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Mobile matter in the aeration zone of the Hainich Critical Zone Exploratory: First results from one-year monitoring by employing novel drain collectors

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Biogeochemical processes in the aeration zone (AZ) may severely affect the fluid flow, composition, and the amount of mobile matter. The AZ is a subsurface part of the Critical Zone (CZ) that connects the soils sensu stricto (SSS) with the aquifers. Depending on the groundwater dynamics, the fluid transiting in the AZ is not only recharged by the ascending seepage, but also by upwelling groundwater. Since the collection of fluids is a rather demanding task, fluid migration and matter transport have not been considered in CZ research so far. To address this research gap, we developed novel drain collectors and installed twenty of them within four different lithologies in the fractured carbonate AZ of the Hainich Critical Zone Exploratory (Hainich CZE) in central Germany. Drainage sampling was done on a regular monthly basis with additional event-based sampling. Size, chemical composition, and physio-chemical properties of the aqueous samples were analyzed by a range of spectroscopic, chromatographic, and microscopic techniques.

The amount of drainage water varied extremely between the locations and lithologies. We attribute this both to the foremost migration pathway operative (i.e., fractures, fluid flow regime, fracture flow, and film-flow) and to the different spatial extents of the “capture zones” that recharge the drainage collectors. For all lithologies, pH and EC were found to be independent of the lithology with rather high contents of organic carbon and showed significant differences between the hydrological summer and winter season. Significant amounts of colloids and larger suspended particles of calcite, clay minerals (Illite), and quartz were identified in almost all samples. While the general hydrochemistry seems to be controlled by the biogeochemical processes in the topsoils, we presume that the percolating water collects the mobilizable materials from exposed interfaces in the AZ. These materials are made “susceptible” to release and transport by weathering within the AZ during the periods of no flow. Additionally, upwelling groundwater may also be replenished the inventory of mobilizable materials in the AZ. Our study suggests that the AZ is not just an “inert” transition zone, but has to be considered as a biogeochemical reactor that may severely alter the seepage composition and properties, and thus the groundwater recharge.