Determining pH-gradients and CO_2-O_2-dynamics in the capillary fringe of a meso-scaled lysimeter approach with different soil types by planar optodes

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Radionuclides originating from deep geological nuclear waste repositories may enter the biosphere and the food chain via the groundwater-soil pathway. This carries the risk of an accumulation of toxic elements in the food chain, resulting in potential harm for humans. Assessing the transport and accumulation behaviour of radionuclides and their homologues from groundwater into soils under different assumed future climatic evolutions is therefore crucial and the aim of the Federal Ministry of Education and Research (BMBF) funded project Trans-LARA (www.trans-lara.de).

A 12-month lasting mesoscale laboratory lysimeter experiment was set up in a climate chamber using four different soils, all with a simulated shallow groundwater-table. Two soils are representatives for the pedogenesis under different climate scenarios in Germany. The lysimeters are equipped with conventional probes for monitoring of physico-chemical parameters as well as suction cups for soil-solution sampling. A novel approach in this project is the setting of three different planar chemical-optical sensors, so-called optodes (VisiSens TD system, PreSens GmbH). Those allow quasi-simultaneous, continuous measurements of pH, O_2 concentrations, and CO_2 partial pressures over the whole depth of the soil columns with a spatial resolution of 150 µm. Therefore, a new protocol for routine measurements and the calibration of the optodes using custom-build calibration-vessels was established. The data evaluation procedure was developed on the base of the PreSens-software in combination with freeware to achieve a semi-automated image-interpretation and processing in order to avoid time-consuming point-and-click data treatment. The workflow for the measurements and the calibration will be presented and the results will be discussed critically with respect to the usability and durability of the optodes in comparison to the conventional in-situ probes installed in the lysimeters. Furthermore, based on the spatially resolved Eh and pCO_2 conditions the speciation of Se, Tc, Th, U, Np, Pu, and Am that are critically depending on these parameters, will be evaluated.