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Event-driven mobilization of dissolved and colloid-associated heavy metals and radionuclides in AMD-influenced shallow groundwaters in a former Uranium mining area in Germany

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The mobilization of heavy metals and radionuclides in soils and groundwater systems can be facilitated by association with mobile organic or inorganic natural colloids and can be further amplified by infiltration of low ionic strength meteoric waters [1]. The test site 'Gessenwiese', located in Eastern Germany, is influenced by acid mine drainage (AMD) and characterized by moderate contamination with heavy metals (HM)/ radionuclides (RN) due to former Uranium mining [2]. On site, bioremediation strategies combined with bioenergy production were implemented within the BMBF-funded USER-II project. The addition of calciferous soil substrate combined with microbial inoculation (mycorrhiza & *Streptomyces*) has led to an increased soil pH as well as reduced mobility of HM/RN within the soil. This study aims to elucidate event-driven mobilization and transport dynamics of dissolved and colloid-associated HM/RN in the < 0.45 µm and < 1 kDa fractions of shallow groundwater from 2020 to 2022. A special focus was the quantification of DOC and specific organic fractions known to exhibit colloidal characteristics using Liquid Chromatography - Organic Carbon Detection (LC-OCD). Median particle concentrations of 3E+07 particles/mL with a median size of 134 nm were determined by Nanoparticle Tracking Analysis (NTA) and SEM imaging. DOC concentrations between 0.8 mg/L and 5.4 mg/L in groundwater were detected. A median pH of 4.7 and median molecular weight of 369 g/mol of the humic substances fraction derived from LC-OCD pointed towards the presence of fulvic acid-like substances. Ultrafiltration revealed that a large percentage of the HM/RN are either truly dissolved or associated with organic fulvic-like compounds in the < 1 kDa fraction. A rain event in September 2022 led to a short-term 10-fold increase in nanoparticle concentrations with a median size of 192 nm. These results highlight the importance of colloid-associated transport of HM/RN in this area, especially during heavy precipitation events.

[1] Kretzschmar, R. and Schäfer, T. (2005). *Elements* 1, (4), 205-210.

[2] Grawunder, A., et al. (2009). *Chemie der Erde-Geochemistry* 69, 5-19.