Potential impacts on groundwater resources of deep CO2 storage: natural analogues for assessing potential chemical effects

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Carbon dioxide Capture and Storage (CCS) is considered as one of the promising options for reducing atmospheric emissions of CO_2 related to human activities. One of the main concerns associated with the geological storage of CO_2 is that the CO_2 may leak from the intended storage formation, migrate to the near-surface environment and, eventually, escape from the ground. This is a concern because such leakage may affect aquifers overlying the storage site and containing freshwater that may be used for drinking, industry and agriculture.

The IEA Greenhouse Gas R&D Programme (IEAGHG) recently commissioned the CO2GeoNet Association to undertake a review of published and unpublished literature on this topic with the aim of summarizing 'state of the art' knowledge and identifying knowledge gaps and research priorities in this field. Work carried out by various CO_2GeoNet members was also used in this study.

This study identifies possible areas of conflict by combining available datasets to map the global and regional superposition of deep saline formations (DSF) suitable for CO_2 storage and overlying fresh groundwater resources. A scenario classification is developed for the various geological settings where conflict could occur. The study proposes two approaches to address the potential impact mechanisms of CO_2 storage projects on the hydrodynamics and chemistry of shallow groundwater. The first classifies and synthesizes changes of water quality observed in natural/industrial analogues and in laboratory experiments. The second reviews hydrodynamic and geochemical models, including coupled multiphase flow and reactive transport. Various models are discussed in terms of their advantages and limitations, with conclusions on possible impacts on groundwater resources. Possible mitigation options to stop or control CO_2 leakage are assessed. The effect of CO_2 pressure in the host DSF and the potential effects on shallow aquifers are also examined. The study provides a review of CO_2 storage-specific regulations in the main countries undertaking CCS evaluation and research. It aims to identify the constraints imposed by existing regulations on the protection of groundwater resources and highlight the inconsistencies and gaps between CCS regulations and Water Protection regulations.

The present paper focuses specifically on potential risks on groundwater quality caused by CO_2 storage in DSF assessed via natural CO_2 analogues from both the literature and detailed European case studies (France, Italy, Germany, Denmark).