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Contribution of neutron imaging to assess key processes at the root-soil interface

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Imaging with neutrons has been shown the last years to be a powerful and precise tool to address not only water content dynamics in soil and sediments, but also to identify and track root structures and root growth. The recent developments have seen a special focus on zooming into the root-soil interface, but also to broaden the perspective by introducing additional methodological procedures for neutron imaging or by coupling to other imaging techniques.

The latter is, for example, aiming to measure life-controlling parameters such as oxygen and pH dynamics in the soil ecosystem. For that aim we coupled neutron radiography with novel fluorescence imaging techniques to study the dynamics of these two essential biogeochemical parameters in the root-zone of plants in combination with water content. Measuring the real-time distribution of water, oxygen concentration and pH enables us to understand where the active parts of the roots are located in respect to water uptake, respiration and output of acids or bases. Roots performance itself is variable as a function of age and local conditions such as water and oxygen availability in soil, and the same is true for micro-organisms living in the root-zone. It is technically challenging to monitor these dynamics in such a small distance from the roots without disturbing them. Moreover, this process network with various links and feed-backs can be interpreted the better, the more aspects of the root-soil interaction can be assessed in the same sample during a particular period of time. We will present results of thin boron-free glass containers filled with fine sand of different grain sizes (inner size 10cm x 10cm x 1cm) with a growing lupine plant, and a built in sensor foil for O2, during night and day cycles of different water content and oxygen deficit.

Another focus is on the spatial distribution of water uptake in the root system. Several factors, e.g. modified hydraulic properties of the soil around the roots, vary along the root system and may change with time. To address the spatial heterogeneity of root water uptake and its reasons water balances and water fluxes need to be quantified for different sections of the root system. One approach here is the hydraulically separate parts of the root system, to allow for local water balances by neutron radiography. Another is to visualize water movement by adding substances that can act as neutron radiography tracers, for example heavy water or Gadolinium complexes. These approaches have to be tested to judge their ability to quantitatively determine water fluxes from soil into the root, or even the other way round.

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