Speciation of sulphur in soils

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Sulphur moves freely within lithosphere, hydrosphere and atmosphere. It is an important element in soils, highly reactive, existing in various oxidation states, and an indispensable nutrient for plants and microorganisms. The soil environment is the primary component of the biogeochemical sulphur cycle. The speciation of sulphur is intimately related to the physico-chemical conditions of the soil environment, such as Eh and pH. Changes are caused by pedogenic and anthropogenic processes and result in changes of soil properties.

In strong contrast to this enormous relevance of sulphur in soils, the status of current methods of chemical analysis for its speciation until recently was highly unsatisfactory. Wet chemical methods can only distinguish total soil sulphur into operationally defined fractions, which only in rare cases can be exactly assigned to a specific S species. Moreover, with conventional methods different sulphur forms can only be assessed for bulk soil samples, but not with spatial resolution. The solution is X-ray spectromicroscopy as a combination of high spectral and high spatial resolution. It allows for a characterization of associations of soil colloids and soil micro habitats regarding structure, sulphur speciation and differences within and between associations.

The aim of the studies presented here is a clear determination of specific sulphur species in soils under varying chemical conditions. A podsol-gleysol-histosol catena representing a hydrological gradient within a small forested watershed has been studied. Here the groundwater level is found in different distances from the soil surface, so the relevance of anaerobic sulphur species strongly increases from podsol to histosol. The intermediate energy scanning X-ray microscope at beamline 2-ID-B of the Advanced Photon Source in the Argonne National Laboratory has been used for these spectromicroscopy studies. Four different sites and four different depths per site have been probed resulting in sixteen sample positions. This documents the entire soil profile including all horizons from the forest floor down to the solid bedrock. A matrix showing the resulting spectra visualizes clearly differences and similarities and will be presented and discussed in detail as well as spatially resolved data. The results presented here prove that it is possible to successfully apply spectromicroscopy even to samples with low total sulphur content. Moreover, spatially resolved studies allow for characterization of associations of soil colloids and soil micro habitats regarding structure and sulphur speciation.