Thesis Abstract

Development of pedotransfer functions for predicting soil hydraulic properties and solute transport parameters using artificial neural network analysis

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Soil hydraulic properties and solute transport parameters are key inputs for models simulating water and chemical transport in soil. However, these properties are not easily obtainable because measuring them is resources intensive. One approach to address this data gap is through the development of pedotransfer functions. Thus, this study was carried out to develop soil water retention curve pedotransfer functions (SWRC-PTFs) and solute transport pedotransfer functions (ST-PTFs) using artificial neural network (ANN) to predict soil water retention and solute transport parameters, respectively, from basic soil physical and hydraulic properties. For comparison purposes, pedotransfer functions using linear and nonlinear regression analysis were also developed.

Results showed that the SWRC-PTFs using neural network were adequate and formed a hierarchy in predicting soil water retention. Among the soil properties, bulk density was an important input variable in the model as it reflects the effect of soil structure on the flow of soil water. Its inclusion in the model increased the prediction of water retention by about 24%. On the other hand, the developed SWRC-PTFs using linear regression did not perform well. However, adjusting their regression coefficients using the global optimization approach significantly improved their performance by more than 117% compared with their linear versions and were comparable with the neural network SWRC-PTFs. Among the eight SWRC-PTFs, six had relative improvement of more than 50% over Rosetta and more than 60% over Neuro-m in predicting water retention curve of Philippine soils. They account for more than 90% of the total variation of soil water retention with coefficient of efficiency (EF) of 0.26 to 0.77. These models further showed adequacy in predicting unsaturated hydraulic conductivity with an R2 and EF as high as 0.83 and 0.61, respectively.

The ST-PTFs also showed great potential in predicting soil pore velocity, dispersion coefficient and dispersivity. About 54% of the total variation of dispersion coefficient was due to pore velocity. The results showed that solute transport parameters can be better predicted from soil physical properties than from water retention parameters. Using soil properties as predictors, the ST-PTFs could account for more than 50% of the total variation of pore velocity, dispersion coefficient and dispersivity. The ST-PTFs, however, are not capable of capturing preferential flows resulting from root channels, cracks and other soil fissures.

Finally, a computer program was developed to package six of the eight SWRC-PTFs and four ST-PTFs. This program provides a user-friendly interface for estimating soil hydraulic properties and solute transport parameters and more importantly has an improved accuracy and considerable degree of flexibility toward available input data.