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Fractal Analysis of Hysteresis in Soil Water Retention Curves as Influenced by Surface Sludge Applications

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The impact of three types of surface applied sludge from the same lot (fresh, composted, and thermally-dried) on the water retention properties of a loam soil (Udic Calciustept) and a sandy soil (Typic Haplustalf) from central Catalonia (NE Spain) was investigated using fractal analysis. First, we proposed a composite fractal model that covers both the low and high suction regimes. This model has four fitting parameters: D_m (the mass fractal dimension), D_s (the surface fractal dimension), A_1 (a compound parameter that includes D_m, the density of water, bulk density, particle density, and the air/water displacement tension), and A_2 (a compound parameter that includes D_s, and the critical tension and water content separating the low and high suction regimes). This model was fitted to the main wetting and drying branches of soil water retention curves obtained from smalldisturbed samples using the chilled mirror dew point method. The equation fitted the data extremely well with adjusted R^2 values ≥ 0.99. Analysis of variance (ANOVA) was performed on the resulting parameter estimates. Few significant effects were observed for the sandy soil. In contrast, all of the model parameters, except D_m, were significantly affected by hysteresis and/or the sludge treatments for the loam soil. Values of A_1 and A_2 from the main drying branch were significantly higher than corresponding estimates from the wetting branch. This trend was reversed for D_s, indicating that pore surfaces are smoother after wetting, as compared to initially dry surfaces. The fresh, composted and thermally-dried sludge treatments all significantly increased the A_1 parameter relative to the untreated loam soil, possibly by decreasing bulk density. The fresh and thermally-dried sludge treatments also significantly increased the A_2 parameter. All three sludge types increased D_s relative to the control when this parameter was determined from the main wetting

branch of the water retention curve. In contrast, D_s estimated from the main drying branch were not influenced by any of the sludge treatments. These analyses indicate that the effects of sewage sludge on hysteresis of the soil water retention curve were still present two years after surface application in the case of the loam soil.