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Methodological issues concerning the application of reliable laser particle sizing in soils

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During the past decade, the evolution of technologies has enabled laser diffraction (LD) to become a much widespread means of particle size distribution (PSD), replacing sedimentation and sieve analysis in many scientific fields mainly due to its advantages of versatility, fast measurement and high reproducibility.

Despite such developments of the last decade, the soil scientist community has been quite reluctant to replace the good old sedimentation techniques (ST); possibly because of (i) the large complexity of the soil matrix inducing different types of artefacts (aggregates, deflocculating dynamics, etc.), (ii) the difficulties in relating LD results with results obtained through sedimentation techniques and (iii) the limited size range of most LD equipments.

More recently LD granulometry is slowly gaining appreciation in soil science also because of some innovations including an enlarged size dynamic range (0,01-2000 μm) and the ability to implement more powerful algorithms (e.g. Mie theory). Furthermore, LD PSD can be successfully used in the application of physically based pedo-transfer functions (i.e., Arya and Paris model) for investigations of soil hydraulic properties, due to the direct determination of PSD in terms of volume percentage rather than in terms of mass percentage, thus eliminating the need to adopt the rough approximation of a single value for soil particle density in the prediction process.

Most of the recent LD work performed in soil science deals with the comparison with sedimentation techniques and show the general overestimation of the silt fraction following a general underestimation of the clay fraction; these well known results must be related with the different physical principles behind the two techniques. Despite these efforts, it is indeed surprising that little if any work is devoted to more basic methodological issues related to the high sensitivity of LD to the quantity and the quality of the soil samples.

Our work aims to both analyse and to suggest technical solutions to address the following key methodological problems: (i) sample representativeness due to the very small amount of soil sample required by LD (e.g. 0,2 g) as compared to ST (e.g. 40 g for densimetry); (ii) PSD reading variability caused by the large number of instantaneous reading on a very small volume of the solution, (iii) the varying soil mineralogy that in turn produce varying refractive indexes affecting PSD results, (iv) the determination of the mass density of the soil samples to compare results with those obtained from ST.

Our results, referring to many different soil types (Vertisols, Regosols, Andosols, Calcisols, Luvisols) show that the listed major technical problems can be successfully addressed by the following set of solutions: (i) adequate subsampling in both solid and liquid phases (including a setup of a dilution system); (ii) preliminary study of the PSD variability to reasonably increase the number of readings per each sample; (iii, iv) preliminary sensitivity analysis of both refractive indexes and mass density in accordance to the specific soil mineralogy.