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Fractal behavior and aggregation processes of humic acids in aqueous suspension as a function of concentration, pH, ionic strength and time

N. Senesi and F. R. Rizzi

Università di Bari, Bari, Italy, senesi@agr.uniba.it / Fax: +39-080-5442850 / Phone: +39-080-5442853

The fractal nature and fractal dimension of soil and peat humic acids (HAs) equilibrated for various lengths of time in dilute aqueous suspensions at various concentration, pH and ionic strength were determined by measuring their turbidity as a function of wavelength in association with particle size analysis and scanning electron microscopy (SEM). The main objective of the work was to relate the fractal dimension to the underlying morphological features and types of aggregation processes that characterize HAs in aqueous suspension under various conditions. The analysis of the power-law deopendence of the turbidity on the wavelength revealed that soil and peat HAs may exhibit either a nonfractal or a mass fractal nature. Peat HA could also be described as a surface fractal. The passage from one regime to another depended on the pH and equilibration time. With an increase of either factor, the mass fractal dimension of HAs decreased from about 2.8 to values close to 1.0. This trend, supported by SEM observations, suggested that HA particles in suspension evolved from compact, almost space-filled structures with smooth surfaces, to less compact, fragmented and elongated structures with increasingly rough and irregular surfaces as the pH or time increased. Low values of the mass fractal dimension measured at near neutral pH reflected an underlying aggregation process for HA particles, which could be described by a cluster-cluster reaction-limited aggregation (RLA) model. High values of the mass fractal dimension measured at acidic pH values suggested the occurrence of extended restructuribg and/or reconformation of HA macromolecules with an underlying diffusion-limited (DLA) model. The fractal dimension thus tepresents a numer-

ical parameter able to describe quantitatively the morphological features assumed by HA particles in suspension and to provide information on the ynderlying aggregation processes.