Remediation of near-surface CO_2 leakage

If CO_2 from a geological storage site leaks, and arrives in the near surface, then what can we do about it? There are many techniques developed by the pollution-clean up industry that could be utilised, though very few have been tested with CO_2. However, the problem that was causing the leak would most probably be at some depth, so we have not looked here at stopping the leak, but as what to do with the CO_2 that reaches the near surface – e.g. the soil, drinking water, or peoples' homes. The leak would probably eventually return the stored CO_2 back to the atmosphere, and hence should be prevented where possible.

The response to a leak would depend on what problems (if any) the CO_2 was causing. CO_2 dissolves in water to form a weak acid which can potentially mobilise toxic metals in ground water aquifers – a problem if the water is extracted for drinking or agriculture. Interestingly, CO_2 in drinking water is not inherently a problem – carbonated drinking water is sold for a premium. Remediation would be implemented when established standards, e.g. the maximum allowable concentrations of metals in drinking water, are exceeded. High levels of CO_2 contamination at ground level can reduce crop yields; could locally impair or kill vegetation; or even make buildings unsafe for human habitation.

The remediation technique that would be used would depend on the local geology – a leak in fractured basement rocks such as granite will be quite different to a leak in soft sediments such as sand, or even in porous sedimentary rocks such as sandstone. The hydrogeology is also important – is the CO_2 leaking into a confined aquifer (i.e. one with a cap of low permeability rock), or is the aquifer unconfined? The use that the land above the leak will also influence the decision as to how to remediate the leak – is the land farmed, or is it wild land, or are there houses? If the leak were under the sea then entirely different remediation techniques would be needed.

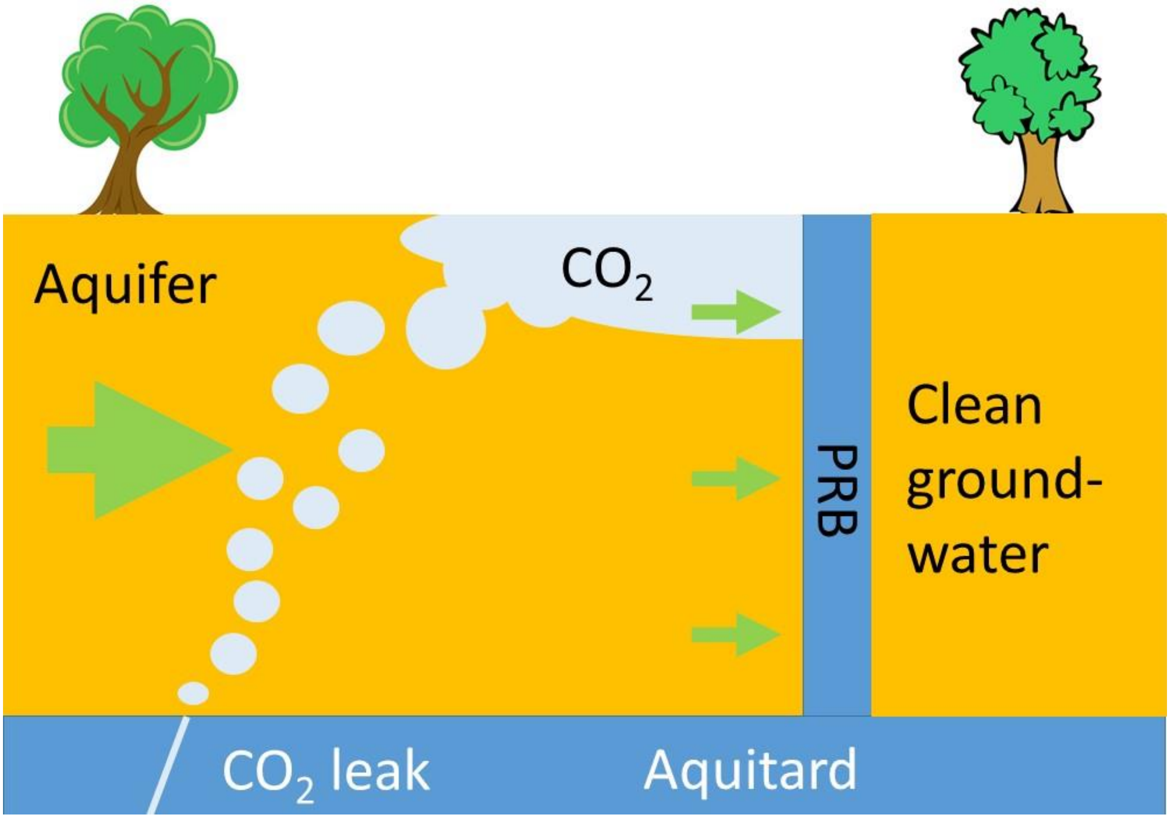

Figure 1 – A cross-section through the ground showing a Permeable Reactive Barrier (PRB) built in an unconfined groundwater aquifer (orange) – i.e. an aquifer at the surface, with low permeability capping bed (aquitard) above it. The green arrows show the direction of groundwater flow, from left to right.

A well-tested technique for cleaning up contaminated ground water is a treatment wall, also called a permeable reactive barrier (PRB; Fig. 1). The wall contains sections that allow the ground water to flow through it, and which contain a reactive material that absorbs the pollution, allowing clean water to continue to flow onwards. A PRB might be used to remove CO_2 from groundwater, or perhaps more likely to remove any heavy metals that the CO_2 has mobilised within the aquifer. A variety of reactive materials have been used within PRB's to absorb pollutants, including limestone and fish bones.

What might a CO_2 leak look like – natural analogues?

To learn what a leak of CO_2 from a storage site to the surface might look like (if one ever occurs), we can study analogues. In this case, an analogue is a place where natural CO_2 is leaking to the surface, usually naturally though occasionally assisted by man-made features such as old oil boreholes. There are quite a few places in the World where this occurs – there are many in Italy for example. One well studied example is near the town of Green River, in Utah, USA (Fig. 1).

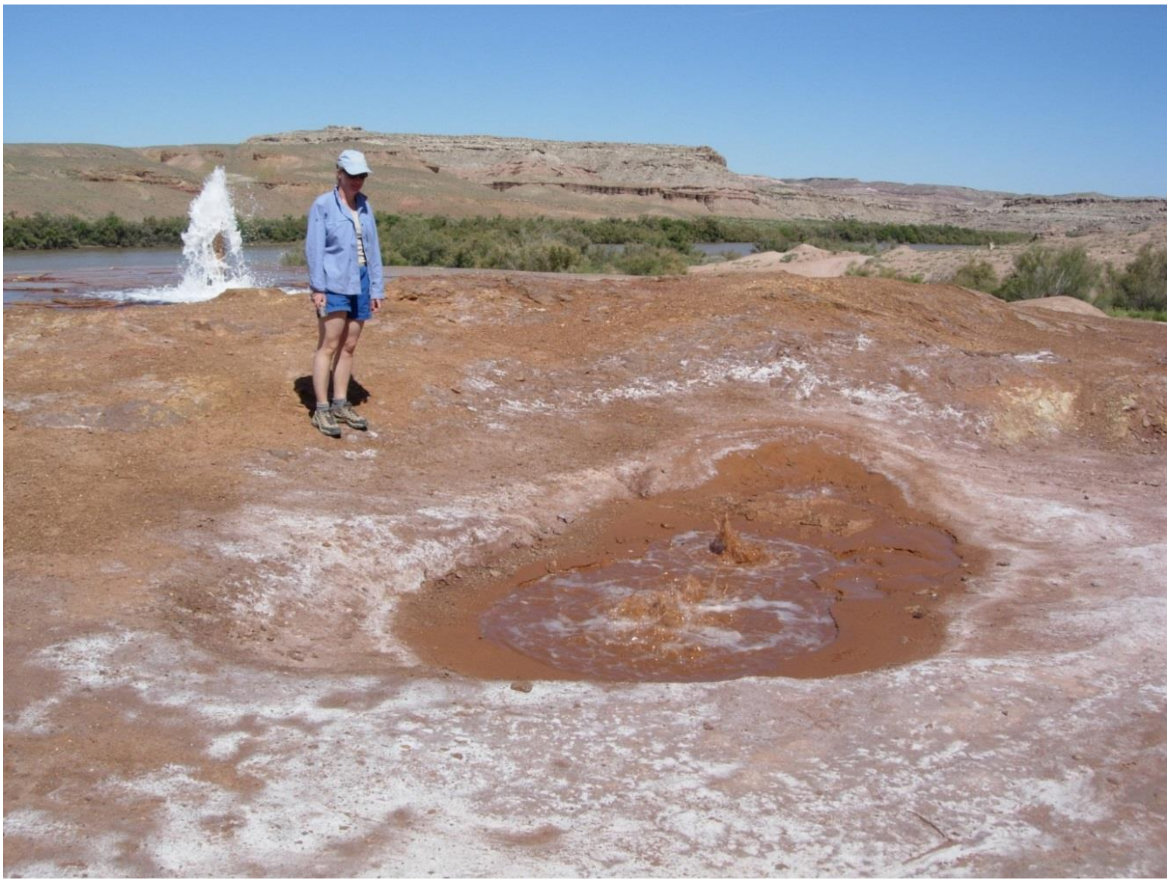

Figure 2 – The water in the foreground bubbling as natural CO_2 escapes at the Crystal Geyser site, Utah, USA. The fountain in the background is the geyser itself, which erupts periodically from an old oil borehole.

The CO_2 escape site at Green River is known as Crystal Geyser, after an old oil borehole which occasionally erupts cold water, driven by the pressure of gas CO_2. Although CO_2 is dangerous if it becomes trapped in, for example, a depression or confined space, at Crystal Geyser it does not build up. Far from being dangerous, Crystal Geyser is one of the main tourist attractions at Green River, and if you visit the town library the staff will draw you a map of how to get there! The site is basically a desert, and there are plants growing around the geyser, living on the erupted water. The water has dissolved minerals, which have built terraces as the water flows across the ground (Fig. 2).

Figure 3 – Miniature travertine pools formed of minerals deposited by water flowing from Crystal Geyser.

Studying natural leakage sites such as Crystal Geyser allows us to work out how large an area a leak might cover; how fast the CO_2 might escape; what water flow we might expect to have driven by the CO_2; and the effects on animal and plant life. We can also test equipment for monitoring CO_2 in a natural setting.

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