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Multiscale characterization of pore size distributions using mercury porosimetry and nitrogen adsorption

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The soil pore space is a continuum extremely variable in size, including structures smaller than nanometres and as large as macropores or cracks with millimetres or even centimetres size. Pore size distributions (PSDs) affects important soil functions, such as those related with transmission and storage of water, and root growth. Direct and indirect measurements of PSDs are becoming increasingly used to characterize soil structure. Mercury injection porosimetry and nitrogen adsorption isotherms are techniques commonly employed for assessing equivalent pore size diameters in the range from about 50 nm to 100 μm and 2 to 500 nm, respectively. The multifractal formalism was used to describe Hg injection curves and N_2 adsorption isotherms from two series of a Mollisol cultivated under no tillage and minimum tillage. Soil samples were taken from 0-10, 10-20 and 20-30 cm depths in two experimental fields located in the north of Buenos Aires and South of Santa Fe provinces, Argentina. All the data sets analyzed from the two studied soil attributes showed remarkably good scaling trends as assessed by singularity spectrum and generalized dimension spectrum. Both, experimental Hg injection curves and N_2 adsorption isotherms could be fitted reasonably well with multifractal models. A wide variety of singularity and generalized dimension spectra was found for the variables. The capacity dimensions, D_0, for both Hg injection and N_2 adsorption data were not significantly different from the Euclidean dimension. However, the entropy dimension, D_1, and correlation dimension, D_2, obtained from mercury injection and nitrogen adsorption data showed significant differences. So, D_1 values were on average 0.868 and varied from 0.787 to 0.925 for Hg intrusion curves. Entropy dimension, D_1, values for N_2 adsorption isotherms were on average 0.582 significantly lower than those obtained when using the former technique. Twenty-three out of twenty-four N_2 isotherms had D_1 values in a relatively narrow range, from 0.518 to 0.666, but the remaining one exhibit a rather large D_1 value of 0,992. The entropy dimension, D_1, is a measure of diversity, so that it gauges the concentration degree of the pore size distribution on a specific pore size range. Therefore, Hg injection curves indicate a relatively homogeneous pore size distribution in the diameter range from 50 nm to 100 μm. In contrast, except for one of the studied samples, D_1 values for N_2 adsorption isotherms reflected clustering and indicated that most of the measure concentrates in a small size domain. The significance of multifractal indices for assessing differences in pore size distributions of the two study soil series under no tillage and minimum tillage was discussed.

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