

## Modelling plant-soil interaction: From the soil particle and fungal scale to root scale

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In this talk I will present models that deal with plant nutrient uptake and the role plant exuded organic acids and mycorrhizae can have on this process. I will begin by describing our recent work on modelling exudation of 2'-deoxymugineic acid (DMA) and the effect this has on plant acquired zinc. We assume that DMA and zinc are both present in two forms in the soil, in the soil solution phase and bound to the soil particles. We will develop a model that describes this competitive binding reaction and then link it up to a model for plant exudation and zinc uptake. In particular we will investigate the effect of the diurnal DMA exudation pattern on the zinc uptake. The second model I will describe deals with the uptake of nutrients, such as phosphate, that in addition to binding to the soil particle surfaces can also diffuse into the soil particle micropores and bind to their internal surfaces. This leads to a so called dual porosity models for the soil and we will show how the results for nutrient uptake by plants differ when one considers simple particle surface binding in comparison to dual porosity nutrient binding. We find that the results are qualitatively and quantitatively very different. This highlights the need for the simultaneous measurement of soil properties and root nutrient uptake properties. A third model I will discuss deals with modelling the effect mycorrhizae have on phosphate uptake by plants. We consider the phosphate movement within the soil, uptake by roots and fungus, and transport of phosphate within the fungus to the root surface. We find that the model predictions for phosphate depletion profiles in the soil differ significantly for two plausible and experimentally reported fungal phosphate uptake rates. Whilst both depletion profiles have support within the literature clearly, only one of them has to be correct. I will suggest a controlled experiment which has not yet been performed that can decide between the two scenarios.

## Binding of uranium to organic-rich soils in an alpine region in Switzerland

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Naturally occurring uranium was found at extremely high concentrations (up to 7,000 ppm) in a soil of the alpine region (Dischma valley), in Grisons, Switzerland. The goal of this study was to characterize the binding of uranium to the soil matrix and to determine its redox state in order to assess the potential for uranium mobilization. Pore water profiles collected from Dischma soil revealed the establishment of anaerobic conditions with increasing soil depth. A combination of chemical extraction methods and spectroscopy was applied to characterize the redox state and binding environment of uranium in the soil. Bicarbonate extraction under anaerobic conditions released most of the uranium (> 63 %) indicating that uranium occurs predominantly in the hexavalent form. Surprisingly, the uranium speciation did not vary greatly as a function of depth. This was confirmed by X-ray absorption near edge spectroscopy (XANES), which indicated that U was present as a mixture of U(VI) and U(IV) with U(VI) dominating. A soil sequential extraction method revealed that the majority of uranium was released concomitantly with soil organic matter. Extended X-ray absorption fine structure (EXAFS) spectroscopy revealed that uranium in the soil matrix is octahedrally coordinated with two axial (at 1.77 Å) and six equatorial oxygen atoms (at 2.36 Å) indicating a short-range uranyl-like (UO<sub>2</sub><sup>2+</sup>) structure. An additional EXAFS signal (at about 3.2 Å), as identified in some spectra, showed that uranium was also bound to a light element such as carbon, phosphorus or silicon.