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Effect of density cut-offs and sonication energy on organic matter density fractionation

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The physical separation of soil organic matter (OM) into discrete fractions aims at rendering a complex mixture into pre-defined pools which should differ by their turnover time, functions in the soil system and/or interaction with minerals. A widely used approach is based on the different density of OM and minerals and has also been combined with the application of ultrasound in order to disrupt aggregates and release the OM occluded therein. In spite of these common rationales, many different density fractionation schemes have been developed and used, obtaining a wide range of so-called "light", "occluded" and "heavy" OM fractions hardly comparable both on quantitative and qualitative terms.

In order to spotlight the differences resulting from variations in the two main parameters of the density fractionation method, i.e., density cut-off and dispersion energy, we fractionated the same soil sample at four Na polytungstate solution densities (1.4, 1.6, 1.8, and 2.0 g cm^{-3}) and three ultrasound intensities (calibrated to 50, 175, and 300 J mL^{-1}). At each density the OM was separated into: (a) one light non-occluded fraction, (b) three light occluded fractions released upon ultrasound applications, and (c) one heavy mineral-associated fraction. For all the fractions, we determined the weight recovery, total organic C and N, and lignin-derived phenols.

The data show remarkable effects of both density and ultrasound intensity on the weight recovery and C content of all the fractions separated. Increasing the density from 1.4 to 1.6 g cm^{-3} enhances light fraction separation as deduced by the congruent increase of weigh and C content. Further increase in densities can cause the floating of mineral particles, with attached OM, which results in a dilution of C content but also in an overestimation of the non-occluded and occluded light OM. The effect is amplified by the higher ultrasound applications.

The lignin analysis shows progressively higher proportion of more oxidized phenols being recovered in the lighter fractions with increasing density and applied energy, further indicating that the combination of high densities solution with high ultrasound intensities favours the dispersion and flotation of organic-mineral associations. Moreover the phenol composition of the occluded light fraction obtained at 300 J mL^{-1} suggests partial OM release from minerals and re-adsorption on newly available surfaces.