Soil Gas Monitoring Techniques and Implications for MMV Plans

Katherine Romanak
The University of Texas Bureau of Economic Geology
Austin, Texas USA
Soil Gas Monitoring

Soil gas Monitoring

Increasing variability

NOT TO SCALE

Figure courtesy of Sue Hovorka
Soil Gas Monitoring

**ADVANTAGES**
- Inexpensive
- Monitors area near “release to atmosphere”
- Important for quantification/accounting
- Aids in assessing impacts to the environment
- Useful for responding to public concerns

**CHALLENGES**
- Locating an anomaly
  - Need wide coverage over large areas
- Attributing source of anomaly
  - natural variation
  - leakage
Attribution: Signal over Noise

Natural CO₂ sources and sinks
- Plant activity
- Organics → CO₂
- Soil carbonate
- Soil moisture
- Weather and seasons

Leak Signal

Background noise

Mimic signal

Dampen signal

False positives

False negatives

Produce CO₂

Consume CO₂
Popular Methods

Background Measurements

- Measure “background” CO$_2$ for 1-3 years before project start to understand seasonal variability.
- Monitor CO$_2$ during project and compare to background.
- Significant increase from background during a project could signal a leak.

Isotopes

- Different isotopic signatures can indicate the source of CO$_2$ whether natural or injected.
Popular Methods-Challenges

Background Measurements

- Natural CO$_2$ variability can mask a moderate leakage signal
- Requires long lead time
- “Baseline” will be dynamic
  - climate, land use, and ecosystem variations during a project
- Background CO$_2$ cannot be measured across all potential leak points

Isotopes

- Not always definitive
News of a “Leak” at the Kerr Farm

January 11, 2011

Land fizzing like soda pop: farmer says CO2 injected underground is leaking

By: Bob Weber and Jennifer Graham, The Canadian Press
Postned: 01/11/2011 10:22 AM | Comments: 9
IEAGHG Weyburn-Midale CO$_2$ Monitoring and Storage Project

- Largest geologic CO$_2$ monitoring and storage project
- Since 2000 > 24 M tonnes of CO$_2$ injected
- CO$_2$-EOR operated by Cenovus Energy
- Studied by an international team of CO$_2$ storage experts
- Managed by Petroleum Technology Research Centre (PTRC)

Site Location

Area of CO₂ injection

Weyburn-Midale Oilfield

Kerr Farm

Cenovus, Site Assessment Weyburn Unit SW30-5-13W2, November 2011
Kerr Farm History

Kerrs acquire the land South of Weyburn in 1975

IEAGHG Weyburn Project Phase 1

Kerrs excavate gravel pit. CO₂ injected near land

Kerrs leave their property

Ongoing Allegations of CO₂ Leakage

Alleged Land Disturbances
Industry and Government Response

- **1998**: (Operator) Weyburn Pump and Water Conditioning, groundwater test report
- **2002 – 2005**: (Operator) Farm well Inventory Project, regional groundwater analysis
- **2004**: (Operator) KBL Land Use Consulting Ltd., gravel pit water and soil samples
- **2005**: (Operator) Enviro-Test Analytical soil sample
- **2005**: (Government) Saskatchewan Health Provincial Laboratory, gravel pit and domestic well water
- **2006**: (Operator) Aqua Terre Solutions Inc., well and gravel pit water test
- **2006**: (Landowner) MR2 McDonald & Associates, water quality investigation
- **2007**: (Landowner) Consultation with Dr. Malcolm Wilson, Office of Energy & Environment, University of Regina
- **2008**: (Government) Ministry of Environment – Review of studies
- **2008**: (Government) SRC Analytical Laboratories, soil, water and air quality monitoring
- **2008**: (Government) Droycon Bioconcepts Inc., Bacteriological content of water
- **2010-2011**: (Landowner) Petro-Find Geochem Ltd., Soil gas surveys.
Petro-Find Conclusion

“The...source of the high concentrations of CO$_2$ in soils of the Kerr property is clearly the anthropogenic CO$_2$ injected into the Weyburn reservoir.”

Petroleum Technology Research Centre Response

“Researchers, engineers, geologists and geophysicists involved in the IEAGHG project have reviewed the Petro-Find report and concluded that it does not support its claim.”

PTRC Response to Petro-Find report
www.ptrc.ca
How To Avoid This?

News of a “Leak” at the Kerr Farm
January 11, 2011

Industry and Government Response

- 2002 – 2005: (Operator) Farm well inventory project, regional groundwater analysis
- 2004: (Operator) KBL Land Use Consulting Ltd., gravel pit water and soil sample
- 2005: (Operator) Enviro-Test Analytical soil sample
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Claim Response Protocol

Response to allegation of an unintentional release of a gas associated with a specific CCS project.

**Site Assessment**
- Validate the allegation

**Risk Communication**
- Correspondence and document review

If a release has occurred:
1. Substances released and scope of the release
2. Release mechanisms
3. Time release was detected
4. Response to the release
5. Consequences of the release
6. Compliance with applicable industry performance standards/best practices
7. Conclusions and recommendations
Step 1- Validating the Allegation

Outcome of Step 1: Was there an unintentional release of gas associated with a specific CCS project?

- Anomaly was located by PetroFind and wrongly attributed to leakage using isotopes.
- We used a new optimized approach to attribute CO$_2$ source
  - 10 sampling locations
  - Minimal number of analytes
- Process-based soil gas method
Process-Based Soil Gas Method

- Does not rely on background CO$_2$ measurements
- Uses ratios among simple gases (CO$_2$, CH$_4$, N$_2$, O$_2$)
- Discerns process
  - In-situ from exogenous gas
  - Mixing with air
  - CO$_2$ dissolution
  - Oxidation of CH$_4$ into CO$_2$
    - Important for CCUS monitoring
Process-Based Soil Gas Method

- Developed at a natural CO$_2$-rich perched playa wetland, West Texas
- Tested at a CCUS field
  - plugged and abandoned well site
  - near-surface soil gas anomaly
- Confirmed at the ZERT controlled release site, Montana, USA

Used at Otway (Australia) and considered for use at QUEST (Canada) and Gorgon (Australia)
Leakage Allegation Discounted

“In a media release, Ecojustice lawyer Barry Robinson, who represented the Kerrs, accepted the IPAC-CO$_2$ study’s findings while emphasizing its necessity, saying that “without a full scale investigation, it has been impossible until now to rule out CO$_2$ contamination.”
Improving the Monitoring Protocols for CO₂ Geological Storage with “CO₂ Attribution Monitoring”


Combined Summary of Monitoring Activities:
• Acquire background measurements
• Assess CO₂ storage performance in the reservoir
• Detect leakage anomalies that may signal leakage
  – and, if leakage is detected, suspected or alleged, then…
• Attribute the source of CO₂
• Quantify leakage and
  And only if CO₂ attributed to injected CO₂, then…
• Assess impacts of leakage

Dixon and Romanak, in review, Improving the monitoring protocols for CO₂ geological storage with CO₂ attribution monitoring, International Journal of Greenhouse Gas Control
Summary

- The Kerr investigation is a case study in response to leakage claims.
- Adopting a protocol to leakage claims in advance of a CCS project is beneficial for avoiding:
  - Long-running allegations,
  - Unqualified sources reaching incorrect conclusions
  - Inaccurate information affecting public perception of CCS.
- Relatively simple tools for responding to claims are now available
  - A process-based approach to assessing anomalies is cost effective, accurate, relatively simple and can be used in areas lacking background data.
- Recommend updating current protocols to reflect CO$_2$ source attribution
More Information

Katherine Romanak
katherine.romanak@beg.utexas.edu
+1 512 471 6136

Sponsor and Collaborators

[Image of sponsors and collaborators]