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Multifractal analysis of soil porosity based on mercury porosimetry and nitrogen adsorption

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The soil pore space is composed of a continuum of pores extremely variable in size which include structures smaller than nanometres and as large as macropores $>$ 20 mm in diameter, i.e. with an upper size limit of the order of centimetres. Thus, a ratio of at least 10^6 is displayed in soil pore sizes. Soil pore size distribution directly influences many soil physical, chemical and biological properties. Characterization of soil structure may be achieved by pore size distribution analysis. There is not a unique method for determining soil pore size distributions all over the size scale. Mercury injection porosimetry and N_2 adsorption isotherms are techniques commonly used for assessing equivalent pore size diameters in selected ranges. The Hg injection technique provides pore size distributions in the range from about 50 nm to 100 μm, whereas N_2 adsorption isotherms may be used for finer pores ranging in size from about 2 to 500 nm. In this work, multifractal formalism has been used to describe Hg injection porosimetry and N_2 adsorption isotherms measured in a Mollisol and in a Vertisol with four different soil use intensities, ranging from native, never cultivated, land to continuous cropping. Three samples per treatment were analyzed resulting in a total of twelve samples per soil. All the Hg injection curves and N_2 adsorption isotherms exhibited multifractal behaviour as shown by singularity spectra and Rényi dimension spectra. The capacity dimension, D_0, for both Hg injection and N_2 adsorption data sets was not significantly different from 1.00. However, significantly different values of entropy dimension, D_1, and correlation dimension, D_2, were obtained for mercury injection and nitrogen adsorption experimental data. For instance, entropy dimension, D_1, values extracted from multifractal spectra of Hg intrusion porosimetry were on average 0.913 and varied from 0.889 to 0.939. However, the corresponding figures for N_2 adsorption isotherms were on average 0.507 with a range from 0.401 to 0.666. The entropy dimension D_1 is a measure of diversity and in our study case gauges the concentration degree of the pore size distribution on a specific pore size range. Values of D_1 for Hg injection curves were close to 1.00 and consequently they indicate more or less homogeneous pore size distribution pattern distributed over the range of pore sizes measured with this method. In opposite D_1 values for N_2 adsorption isotherms were much lower, which reflects clustering and indicates that most of the measure concentrates in a small size domain for finer pore scales. The use of multifractal indixes as indicators for characterizing soil structure and as well as for deriving soil physical properties is discussed.

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