Effects in Soil Chemistry by Potential Leaks of CO_2

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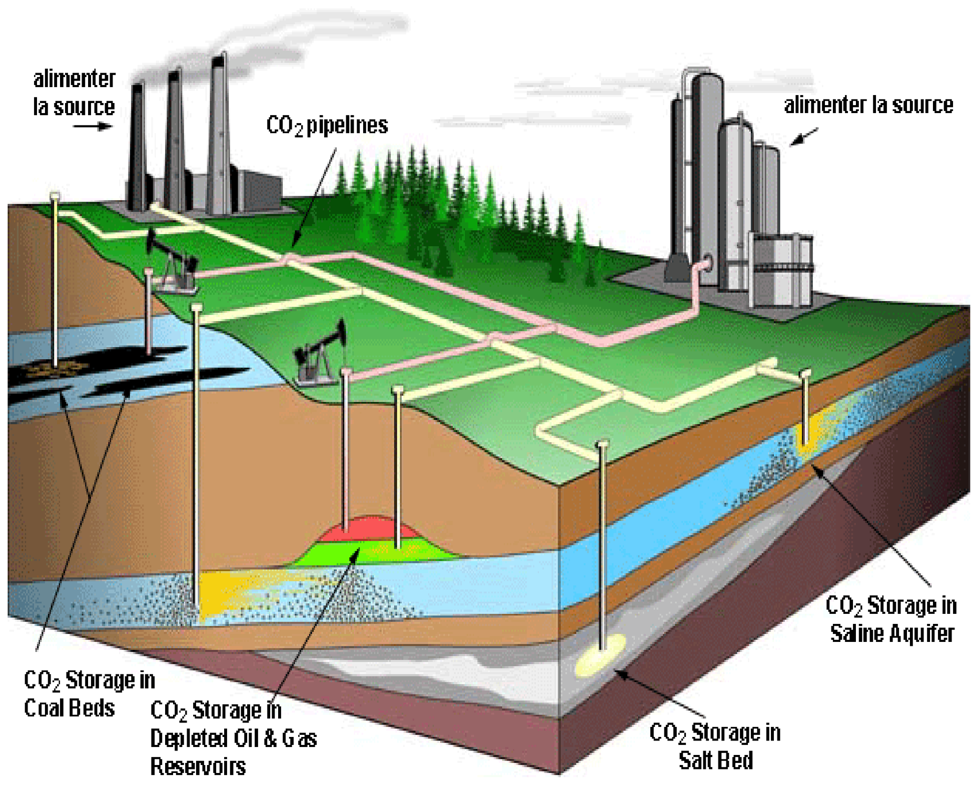
Introduction

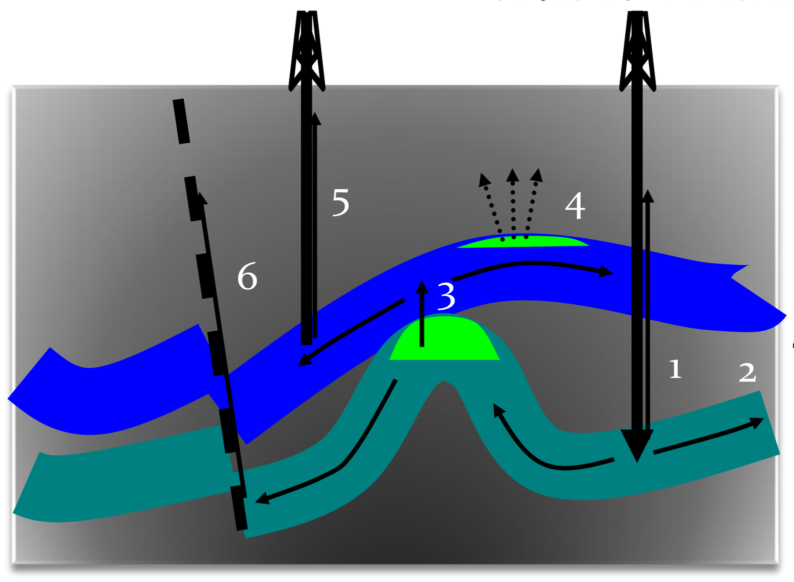
Carbon Capture and Storage (CCS) is an attractive technology to mitigate climate change. However, there may be leakage via pipeline transportation or through abandoned wells. In certain storage scenarios, the flue gas may also contain impurities that are more toxic and dangerous than CO_2 alone. It is therefore essential to assess the environmental consequences of potential leaks of impure CO_2.



Aims

Determine the potential environmental impacts of leaks from CO_2 geological storages sites by investigating the impacts of CO_2/SO_2 mixtures on soil pH and availability of minerals (both nutrients and toxic minerals).

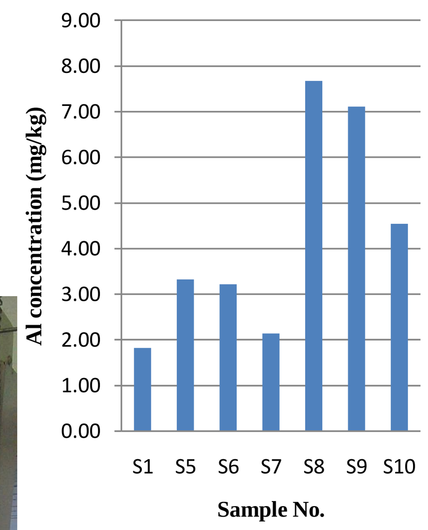
Main leakage pathways

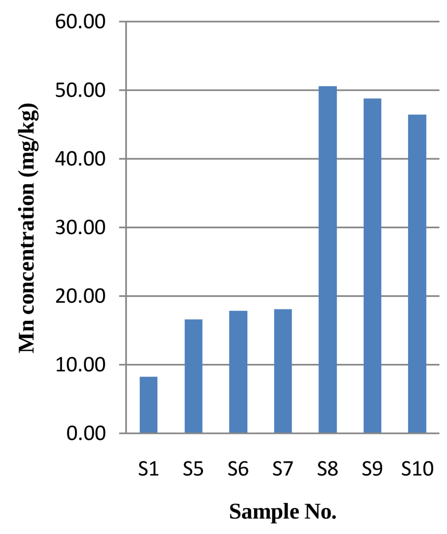


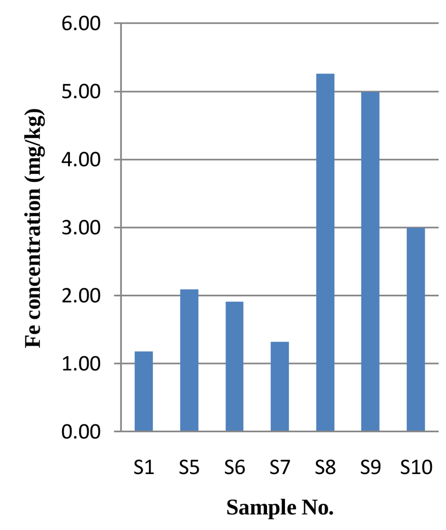
1. Leak through injection well during the storage process
2. Dissolved gas escapes to atmosphere and ocean
3. Escape through 'gap' in cap rock into overlying aquifer
4. Leak passes through the bedrock
5. Leak via an abandoned well
6. Leak through a fault zone

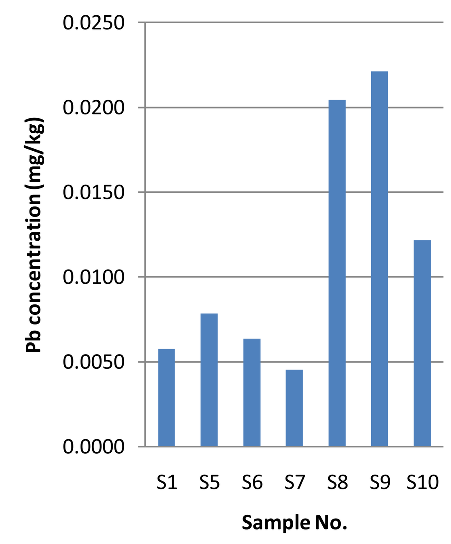
Preliminary Results: Stage I

No.	DESCRIPTION	
S1	Top-soil	no incubation
S2	Top-soil	oven-dried and incubated
S3	Top-soil	oven-dried and incubated
S4	Top-soil	oven-dried and incubated
S5	Top-soil	16.7% moisture content and incubated
S6	Top-soil	16.7% moisture content and incubated
S7	Top-soil	16.7% moisture content and incubated
S8	Top-soil	28.6% moisture content and incubated
S9	Top-soil	28.6% moisture content and incubated
S10	Top-soil	28.6% moisture content and incubated









1. Greater moisture in the soil resulted in higher CO_2 uptake during the incubation.
2. When soil was exposed to 100% CO_2, $CaCl_2$-exchangable metal concentrations in soil solution increased for Mg, K, Al, Ti, V, Cr, Mn, Fe, Co, Cu, Rb, Sr, Mo, Cs, Ba, Pb, Th and U, while the metal concentrations decreased for Zn and Cd. Other trace elements did not show a regular trend.

Methodology

Stage I- Closed experimental system

1. Samples were incubated in a Parr reactor model 4843 (Figure 1) under the following conditions: 25˚C and 25 bars for 3days;
2. The availability of biologically-important nutrients and toxic minerals was tested after incubation.

Figure 1 Parr reactor model 4843

Stage II- A Continuous flow reactor

1. Inject a controlled CO_2/SO_2 gas mixture into a vertical soil column, which is filled with pre-mixed soils of different compositions (Figure 2).
2. Measure metal concentration in soil pore water, soil pH, flow rate and concentrations of the gas mixture at inlet and outlet, gas concentrations at different depths and compare afterwards.

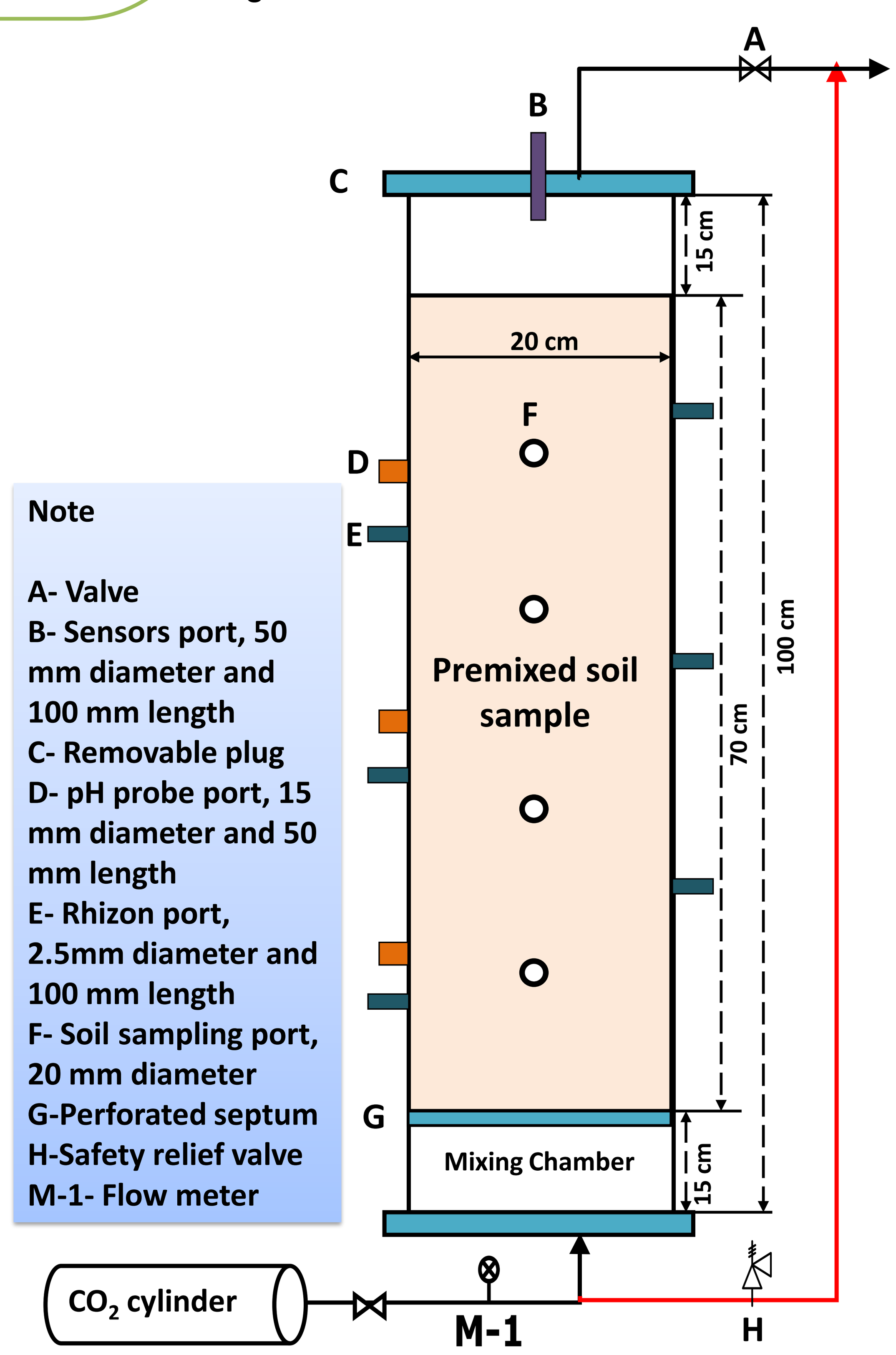


Figure 2 A continuous flow reactor design

Conclusion

Although toxic elements were mobilised after incubation, they remained below plant tolerance limits. However, the incubation was short and did not include impurities. Separate experiments with dilute $SO_2:CO_2$ mixtures show much greater mobilisation. Longer experiments under more realistic conditions are required.

Future work

Run experiments with the continuous flow reactor, and test the effects of impure CO_2 with up to 1% SO_2 in the mixture to assess the potential impacts caused by impurities.

Acknowledgment

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