Modelling Bulk Density According to Structure Development: Toward an Indicator of Microstructure Development in Ferralsols.

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Ferralsols have a ferralic horizon at some depth between 30 and 200 cm that results from long and intense weathering. Their clay fraction is usually mainly low-activity clay consisting of kaolinite with hematite, goethite and gibbsite in different proportions. Ferralsols show little or no horizonation, and their macrostructure is absent to moderate. On the other hand, they have typically a strong microstructure consisting of microaggregates < 1 mm in size. Because of the lack or small development of macrostructure, porosity of Ferralsols is closely related to the development of microstructure and the assemblage of elementary particles within the microaggregates with a small contribution of large pores resulting from root development and macrofaunal activity. Their physical properties are then closely related to the development of this microstructure. However, there is still no model in the literature that predicts changes of microstructure of these soils using easily accessible soil properties when land-use is modified. The objective of this work was to relate microstructure development to the bulk density (D_b) in Ferralsols and then to make possible the use of D_b as an indicator of microstructure development.

Ferralsols under native vegetation and cultivated pasture were sampled in the Brazilian Cerrado region. Bulk density, sand, silt, and clay content and aggregate size distribution were measured from the surface to 1.6 m depth with increments of 0.1 m. Thin sections were prepared from undisturbed samples collected at different depths and backscattered electron scanning images (BESI) were generated.

Results showed that clay content ranged from 18.6 to 79.8 % and bulk density between 0.80 and 1.25 g cm^{-3} among the 108 samples studied. Visual assessment of BESI showed that soil material corresponded to either microaggregates (0.1 to 0.5 mm in size) in loose arrangement or to microaggregates in close arrangement forming much larger aggregates (> 5 mm). From calculations with D_b we demonstrated that the pore volume of the microaggregates (V_p in cm^3 g^{-1}) can be described by a single linear relationship with the clay content whatever the type of microaggregate arrangement and land use (V_p = 0.003 %clay + 0.0029, R^2 = 0.99). Accurate analysis of the microaggregate size showed that 96.2 and 95.7 % of microaggregates were < 0.8 mm with 73.2 and 95.7 % between 0.1 and 0.5 mm under native vegetation and pasture, respectively. The mass proportion of microaggregates in loose arrangement was estimated for a subset of clayey Ferralsols using the < 0.8 mm soil material that was obtained by dry sieving ($\Phi_{<0.8}$). Linear regression coefficients were calculated for the relationship between $\Phi_{<0.8}$ and the reciprocal of bulk density ($1 / D_b$) ($\Phi_{<0.8} = 1.97\ (1 / D_b) - 1.52$, R^2 = 0.82), assuming no interaction between microaggregates in loose arrangement and those in close arrangement forming the aggregates > 5 mm in size. The porosity of these two arrangements was estimated as 0.71 and 0.51, respectively.

Thus, D_b can then be used as single indicator of microstructure development in clayey Ferralsols with 70 < clay content < 80 %. For Ferralsols with a smaller clay content, D_b corrected by the clay content can also be used as an indicator of microstructure development. Thus, whatever the clay content, D_b might be discussed in term of consequences of agriculture practices on microstructure development, making easier to infer consequences for other physical properties such as resistance to penetration, water retention and hydraulic conductivity.