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Impact of a CO_2 leak on the release of trace elements in a shallow carbonated freshwater aquifer in relation to hydrodynamic conditions

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The present work is part of the "Aquifer-CO_2-Leak" project funded by ADEME, which evaluates the impacts of CO_2 leakages from a geological storage site on aquifers and develops new monitoring tools and methodologies. This study aims to characterize, quantify, and model the geochemical impacts of CO_2 leakages on a shallow freshwater carbonated aquifer during two extreme hydrogeological contexts to evaluate the importance of the hydrodynamics conditions.

Two CO_2-rich-water leak experiments were carried out in a shallow freshwater carbonate aquifer during low and high-water levels periods respectively in July 2019 and June 2020 at the Saint-Emilion experimental site (France) [1]. These experiments have been performed within an Oligocene carbonate underground quarry of around 25-meter-thick which shows wackestone to grainstone facies, with values of porosity from 20 to 43%, permeability between 1 and 26D and a very high calcite content (98 ± 2% $CaCO_3$). In each time, a volume of 200 L of gasified water was introduced into the aquifer upstream of the hydraulic gradient. The monitoring of the plume was conducted thanks to seven observation wells lined up with the hydraulic gradient and equipped with CO_2 and physicochemical parameters probes. Water has been sampled at regular intervals to determine the concentrations of major ions and trace elements.

Results showed that the dissolution of calcite occurred with the increase of concentrations of dissolved CO_2, (also showed by calcium concentration and electrical conductivity increase as the pH values decreased), but the strong dilution effect during the high-water level period mitigated the effect of the leak and its detection. Major and trace element concentrations also increased, but peak concentrations are significantly lower in the high-water level experiment and stayed under the exceed WHO/UE drinking water standards. Also, the path taken by the plume was different during the two experiments, highlighted the preferential pathway into the aquifer explain this by the physical heterogeneity (permeability and transmissivity) at a high scale. These results show the importance of setting up a monitoring strategy adapted to each hydrogeological context in order not to miss a leak.

[1] Rossi et al., 2022. IJGGC. 114:103561. https://doi.org/10.1016/j.ijggc.2021.103561, and references theirin.