1.3207	1.3811	1.4141	1.347	1.2407	**1.6444**
(m)	0.2428	0.2759	0.2928	0.2579	0.2252	**0.3919**

Table (9) demonstrates the VG parameters values calculated by using five PTFs and measured vales for depth one,D1 for Koradare Silty Clay soil and good calculation were for (α, n, and m) compared to the measured values



Fig(6):- the relationships between measured and calculated VG parameters by using five pedotransfer for **Koradare, D1** soil

Fig.(6) revealed the relationships between measured and calculated values by using hierarchical PTFs based on five levels of input data for Koradare,D1 soil,that the all hierarchical PTFs performance very well for prediction through using coefficient of determination (R^2) as indicator for comparison, and also the five PETs gave high coefficient of determination for depth one, D1 of Koradare Silty Clay soil and ranged between (0.9922,0.9917,0.9912,0.9897 and 0.9831) for PTFs (H1,H2,H3,H4 and H5) respectively and the best performance was for H1 (0.9922) and the others gave (R^2) more than 0.98(Table 9).

akram.khalaf@uod.ac

Table (10) :-shows van Genuchten parameter values Van Genuchten depth two, D2 for Koradare Silty Loam soil.

Koradare	Depth 2 Silty Loam					
Soil Property	H1 T.C	H2 % S,Si.C	H3 % + BD g/cc	H4 % + BD+ 33kpa	H5 % + BD + 33kpa +1500kpa	Measured
Theta-r (θr)	0.0645	0.0551	0.053	0.0495	0.039	**0.0810**
Theta-s (θs)	0.4387	0.4095	0.3804	0.8864	0.3889	**0.6004**
Alpha (□)	0.0051	0.0054	0.0065	0.0067	0.0065	**0.2914**
(n)	1.6620	1.626	1.611	1.534	1.488	**1.4320**
(m)	0.3985	0.385	0.3795	0.3482	0.3283	**0.3107**

Table (10) demonstrates the VG parameters values calculated by using five PTFs and measured values for depth one,D2 for Koradare Silty Loam soil and good calculation were for (n and m) compared to the measured values.

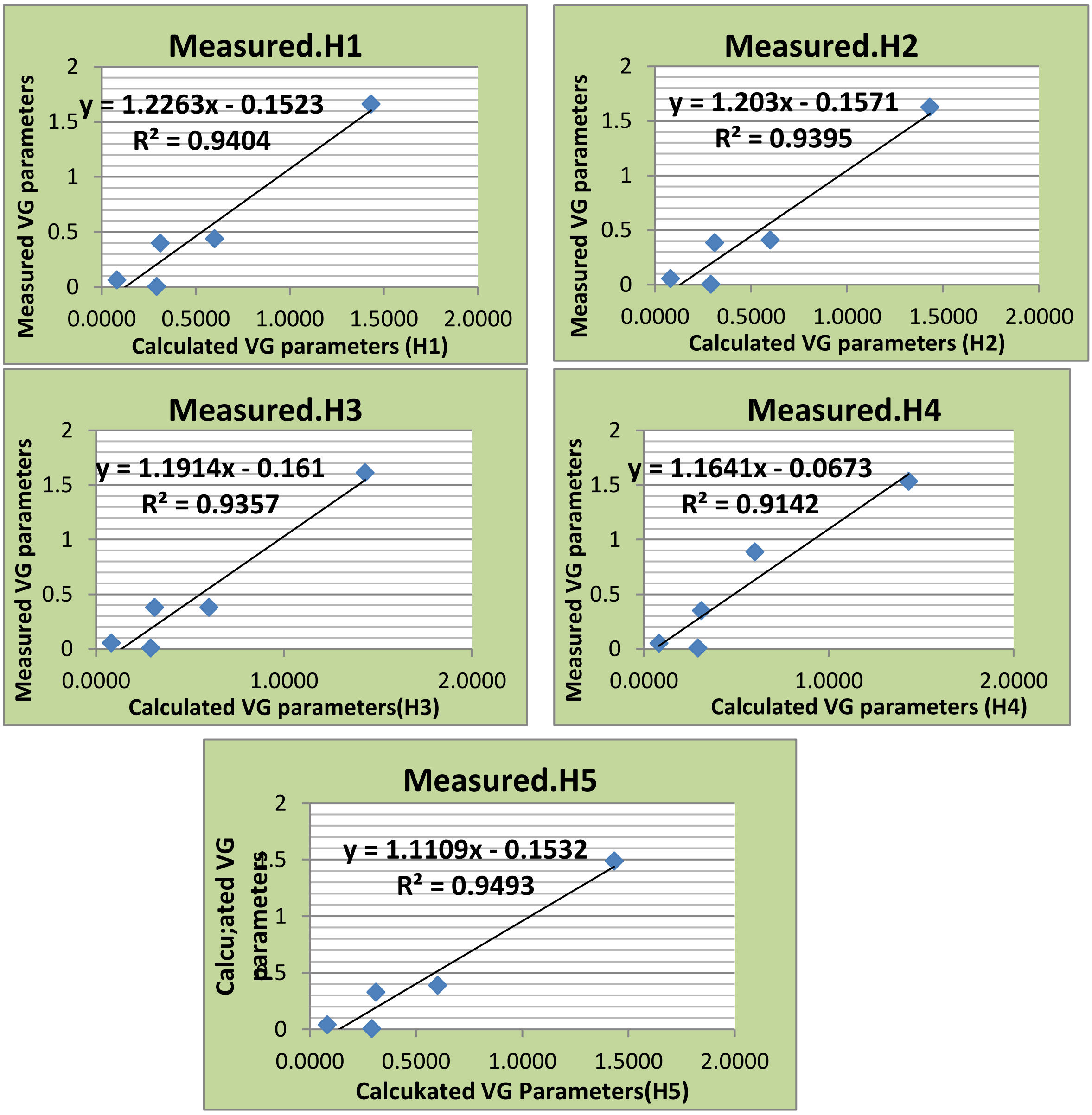


Fig. (7):- The relationships between measured and calculated VG parameters by using five pedotransfer for **Koradare, D2 soil**.

akram.khalaf@uod.ac

Fig.(5) revealed the relationships between measured and calculated values by using hierarchical PTFs based on five levels of input data for Koradare,D2soil, that the all hierarchical PTFs performance very well for prediction through using coefficient of determination (R^2) as indicator for comparison, and also the five PETs gave high coefficient of determination for depth one, D1 of Koradare Silty Loam soil and ranged between (0.9404,0.9395,0.9357,0.9142 and 0.9493) for PTFs (H1,H2,H3,H4 and H5) respectively and the best performance was for H5 (0.9493) and the others gave (R^2) more than 0.91(Tabl10).

EVOLUTION OF PEDOTRANSFER, PTFS:

1- Determination coefficient (R^2):

Table (11) :-Determination coefficient of measured and predicted parameters of van Genuchten by using five pedotransfer for studied soils.

Location	Soil Depth (cm)	R^2 H1	H2	H3	H4	H5
Zaweta						
CL	**L1**	**0.9644**	**0.9686**	**0.9668**	**0.9718**	**0.9808**
L	**L2**	**0.9973**	**0.9967**	**0.9967**	**0.9942**	**0.9923**
Swaratoka						
CL	**L1**	**0.9889**	**0.9912**	**0.9899**	**0.9900**	**0.9867**
C	**L2**	**0.9750**	**0.9653**	**0.9356**	**0.9726**	**0.9784**
Koradare						
SiC	**L1**	**0.9922**	**0.9917**	**0.9912**	**0.9897**	**0.9831**
SiL	**L2**	**0.9404**	**0.9395**	**0.9357**	**0.9142**	**0.9493**

The values of determination coefficients(R^2) between measured and calculated values are exhibit in table(9), It shows that30% determination coefficients(R^2) gave more than 0.99 and 50% gave more than 0.98 and the others gave between (0.91-0.97) at applying the PTFs at two depths for the studied soils of(Zawita, Swaratoka Koradare),and the highest values were for Zawita loamy soil, depth two at applying PTFs (H1,H2,H3,H4 and H5).

2.RMSE:

Table (12):- Root Mean Square Error (RMSE) of measured and calculated parameters of van Genuchten by using Five PTFs for studied soils.

Location	Soil Depth (cm)	RMSE H1	H2	H3	H4	H5
Zawita						
CL	**L1**	**0.1399**	**0.1560**	**0.1263**	**0.1285**	**0.1496**
L	**L2**	**0.0299**	**0.0299**	**0.0316**	**0.0508**	**0.0730**
Swaratoka						
CL	**L1**	**0.3579**	**0.3762**	**0.3555**	**0.3826**	**0.4153**
C	**L2**	**0.1597**	**0.1376**	**0.1394**	**0.1321**	**0.1478**
Koradare						
SiC	**L1**	**0.1828**	**0.1626**	**0.1433**	**0.1717**	**0.2157**
SiL	**L2**	**0.1838**	**0.1800**	**0.1828**	**0.1874**	**0.1619**

The values of RMSE of VG parameters for five PTFs are listed in table (12), and noticed that lowest values of RMSE were exhibit by all soils (Zawita, Swaratoka and Koradare and two depths D1 and D2 exceptD1 of Swaratoka Clay loam soil and at different textures, and the minimum value was (0.099) at using H2 PedotransferforD2,Zawita loamy soil, whereas the maximum value was(0.4153) for Swaratoka Clay Loam,D1 and at using H5 pedotransfer

akram.khalaf@uod.ac

3-NSE

Table (13):- Nash Sutcliffe Efficiency of measured and predicted parameters of van Genuchten by using five pedotransfer for studied soils.

Location	Soil Depth	NSE				
	(cm)	H1	H2	H3	H4	H5
Zaweta						
CL	L1	0.9244	0.9729	0.9653	0.9527	0.9634
L	L2	0.9968	0.9953	0.9964	0.9907	0.9809
Swaratoka						
CL	L1	0.8128	0.8686	0.9653	0.7805	0.8523
C	L2	0.8948	0.9218	0.9198	0.9280	0.9098
Koradare						
SiC	L1	0.9526	0.9624	0.8511	0.9239	0.9339
SiL	L2	0.8497	0.8559	0.8514	0.8438	0.8834

Values of NSE of calculated VG parameters to measured parameters are illustrated in table (13) and revealed that the maximum values more than (0.99)were found in Zawita loamy soil and at depth two,D2 whereas the minimum values were noticed in Koradare Silty Loam and at depth two,D2and the highest value was(0.9968) for Zawita loamy soil,D2 at applying H1 whereas the lowest value was (0.7805) for Swaratoka Clay loam soil at using H4 PTFs.

DISCUSSION

It could be dividing the discussion to two parts:

Part 1

Related to the closed expressions of van Genuchten parameters(ɵs,ɵr, α,n,m)the results appeared high values of volumetric moisture content at saturation, ɵs, for soils of Zawita, Swaratoka and Koradare because of high percent of clay which high specific area and large ratio of capillary pore space specially in D1 for three mentioned soil and same found for,ɵr I and these finding in line of investigations of Klute,1986;Boma,1989 and Arya et al 1999.While The values of α have illustrations as concerned to α values high limits found in soils of Zawita, Swaratoka for D1 and D2 and low limits appeared in Koradare soil and for same depths(D1 and D2),as related to to values of n and m which has same trend ,the large values noticed in light soil which contain less percent of clay comparing to heavy soil which poses high clay percent It is worthy to mention here that one of the most important explanation is that related to the texture of soil in Zawita loamy soil and at depth two,D2 is considered as light comparing to D2 Koradare Silty Loam, which has heavy texture .many researchers confirmed that increasing of clay present cause decreasing of value of n parameter and this finding in agreement of (VG,1980;Vogel et al;2001, Schaap and Van Genuchten,2006)

Part 2

The second part of discussion concerned to evaluation of pedotransfer which include tree indices are Coefficient of Determination, R^2, Root Mean Square od Difference, RMSD, and Nash Sutcliffe Efficiency as related to coefficient of determination (R2) describe the degree of collinearity between simulated and measured data. The correlation coefficient, which ranges from −1 to 1, is an index of the degree of linear relationship between observed and simulated dataR2 describes the proportion of the variance in measured data explained by the model. R2 ranges from 0 to 1, with higher values indicating less error variance, and typically values greater than 0.5 are considered acceptable (Santhi et al.,2001, Van Liew et al., 2003). All R^2 values are much than 0.s for three different textures and for depth one, D1 and depth two,D2(Table11)

RMSE is one of the commonly used error index statistics (Chu and Shirmohammadi, 2004; Singh et al., 2004; Vasquez-Amábile and Engel, 2005).

Although it is commonly accepted that the lower the RMSE the better the model performance. minimum RMSE value was 0.0299 for Zawita soil at D2 and applying PET H2 whereas maximum RMSE value was 0.4153 for Swaratoka soil at applying PET H5 for D1 (Table 12)

The Nash-Sutcliffe efficiency (NSE) is a normalized statistic that determines the relative magnitude of the residual variance (“noise”) compared to the measured data variance (“information”) (Nash and Sutcliffe, 1970). NSE indicates how well the plot of observed versus simulated data fits the 1:1 line. NSE is computed

akram.khalaf@uod.ac

as shown in equation 3: NSE was recommended for two major reasons:
(1) it is recommended for use by ASCE (1993) and Legates and McCabe (1999), and
(2) it is very commonly used, which provides extensive information on reported values.

Sevat and Dezetter (1991). According to the results of Table 13 the values of NSE ranged between minimum of 0.8128 for Swaratoka soil at depth,D1 and applying PTF H1 to maximum of0.9964 for Zawita soil at applying PTF H1 for depth,D2

CONCLUSIONS

1- There are noticeable variations in water behavior among the studied soil samples which means that the different water management is required.
2-This study tested the application of the pedotransfer function Rosetta to identify the level of input needed in order to use Rosetta as a tool to calculate the VG parameters.
3- Based on the conducted results we conclude that Rosetta PTF is a useful tool that can be used to calculate Ks in the absence of measured values and that for this particular soil, the hierarchical level 5 of Rosetta yielded the best results with the measured input data. The better prediction of VG parameters by using the hierarchical level 5 of the PTF Rosetta confirms the findings of Gülser et al. (2008) and Acosta-Carlos Alvarez et al. (2012).

Recommendations:

To conduct more investigation related to the soil hydraulic properties of different types of soils our region in order to put proper plans for water and soil management.

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akram.khalaf@uod.ac