Geophysical Research Abstracts
Vol. 16, EGU2014-15903, 2014
EGU General Assembly 2014

Formulation of soil hydraulic conductivity from water retention curve, based on data inversion results, interpreted in terms of tortuosity, connectivity and flow turbulence.

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In order to refine hydraulic conductivity determination from soil water retention curve, we calculated the correcting factors, by data inversion, using a generalised formulation issued from Burdine or Mualem hydraulic conductivity. These formulations use the laminar flow, obeying Poiseuille law, through a bundle of cylinders of different radii, and correcting factors traducing the gap with real flow and real soil geometry. A general correcting factor is supposed to be proportional to water content, with an exponent a. An inner correcting factor is a function of pore size and/or water content and is inside the integral. We did not presuppose any analytical form for this inner correcting function.

We used soil data obtained from clayey Amazonian tropical ferralsols composed of around 7/8 of clay fraction and fine silt (mainly kaolinite with some gibbsite and goethite) and 1/8 of coarse sand (quartz and kaolinite aggregates), with 0,2 to 1,5 % organic carbon content. Data were obtained using three different techniques : high pressurized water extraction disposal, evaporation experiment (Wind method) and in situ infiltration. The explored pore size domain was very large, ranging from 2 micrometers to 2 mm, completed by some data around 0,1 micrometer, so three to four orders of magnitude. We precised pore distribution in the range from 4 nm to 2 micrometers with mercury injection porosimetry corrected from drying effects. The pore distribution is bimodal, with a very small pore volume around 0,25 micrometer pore size. Such pore distribution allows observing separately the effects of pore size and water content on hydraulic conductivity, as water content is not a regularly increasing function of largest filled pores size.

The results showed that a general correcting factor as an exponent of water content over all the described domain is inappropriate, as we encountered the smallest spreading of the inner correcting function when the exponent a is zero. The general correcting factor was taken constant with respect to water content ; it decreased with increasing organic carbon content (decrease of a factor 2). For the inner correcting factor, we shall interpret separately two domains, pores smaller or greater than 0,1 mm. For pores greater than 0,1 mm, hydraulic conductivity increase was simply proportional to water content increase : Poiseuille law does no longer apply as flow gets turbulent. For pores smaller than 0,1 mm, Poiseuille law applies, hydraulic conductivity increase (6 orders of magnitude) was explained, the inner correcting function extreme values ratio was 50. The correcting function variations correlated with the poral volume of the two orders of magnitude smaller than the size of the largest pores filled with water, we interpreted this as the connectivity effect. The remaining correcting factor extreme values ratio was then 2.7, that we interpreted as the square of tortuosity variations, that should depend on soil mineralogy and must be defined by some hydraulic conductivity data. Then the whole hydraulic conductivity curve can be predicted from poral data and organic carbon content.