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Potential environmental impacts of offshore UK geological CO_2 storage

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Geological carbon dioxide storage in the United Kingdom (UK) will almost certainly be entirely offshore, with storage for over 100 years' worth of UK CO_2 output from industry and power generation in offshore depleted hydrocarbon fields and sandstone formations.

Storage capacity can be limited by the increase in formation water pressure upon CO_2 injection, therefore removal and disposal of formation waters ('produced waters') can control formation water pressures, and increase CO_2 storage capacity. Formation waters could also be produced during CO_2-Enhanced Oil Recovery (CO_2-EOR). The precedent from current UK North Sea hydrocarbon extraction is to 'overboard' produced waters into the ocean, under current regulations.

However, laboratory and field scale studies, with an emphasis on the effects on onshore shallow potable groundwaters, have shown that CO_2 dissolution in formation waters during injection and storage acidifies the waters and promotes mobilisation from the reservoir sandstones of major and trace elements into solution, including heavy metals. Eight of these elements are specifically identified in the UK as potentially hazardous to the marine environment (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn).

A comparison was made between the concentrations of these eight trace elements in the results of laboratory batch leaching experiments of reservoir rock in CO_2-rich saline solutions and overboarded waters from current offshore UK hydrocarbon production. This showed that, taking the North Sea as a whole, the experimental results fall within the range of concentrations of current oil and gas activities. However, on a field-by-field basis, concentrations may be enhanced with CO_2 storage, such that they are higher than waters normally produced from a particular field. Lead, nickel and zinc showed the greatest concentration increases in the experiments with the addition of CO_2, with the other five elements of interest not showing any strong trends with respect to enhanced CO_2.

The origin of the increased trace element concentrations was investigated using sequential leaching experiments. The analysis of the experimental results showed that prediction of trace element release from sandstones with weak CO_2-acid leaching is difficult. However, the experiments did show that carbonate and feldspar mineral dissolution was a primary source of these elements, where mobilised, regardless of their abundance within the sandstone.

While the environmental risks associated with future offshore CO_2 storage are considered to be comparable with existing oil and gas operations, treatment of produced waters may be required to reduce the trace element load and should be assessed on a field-by-field basis.