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Micro-scale redox gradients in the saturated zone and their implications for hydrochemical process studies

G. Lischeid (1), C. Alewell (2), and S. Paul (3)

(1) University of Bayreuth, Germany (gunnar.lischeid@bitoek.uni-bayreuth.de), (2) University of Basel, Switzerland, (3) University of Göttingen, Germany

Water samples from water-logged soils often reveal considerable spatial heterogeneity. However, we found some evidence that micro-scale gradients that cannot be resolved by the standard sampling techniques might be more crucial for understanding solute transport and turnover processes. The saturated zone of the riparian zone in the Lehstenbach catchment was sampled at biweekly intervals via groundwater tubes and suction cups during a three years period. Although the devices were installed close to each other and at the same depth, concentrations of most solutes differed significantly depending on the type of sampling device. In general, groundwater tube samples systematically resembled more those of suction cups in more shallow depth, indicating less reduced conditions and shorter residence time compared to suction cup samples from the same depth. Moreover, groundwater tube samples exhibited clear and similar seasonal patterns of solute concentration, but corresponding patterns could not be identified in suction cup samples. Last but not least, stormflow response of a nearby channel indicated a significant contribution of groundwater tube-like water rather than suction cup-like water. We conclude that, analogously as has been described for the saturated zone, suction cups sample more of the immobile fraction of the soil water compared to the groundwater tubes. Consequently, suction cup water samples are much more affected by redox processes than groundwater tube samples from the same depth, but only the latter represent the fraction of water that is mobilized and transported to the stream during stormflow. These findings helped considerably to better understand the hydraulic connections between saturated zone processes and the stream.