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Entropy Characterization of Soil Pore Systems Derived from Soil Water Retention Curves

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The concept of entropy as a measure of randomness was used in soil science to characterize the distribution of particle sizes and pore configuration measured on images, and also to the development of soil horizons, the spatial structure of soil cover, and the evolution of landscape relief.

Previous studies have defined entropy of soil properties from discrete classes covering a particular range of measurements. Calculation of entropy from discrete classes require normalization to avoid the dependency of the result on resolution (number of intervals used) and it could be computationally demanding in cases of numerous class intervals. An alternative way to estimate entropy is from the parameters of probability density functions, which result in the estimation of entropy with analytical expressions that are function of the first two moments of a distribution. An advantage of such approach is that the impact of anthropogenic alterations of soil on each moment of a distribution and, in turn, on entropy can be distinguished.

The objective of this study was to estimate entropy of pore size distributions from the parameters of a water retention model, including the saturated (qs) and the residual (qr) water contents. The model assumes a log-normal distribution of pore sizes and characterizes a distribution with the geometric mean and the geometric standard deviation of pore sizes. The proposed concept was tested with water retention data and model parameters taken from published studies on soil degradation or soil structure regeneration.

Entropy values estimated from log-normal distributions are positively correlated with geometric mean, geometric standard deviation and with the difference between saturated and residual water contents (qs - qr). Assuming constant values of (qs-qr), entropy will tend to a maximum value when pore sizes (or size classes) have a uniform probability of occurrence and to a minimum value when only a single size class is present.

Entropy values derived from water retention increased with sand content and they were significantly greater in soil aggregates from the rhizosphere of three crops than in aggregates sampled away from the roots. Compaction decreased the values of entropy by decreasing the values of one or both parameters characterizing a pore size distribution. Entropy was also correlated to saturated hydraulic conductivity.

The proposed entropy function summarizes in one value the first two moments of pore size distributions making entropy a potentially useful measure of soil structure. Because of the additivity principle, this approach can be applied to n-modal pore size distributions as a superposition of n entropy values each representing a domain of pore sizes. The proposed approach is not restricted to a particular mathematical model of soil water retention.