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A model of near-saturated hydraulic properties

N. Jarvis (1)

(1) Dept. Soil Sci., SLU, Uppsala, Sweden (nicholas.jarvis@mv.slu.se / Fax: +46 18 672795)

Continuum macropore flow models require a description of the hydraulic properties in the near-saturated region. Very little is known about the suitability of different approaches, nor how the parameters describing hydraulic functions in these various models can be estimated. In this presentation, some conceptual and practical limitations in existing approaches are first briefly discussed. A new closed-form model is then developed, based on the generalized Kozeny-Carman equation, the pore scale tortuosity factor proposed by I. Fatt and H. Dykstra, and the functional form for the soil water characteristic proposed by P.J. Ross et al. (Soil Sci. Soc. Am. J., 55, 923-927). The model is then fit to published data on near-saturation wetting characteristics and hydraulic conductivity for seven soils (five undisturbed soils in the field and two repacked under laboratory conditions). The model describes this limited dataset quite well, considering the difficulties involved in measuring small changes in water content in the macropore region close to saturation. For the five field soils, no change in pore tortuosity was apparent across the range of tensions investigated (i.e. the tortuosity factor could be set to zero). Thus, the simple capillary bundle model first suggested by Purcell in 1949 appears to be an appropriate model of soil macropore conductivity. However, as has also been noted in many other studies, the conducting macroporosity was only a very small fraction of the wetted macroporosity (c. 0.1 to 1%) which probably reflects simplifications in this model, especially the neglect of pore necking and connectivity (i.e. dead-end pores). For a small dataset (n=12) of Swedish soils, the pore size distribution parameter in the simple Purcell/Ross model could be related to soil texture and macroporosity. It is concluded that this simple physico-empirical model shows promise, both as a description of macropore hydraulic properties in dual-permeability models, and as a conceptual framework to support the development of pedotransfer functions for macropore hydraulic conductivity.