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Partitioning of primary and secondary soil particles by ultrasonic energy: consequences for microstructure organization

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The unclarity of terminology and the absence of unifying concepts of soil structure organization based on unified methodological principles hinder the development of ideas about soil functioning and subsequent applications. Goal of this presentation is a theoretical distinction and experimental confirmation of such terms as primary soil particles, elementary soil particles and microaggregates.

This goal can be pursued by combining the physical and morphological approaches. Nine soils (each with 3-9 horizons) contrasting in their soil-forming processes, parent materials and texture were studied. Microaggregate resistance was assessed by ultrasonic dispersion energy from 65 to 1101 J/ml (12 levels in total) by horn type disruptor. The output of ultrasonic power was calibrated calorimetrically. Soil samples pretreated with different energies were analysed for particle size distribution by laser diffractometry and by scanning electron microscope. For most of soils, microaggregates disruption ceases until the energy of 450 J/ml - clay content (<2 μm, %), sum of particles <10 μm and median particle size have reached a plateau. Exceptions are samples from middle and lower parts of Ferrasols, where even at higher energy levels a further segregation continues to evolve. The soils were separated in two groups based on their resistance to ultrasonic energy. Disruption of soil samples with sustainable microstructure was described by power equation MWD=AE^B (R^2 from 0.79 to 0.95), where MWD – mean weighted diameter (μm) of soil particles, E – ultrasonic energy (J/ml). Parameters A and B reflect the strength of microaggregates bounds. Strong links with total carbon and iron was absent. For some soil samples characterised by unsustainable for ultrasonic dispersion microstructure (Podzols, Albeluvisols, Phaeozem and B horizon of Chernozem) maximum yield of particles <10 μm was common already after minimal energy impact (65 J/ml) and the MWD immediately becomes stable. Microscopic investigations of Chernozems' samples have shown that particles <20 μm are clay complexes with 3D structure. Samples of Rustic Podzols formed on weathering products of quartzite–sericite schist have a fragile structure and break rather then segregate by strong ultrasonic dispersion. Profile distributions of particles after pretreatments for removing binding agents were also received, by which were described features of soils microstructure organization. We propose the notion of primary and secondary soil microstructure. Primary soil particles are the individual lithomatrix grains. Elementary soil particles (ESP) - solid-phase pedogenic products consisting from lithomatrix grains, amorphous organic (e.g. specific organic compounds) and inorganic (e.g. Si and Fe oxides) compounds, bound together by physicochemical and chemical interactions. The threshold ultrasonic dispersion energy to separate ESP from microaggregates is 450 J/ml. The distinction of specific aggregation mechanisms is difficult and requires further studies. Soils with primary microstructure (Podzols, sandy soils) can be dispersed into individual grains without removing of binding agents. Soils with secondary microstructure have a well developed organization (Ferrasols, Chernozems) represented by various types of ESPs and microaggregates.