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How to interpret rheometry, an innovative technique in soil physicochemistry, correctly – explained by critical users

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In soil physics some new methods were developed in the past years, e.g. with regard to observe soil structure non-invasively by means of micro-computed tomography, while the range of methods that investigate a soil's behavior in motion, e.g. under the impact of mechanic stresses, was enlarged by rheometry. The adjustment to the specific conditions of soil as a relatively dry and heterogeneous media opened a new field compared to the materials under investigations till then, like concrete or clay dispersions. The potential of this methodology is not fully appreciated yet which we would like to change with the help of our findings and the deduced guidelines.

Rheology itself has been making part of soil science already for many years; however, the technical investigation was mostly done at a large scale, by means of triaxial shear or shear frame or compression tests etc. The corresponding measuring device, the rheometer, hence was tested and developed by and for the industries of food, cosmetics, paintings and coatings and only quite recently found to be applicable to soil also. The most interesting aspect was the possibility to combine soil physics with soil chemistry, namely to relate the behavior of soil under mechanical stresses to chemical interactions like e.g. particle charge and friction between single particles by means of an amplitude sweep test. Meanwhile, many different soils of different texture, organic matter and oxides and hydroxides content, and fertilization levels have been investigated at different matric potentials and allowed for a comparatively broad classification system. Therewith, the microstructural stability of a given soil by means of stiffness degradation during an amplitude sweep test can be categorized as a function of texture and matric potential.

The micro scale soil stability furthermore influences the processes and thus soil structural stability at larger scales, which supports the investigations of relationships between different scales. Transferability to field situations is given due to the character of the mechanic stress which equals those appearing e.g. under a tractor tire exerting vibrating, compressing and shearing forces. Unfortunately, the multiple results of this single test can impede the use of rheometry as their interpretation requires intensive data analysis. By pointing out the single results and their meaning for soil structure, we aim at facilitating the use of rheometry. We also suggest moderate alterations to take into account more strongly the vertical compression of soil for a more comprehensive implementation of a micro shear test. Additionally, we point out further uses of a rheometer in soil physics, which is the viscosity, i. e. the ability of a fluid to penetrate into a porous system and to be relocated within. Herewith, quite complex fluid characteristics, e.g. of animal manure, anaerobic digestates, but also pesticides in aqueous solution, root mucilage etc. can be determined and applied as improved, because more detailed, model parameters in soil water transport.

As a conclusion, our contribution aims at further promoting a promising method for investigating the fundamentals of soil physics at the interface to soil chemistry.