Role of Pedotransfer Technology in Soil Properties

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What Is Pedotransfer Technology

Parameters governing the retention and movement of water and chemicals in soils are notorious for the difficulties and high labor costs involved in measuring them. Often, there is a need to resort to estimating these parameters from other, more readily available data. BRIGGS and SHANTZ (1912), quantified and interpreted relation-ships between soil properties. Such terms as "*prediction of*" or "*predicting*" soil properties, "*estimation of*" or "*estimating*" soil properties, "*correlation of*" or "*cor-relating*" soil properties, were used interchangeably to name the contents, procedures and results of these types of studies .

Relatively recently, equations expressing relationships between soil properties were proposed to be called "*transfer functions*" (BOUMA & VAN LANEN, 1987) and later "*pedotransfer function*"' or PTFs (BOUMA, 1989). Recently the number of PTF applications has increased significantly due to the development of GIS-based regional modeling. According to the SCOPUS database, more than 55% of all pedotransfer papers were published in 2009–2015.

History of Pedotransfer Function

The first PTF came from the study of Lyman Briggs and McLane (1907). They determined the wilting coefficient, which is defined as percentage water content of a soil when the plants growing in that soil are first reduced to a wilted condition from which they cannot recover in an approximately saturated atmosphere without the addition of water to the soil, as a function of particle-size:

$$\textit{Wilting coefficient} = 0.01\,\textit{sand} + 0.12\,\textit{silt} + 0.57\,\textit{clay}$$

With the introduction of the field capacity (FC) and permanent wilting point (PWP) concepts by Frank Veihmeyer and Arthur Hendricksen (1927), research during the period 1950-1980 attempted to correlate particle-size distribution, bulk density and organic matter content with water content at field capacity (FC), permanent wilting point (PWP), and available water capacity (AWC).

In the 1960s various papers dealt with the estimation of FC, PWP, and AWC, notably in a series of papers by Salter and Williams (1965). They explored relationships between texture classes and available water capacity, which are now known as class PTFs. They also developed functions relating the particle-size distribution to AWC, now known as continuous PTFs. They asserted that their functions could predict AWC to a mean accuracy of 16%.

Jurgen Lamp and Kneib (1981) from Germany introduced the term pedofunction, while Bouma and van Lanen (1986) used the term transfer function. To avoid confusion with the term *transfer function* used in soil physics and in many other disciplines, Johan Bouma (1989) later called it *pedotransfer function*. (A personal anecdote hinted that Arnold Bregt from Wageningen University suggested this term).

Since then, the development of hydraulic PTFs has become a boom research topic, first in the US and Europe, South America, Australia and all over the world.

Although most PTFs have been developed to predict soil hydraulic properties, they are not restricted to hydraulic properties. PTFs for estimating soil physical, mechanical, chemical and biological properties have also been developed.

Soil hydraulic properties and Pedotransfer Function:

The aim of soil hydraulic modelling is to provide a simplified and abstract view of the complex hydraulic patterns in a soil sample. Soil hydraulic properties are key aspects in determining soil quality and soil function. Soil hydraulic properties and their associated soil hydraulic models are used in a wide range of applications, including irrigation (Coppola et al., 2004; Grashey-Jansen, 2014), soil leaching losses (Wheeler et al., 2003), soil management (Bodner et al., 2013; Horne and Scotter, 2016), and long-term studies on the effect of climate and land use change (Kellomäki and Vaisanen, 1997; Sulis et al., 2011). Besides this many soil water and solute transport models are currently applied for the investigation and prediction of a wide range of complex environmental processes, which are indicative of soil quality, for example, infiltration capacity. These models require data on soil water retention and hydraulic conductivity characteristics. However, collection of these data is difficult, time consuming and sometimes rather costly, so there is a continued interest in the establishment of pedotransfer functions (PTF), which predict soil hydraulic properties from other - more easily measured - soil properties. Pedotransfer functions can define as predictive functions which relate more easily measurable soil data such as soil texture (sand, silt and clay), bulk density, organic matter (organic carbon) content and/or other data routinely measured or registered in soil surveys with hydraulic parameters such as the soil water retention characteristic.

Bouma (1987) introduced the term pedotransfer function (PTF), which he stated as translating data that we have (soil survey data) into data that we need (soil hydraulic data). The PTFs are multiple regression equations or models, which correlate soil water retention characteristics with easily available soil properties. (Salchow *et al.* 1996) like particle size distribution, organic matter content and bulk density (BD).

Lal (1979) considered sand, silt, clay and organic matter content as predictors in PTFs for estimating the field capacity and wilting point in tropical soils.

There are a variety of methods that can be used to develop PTFs for soil given an adopted property definition, and the choice of which method is used depends on the range of soil characteristics available, the constraints the modeller may wish to apply to take into account the known functional behaviour of soil water dynamics, and the application or model in which the PTFs are likely to be used. For instance, some applications or models may require knowledge of water content over the full range of tensions, while others only require water content for a few specified tension values. During the last decades, most existing and published PTFs have been developed using data from soils of temperate regions (Tomasella *et al*., 2000). Yet, van den Berg *et al.* (1997) argue that physical and chemical differences between "temperate" and "humid tropical" soils might be the causes of the poor performance of "temperate soils" PTFs when applied to highly weathered tropical soils. These differences originate from marked differences in mineralogical properties (Tomasella and Hodnett, 1998, 2004). Based on what is indicated above, we consider that a low quality of the estimation of hydraulic properties may influence the overall quality of the outputs of the whole modelling process.

However, the PTFs derived for estimating soil water retention curves of a specific geographical region cannot be applied to other regions with acceptable levels of accuracy (Cornelis *et al.* 2001; Li *et al.* 2007).

Conclusion:

The pedotransfer functions (PTFs) are defined as predictive functions of certain soil properties derived from other easily measured soil properties. The PTFs are important tool that can be effectively used to estimate the soil water characteristics from limited experimental data points assuming certain functional forms, hence pedotransfer function (PTF) is a translating data that we have (soil survey data) into data that we need (soil hydraulic data). The PTFs are multiple regression equations or models, which correlate soil water retention characteristics with easily available soil properties like particle size distribution, organic matter content and bulk density(BD).

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