Geochemical sensitivity to CO2 leakage in shallow aquifers

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Interest continues to increase in carbon (CO₂) capture and storage (CCS), particularly from large point sources such as power plants, transporting it and storing it in deep saline formations (DSF) for mitigation of greenhouse gasses. However, concern has been voiced about CO₂ leakage into overlying aquifers through preferential pathways, such as faults and active and abandoned wells, potentially impacting overlying aquifers. Hence, monitoring groundwater chemistry in overlying aquifers is one of the options for CO₂ leakage detection. Several geochemical parameters (groundwater pH, bicarbonate concentration, dissolved CO₂, alkalinity and dissolved inorganic carbon) have been proposed as indicators. However, it is unclear how these geochemical parameters are sensitive to CO₂ leakage.

In this study, a generic model was used to simulate CO_2 leakage into different aquifers which have different mineralogy (quartz only, quartz + albite, quartz + calcite). Three set of groundwater chemistry data were selected in the model from the SACROC shallow aquifer in Western Texas, the Cranfield shallow aquifer in Mississippi, and a shallow aquifer in Montana, representing a wide variety of groundwater chemistry in USA. PHREEQC developed by USGS was used to simulate interactions among water, rock and CO_2 and the sensitivity of each geochemical parameter was then calculated from the modeling results.

It appears that dissolved inorganic carbon and dissolved CO_2 show strong sensitive to CO_2 leakage and independent of presence of carbonate in the aquifer sediments. Sensitivities of alkalinity and pH to CO_2 leakage depend on whether carbonates are present in the aquifer sediments. Modeling results suggest that initial groundwater chemistry shows minor impacts on geochemical sensitivity to CO_2 leakage. Geochemical sensitivity to CO_2 leakage evaluated with the generic model is compared with a field test where newly-developed sensors is installed for monitoring real-time dissolved CO_2 and pH in shallow aquifers.