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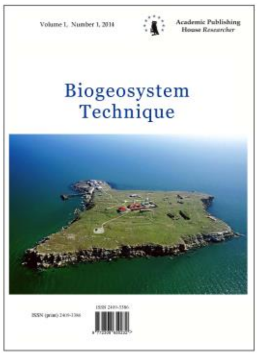

Soil Saturated Hydraulic Conductivity Assessment by Direct and Pedotransfer Functions Methods

[1] Evgeny V. Shein
[2] Ahmed Y. Mady
[3] El Hassna A. Mohamed

[1-2] Lomonosov Moscow State University, Soil Science Faculty, Soil Physicis and Reclamation Department. Leninskie Gory. 119991 Moscow RUSSIA;
[2-3] Ain Shams University, Faculty of Agriculture, Soil science Department, Hadayek Shoubra 11241, Cairo, Egypt
[1] Head of Soil Physics and Reclamation Department, Soil Science Faculty, Moscow State University. 119991, Moscow
E-mail: evgeny.shein@gmail.com
[2] PhD. Student of Soil Physics and Reclamation Department
Lomonosov Moscow State University and Assistant Lecturer in Soil Science department, Faculty of Agriculture, Ain Shams University, Hadayek Shoubra 11241, Cairo, Egypt
[3] Professor of Soil Physics, Soil Science Department Ain Shams University, Faculty of Agriculture, Ain Shams University, Hadayek Shoubra 11241, Cairo, Egypt

Abstract

The aim of the work is to study the efficiency of PedoTransfer Functions (PTFs) to estimate saturated hydraulic conductivity (Ks) from indirect methods (PTFs), by comparing the experimental saturated hydraulic conductivity (Ks0) that was determined from direct method with Ks were estimated from indirect methods (PTFs). Different indirect methods (PTFs) are used to estimate Ks: Wösten (1997) (Ks1), Wösten et al (1999) (Ks2), Cosby et al (1984) (Ks3), Saxton et al (1986) (Ks4), Vereecken et al (1990) (Ks5) and Ferrer-Julia et al (2004) (Ks6). The results observed that (PTFs) are depending on: bulk density, organic matter, Clay and Sand contents. The efficiency of (PTFs) is estimated on the correlation between these parameters and saturated hydraulic conductivity. (PTFs) depend on clay and sand percents which forming macro and micro pores while don’t depended on silt content .There were positive strong correlations between Ks0 and (Ks1), (Ks4), (Ks3), (Ks6) and (Ks5), correlation (r^2) were (0.846, 0.798, 0.785, 0.719 and 0.667) respectively.

Keywords: soil, saturated hydraulic conductivity, pedotransfer functions (PTFs), soils of Gaza Governorate.

Introduction

The concept of (pedotransfer function) (PTFs, pedotransfer functions) in today's broad enough understanding was introduced by J. Bouma **(**1989**)** to describe mathematical functional dependencies, allows to convert information about the main traditional soil properties (predictors) in the information of the soil water, matter and energy soil characteristics Usually this term is referred functions to restore the curve of water retention on such predictors as both particle size distribution, mineralogical composition, soil density. organic matter content, and others. At present, this term is not only used in Hydrophysics soil, but also in a wider sense, in almost all areas of soil science to refer to any mathematical relationships between soil properties. Currently, scientific interest and practical need for PTFs are growing rapidly, primarily because of the calculated predictive mathematical model of hydro-dependencies require that it is difficult to determine experimentally and costly, and restore on the fundamental properties of traditionally defined -significantly easier and cheaper. Currently, there was also the target of a PTFs monograph on their accuracy, their possible use for all sorts of calculations, in particular, collective monograph published in 2004 by the publishing house "Elsevier", edited by Ya. Pachepsky and W.J. Rawls "Development of Pedotransfer Functions in Soil Hydrology" (Pachepsky Ya., Rawls W.J. Preface: Status of pedotransfer functions. In: Development of (pedotransfer functions) in soil hydrology. Elsevier, 2004. Pp.512.). However, apart from the equilibrium water retention curves for hydrological calculations required and the conductivity function, which is based on the use of such an important hydrological characteristics as the saturated hydraulic conductivity of the soil. It is also possible to define only experimentally in the field, it is very costly and time consuming. It is therefore natural to expect attempts to use PTFs for the calculation of this important hydrological characteristic.

The aim of the work is to study the efficiency of PedoTransfer Functions (PTFs) to estimate saturated hydraulic conductivity from indirect methods (PTFs), by comparing the saturated hydraulic conductivity Ks-0 that was determined from direct method with saturated hydraulic conductivity were estimated from indirect methods (PTFs). Saturated hydraulic conductivity is an important soil physical property, especially for modeling water flow and solute transport in soil, irrigation and drainage design, groundwater modeling and other agricultural and engineering, and environmental processes. Many direct methods have been developed for its measurement in the field and laboratory (Libardi et al., 1980; Klute and Dirksen, 1986). Direct measurement techniques of the hydraulic conductivity are costly and time consuming, with large spatial variability (Christiaens and Feyen, 2002; Islam et al., 2006). Alternatively, indirect methods may be used to estimate hydraulic conductivity from easy-to-measure soil properties. Many indirect methods have been used including prediction of hydraulic conductivity from more easily measured soil properties, such as texture classes, the geometric mean particle size, organic carbon content, bulk density and effective porosity (Wösten and van Genuchten, 1988) and inverse modeling techniques (Rasoulzadeh, 2010; Rasoulzadeh and Yaghoubi, 2011). In recent years, pedotransfer functions (PTFs) were widely used to estimate the difficult-to-measure soil properties such as hydraulic conductivity from easy-to-measure soil properties.

Material and Methods

The soil samples were collected from two locations. The first one is El- dokki green house of Climate Agriculture Research, Minister of Agriculture, Gaza Governorate. Three soil profiles were dug, then soil samples were collected according to the difference in morphological features Coordinates Latitude 30° 2' 46'' N Longitude 31° 12' 19'' E , Coordinates Latitude 30° 2' 47'' N Longitude 31° 12' 18'' E and Latitude 30° 2' 47'' N Longitude 30° 12' 19'' E respectively. The second location is El harm green house, Minister of Agriculture, Gaza Governorate. Four soil profiles were dug in sites were the soil was under conventional tillage every year before the cultivation. Coordinates Latitude 29° 59' 71'' N Longitude 31° 10' 06'' E , Latitude 29° 59' 72'' N Longitude 31° 10' 05'' E, Latitude 25° 59' 7 '' N Longitude 31° 10' 08'' E and Latitude 29° 59' 72'' N Longitude 31° 10' 07'' E respectively. Soil profiles were dug down to different depths, selected soil sample were taken from different layers in each profiles. All soil profiles were carefully examined in the field and morphologically described according to the procedure outlined by the Soil Survey Staff (1993) and to the FAO Guide Lines for soil description (2006). Disturbed and undisturbed soil samples were collected from profile layers according to their difference in morphological features. Undisturbed soil samples were taken by metallic cylinders of 5cm high and 5cm inner diameter. Particle size distribution was determined according to the International pipette method by Gee and Bauder (1986). Soil bulk density was determined in the studied soil samples by core method Klute and Dirksen (1986).Organic matter was determined by Walkely–Black rapid titratoin method (Nelson, Sommers, 1982). Saturated hydraulic conductivity was determined direct method using constant head method technique according to Klute and Dirksen (1986), and pedotransfer functions for estimating saturated hydraulic conductivity (PTFs) were calculated: PTFs which used to estimate saturated hydraulic conductivity (Ks) were developed using texture classes, the geometric mean particle size, organic carbon content, bulk density and effective porosity as predictor variables. Many PTFs were presented to predict Ks. Here the following PTFs for Ks are considered. All PTFs give Ks in [m/s]. We estimate KS using six equations to estimate efficiency of each one. Theses equations Wösten (1997) presented a function for determining Ks, and then Wösten et al. (1999) represented another function as follows:

Ks = 1.15741 .10-7 exp(x)

Where (x) depend on soil texture, percent of clay, organic matter and bulk density. The Cosby's pedotransfer function (Cosby et al., 1984) was derived based on Sand and Clay contents then Saxton et al. (1986) suggested a pedotransfer function to estimate Ks as follows

Ks = 2.778 .10-7 exp(x)

Where x depend on are the percentage of clay and sand, respectively, and saturated water content. Vereecken et al (1990) provided a equation for estimating Ks as follows:

$Ks = 1.1574 .10^{-7} \exp (20.62-0.96 \ln(clay)-0.66 \ln (sand) -0.46 \ln(O.M)-0.00843(B.D))$

Ferrer-Julia et al. (2004) derived a relationship between Ks and sand content of soil. Statistics analysis using program SPSS

Table 1

Correlations between Experimental Field saturated Hydraulic conductivity (Ks0) and estimated by different Pedotransfer functions (PTFs) presented in the table

Correlations (25 repetitions)								
		Ks0	Ks1	Ks2	Ks3	Ks4	Ks5	Ks6
Ks0	Pearson Correlation	1	,846**	,484*	,785**	,798**	,667**	,719**
	Means Significance		,000	,014	,000	,000	,000	,000
Ks1	Pearson Correlation	,846**	1	,674**	,580**	,748**	,390	,550**
	Sig. (2-tailed)	,000		,000	,002	,000	,054	,004
Ks2	Pearson Correlation	,484*	,674**	1	,436*	,317	-,117	,516**
	Sig. (2-tailed)	,014	,000		,029	,122	,576	,008
Ks3	Pearson Correlation	,785**	,580**	,436*	1	,598**	,573**	,979**
	Sig. (2-tailed)	,000	,002	,029		,002	,003	,000
Ks4	Pearson Correlation	,798**	,748**	,317	,598**	1	,616**	,541**
	Sig. (2-tailed)	,000	,000	,122	,002		,001	,005
Ks5	Pearson Correlation	,667**	,390	-,117	,573**	,616**	1	,424*
	Sig. (2-tailed)	,000	,054	,576	,003	,001		,035
Ks6	Pearson Correlation	,719**	,550**	,516**	,979**	,541**	,424*	1
	Sig. (2-tailed)	,000	,004	,008	,000	,005	,035	
*and**-Correlation is significant at the 0.05 and 0.01 level;								
*** - Means Significance* (2-tailed)								

Results and discussion

Table 1 shows saturated Hydraulic conductivity estimated by different Pedotransfer functions (PTFS) and experimental ones. The best were the ones that had the highest correlation coefficients with experimental values. The results observed (table 1) that the best (PTFs) can be used to estimate saturated hydraulic conductivity were the next PTFs: (Ks1) (Wösten 1997), (Ks4) Saxton et al (1986), (Ks3) Cosby's pedotransfer function, (Ks6) Ferrer-Julia et al.(2004) and **(**Ks5) Vereecken et al (1990) respectively, where there were high positive strong correlations with Ks0 and (Ks1) ,(Ks4),(Ks3),(Ks6) and (Ks5), correlation were(0.846-0.798-0.785-0.719 and 0.667) respectively. It was observed that the relationships between Ks 0 and the parameters (predictors) that used in (PTFs) were: Bulk Density (-0.602), Organic Matter percent (0.794), Clay (-0.761), Silt (0.365) and Sand percent (0.627), respectively. So such (PTFs), – (Wösten 1997), Saxton et al (1986), Cosby's pedotransfer function, Ferrer-Julia et al (2004) and Vereecken et al (1990) that depend on these parameters, were more significant with Ks0 (table 1). While we have a low correlation between Ks0 and (Ks2) (correlation was 0.484); we propose that in this case PTFs use the silt percent as predictor, but the correlation between Ks0 and silt percent correlation is rather low (0.365). Soil Saturated Hydraulic conductivity first of all depends on organic matter (%), clay and sand content (%), and soil density (g/cm^3). PTFs that depend on theses parameters were more significant and high efficiency.

Conclusion

The results observed (table 1) that the best PTFs can be used to estimate saturated hydraulic conductivity were the next: (Ks1) (Wösten 1997), (Ks4) Saxton et al (1986), (Ks3) Cosby's pedotransfer function, (Ks6) Ferrer-Julia et al.(2004) and **(**Ks5) Vereecken et al (1990) respectively, where there were high positive strong correlations with direct field experimental values (Ks0). Saturated hydraulic conductivity researches in soils of different particle size distribution and density, with a large range of organic matter will clarify listed correlation relations and the use of RTF (“Development of pedotransfer functions …”. 2004; Kalinitchenko et al, 2010, 2012, 2014 et al)**.**

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