ARB CCS technical discussion: soils and atmosphere

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Questions

1. What risk does a CO2 leak pose to biological life in the soil? For example, how might CCS negatively impact microbes and/or plant root systems?

2. Given some CO2 gas is naturally present in most soils, how much CO2 can be present in the soil before negative impacts are observed? Please be specific on the scale and intensity of impacts.

3. Once a leak is stopped, is soil recovery from the negative impacts possible, and if so, how long would it take? What conditions might affect this recovery rate? What methods are available to speed soil recovery? How much do such methods cost?

4. What risk does a CO2 leak pose to biological life if released into the atmosphere? What impact would it have on plants, animals, and humans?

5. Given that CO2 gas is naturally present in the atmosphere, how much CO2 can be present in the air at ground level before negative impacts are observed? Please be specific on the scale and intensity of impacts. Does the space that the leak enters affect these concentrations (e.g., open area, topographical depression, basement/building)?

6. Should health risks due to leaks of CO2 to the soil or atmosphere be addressed by the CCS QM or are those risks better addressed by the local permitting and CEQA and NEPA2 determinations?
Ginninderra controlled release facility

- Collaboration between Geoscience Australia and the CO2CRC
- Hosted at CSIRO Ginninderra Experiment Station
- 800 hectares of cropping/grazing land
- Fluvial soils
- Aim: Evaluate the effectiveness of different monitoring techniques
Three sub-surface release experiments

- 2 x 144 kg CO$_2$/d
- 288 kg CO$_2$/d
- 7-9 weeks continuous injection
- 2012 - 2013
Ginninderra - techniques trialled to date

- Soil gas
- Soil flux
- Soil analysis
- Atmospheric tomography
- Scanning laser
- Eddy covariance
- Tracer studies (soil gas and atmospheric analysis)
- Ground penetrating radar

- Airborne CO$_2$ detection using a rotorcraft UAV
- Electromagnetic surveys
- Airborne hyperspectral and thermal imaging
- In-field phenotyping (hyperspectral, thermal, 3D imaging)
- Microbial soil genomics
- Plant biochemistry and physiology
Leak is “patchy” and moved depending on climatic conditions

(Wet season)  (Dry season)
Similar leakage features observed worldwide
Question 1?

What risk does a CO$_2$ leak pose to biological life in the soil? For example, how might CCS negatively impact microbes and/or plant root systems?

Can kill plants and change microbial populations, but area of impact localised
CO$_2$ impact on plants clearly visible, but small in area

Background

2 weeks exposure to CO$_2$
... but not using airborne techniques

- CO₂ impacts on vegetation clearly visible at ground level, but current airborne technique suffer from many false positives
- Plant affected area smaller than that detected elevated soil flux/gas levels
Observed shift in microbial populations towards more anaerobic, acid/metal tolerant species

**Firmicutes**

**Nitrospira**
Natural CO$_2$ leaks at Latera Caldera, Italy

~20 t/d natural CO$_2$ leak, but localised
Given some CO$_2$ gas is naturally present in most soils, how much CO$_2$ can be present in the soil before negative impacts are observed? Please be specific on the scale and intensity of impacts.

Observed detrimental plants impacts at CO$_2$ >40%, limited between 5 - 40% depending on plant type.
Relationship between surface and soil gas (1m)

CO₂ surface flux expression < CO₂ soil gas footprint (1m depth)

Depends on groundwater levels and extent of vadose zone ++
Plant impacted area small, but different plants have different sensitivities to CO₂ in soil gas.

Field peas

Wheat

% CO₂ in soil gas

- <2.5
- 2.5 - 5.0
- 5.0 - 10
- 10 - 20
- 20 - 40
- 40 - 87.5

Graphs showing changes in chlorophyll C (ppm) over different distances and time periods.
Question 3?

Once a leak is stopped, is soil recovery from the negative impacts possible, and if so, how long would it take? What conditions might affect this recovery rate? What methods are available to speed soil recovery? How much do such methods cost?

• Yes, ~ months at Ginninderra. No adverse impact observed in tillering plants (~2 weeks old) <5 months after closure of last experiment.

• CO$_2$ soil gas back to background < 12 weeks after stopping CO$_2$

• Size of leak/ volume of CO$_2$ in vadose zone/ still buoyancy- pressure drive to CO$_2$ plume?

• Natural atmospheric pumping probably sufficient
Question 4?

What risk does a CO$_2$ leak pose to biological life if released into the atmosphere? What impact would it have on plants, animals, and humans?

- Since CO$_2$ heavier than air, only a problem if atmosphere is still, there is a lot of CO$_2$, and it accumulates in hollows, basements, burrows.

- Slightest breeze, and CO$_2$ quickly disperses to atmospheric concentrations marginally above background within meters of release point.

- May have a crop fertilization effect on adjacent plants (enhance growth).
Question 5?

Given that CO2 gas is naturally present in the atmosphere, how much CO2 can be present in the air at ground level before negative impacts are observed? Please be specific on the scale and intensity of impacts. Does the space that the leak enters affect these concentrations (e.g., open area, topographical depression, basement/building)?

- Depends on atmospheric stability and size of leak.
- Accumulations in depressions, basements a key risk factor (equip at risk facilities with gas detectors, similar to Radon?)
- TWA exposure standard 5,000 ppm
- Studies show crop fertilization effect at ~500+ppm
Question 6?

Should health risks due to leaks of CO2 to the soil or atmosphere be addressed by the CCS QM or are those risks better addressed by the local permitting and CEQA and NEPA2 determinations?

- Recommend that each project assesses risk of CO$_2$ accumulations in basements etc via a risk management process, i.e. project specific.

- Risk needs to consider location of potential leakage pathways, e.g. wells and faults.

- Each site will be unique in terms of risks and possible leakage pathways.
Any further questions?