Effects of the soil pore network architecture on the soil's physical functionalities

Smet S[1,*], Beckers E[1], Leonard A[2], Degré A[1]

[1]Univ. Liège, Gembloux Agro-Bio Tech, BIOSE, Echanges Eau-Sol-Plantes. 5030, Gembloux, Belgique
[2]Univ. Liège, Department of Chemical Engineering, PEP's. 4000, Sart Tilman, Belgique

The soil fluid movement's prediction is of major interest within an agricultural or environmental scope because many processes depend ultimately on the soil fluids dynamic. It is common knowledge that the soil pore network structure governs the inner-soil convective fluids flow. There isn't, however, a general method that consider the pore network structure as a variable in the prediction of the soil's physical functionalities, in other words, that weigh up the microscopic scale, where the pore is the main constituent, to the macroscopic soil behavior, namely at the core scale. There are various possible representations of the microscopic pore network: sample scale averaged structural parameters, extrapolation of theoretic pore network, or use of all the information available by modeling within the observed pore network. Different representations imply different analyzing methodologies. To our knowledge, few studies have compared the micro-and macroscopic soil's characteristics for the same soil core sample. The objective of our study is to explore the relationship between macroscopic physical properties and microscopic pore network structure.

The saturated hydraulic conductivity (Ksat), the air permeability ($k_a(\varepsilon_a)$), the retention curve, and others classical physical parameters were measured for ten soil samples from an agricultural field. The pore network characteristics were quantified through the analyses of X-ray micro-computed tomographic images (micro-CT system Skyscan-1172) with a voxel size of 22 µm³.

First results suggested that log(Ksat) and log(k_a(10kPa)) followed a linear relationship as already described in others studies. The slope of the linear relationship log(k_a)-log(ε_a), followed a negative power-law function of log(Ksat) and there was a negative correlation between that first parameter and the averaged pore volume. These two observations suggested that air flow depends mostly on the pore connectivity and tortuosity than on the total porosity volume. Then, the fractal dimension calculated from the X-ray images (FD_CT) and the fractal dimension calculated from the retention curve (FD_PF) were significantly different. The difference between the two values (FD_CT - FD_PF) was negatively correlated to the porosity calculated on the X-ray images and positively correlated to the length of the pore network. The divergence between FD_CT and FD_PF is likely due, on one hand to the fact that the soil porosity is not entirely visible on the X-ray images and, on the other hand to the pore network complexity which is visible on the X-ray images but not considered when calculating FD_PF.

We cannot, however, conclude without questioning the methodology: would the results be similar with a different voxel size? What are the calculated and measured parameters uncertainties? Our communication will tend to answer those questions.

Sarah Smet, as a research fellow, acknowledges the support of the National Fund for Scientific Research (Brussels, Belgium).