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Potential impacts on groundwater resources of deep CO2 storage

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Research into carbon dioxide (CO2) geological storage has been carried out over two decades, as part of studies to evaluate the feasibility of Carbon Dioxide Capture and Storage (CCS). Recently, there has been an increasing focus on potential impacts to surrounding geological formations and particularly, shallow aquifers and associated potable groundwater resources. Potential leakage of CO2 in supercritical and gaseous form from onshore or near-shore deep saline formations (DSF), or of the associated formation brines, is frequently cited as a key risk scenario for the overlying or neighbouring shallower groundwater. To date, the impact of CO2 storage has mainly been studied at near-well and reservoir scale, whereas risks in the context of regional multilayered groundwater systems have not yet been systematically assessed. Recent studies have begun to address this topic, using hydrodynamic and geochemical modelling approaches, and have identified several potential mechanisms that can lead to negative impact on groundwater quantity and/or quality.

The IEA Greenhouse Gas R&D Programme (IEAGHG) recently commissioned the CO2GeoNet Association to undertake a literature review and unpublished original work on this topic, with the aim of summarising 'state of the art' knowledge and identifying knowledge gaps and research priorities in this field.

This paper is a summary of this report. As a first step, possible areas of conflicts between potential DSF CO2 storage and overlying freshwater aquifers have been identified by combining available datasets to map the global and regional juxtaposition of groundwater resources and potential CO2 storage sites. A scenarii classification has been developed for the various geological settings in which conflicts could occur, with testing of this method being conducted for Europe where groundwater resources and potential CO2 storage sites are relatively well documented. Two approaches have been used to address potential impact mechanisms of CO2 storage projects on the hydrodynamics and chemistry of shallow groundwater. The first approach classifies and synthesises observations of water quality changes obtained in natural or industrial analogues, and in laboratory experiments. The second approach reviews hydrodynamic and geochemical models, including coupled multiphase flow and reactive transport, with the aim of linking leakage scenarios to possible impacts on groundwater resources. Various models are discussed in terms of their advantages and limitations, with conclusions obtained from case studies. Possible mitigation options that could be implanted to stop or control CO2 leakage from the storage formation to the surrounding geological strata have been assessed. In particular, the effect of CO2 pressure in the host DSF and potential effects on shallow aquifers have been examined. In the literature, such options are mainly addressed through modelling. Techniques for proper and effective mitigation of the impact of stored CO2 on fresh water resources have been identified.