BASELINE SOIL GAS MONITORING AT THE BELL CREEK COMBINED CO_2 EOR AND CO_2 STORAGE PROJECT

John A. Hamling, Daniel J. Stepan, Nicholas S. Kalenze, and Ryan J. Klapperich

Energy & Environmental Research Center, University of North Dakota
15 North 23rd Street, Stop 9018, Grand Forks, ND 58202-9018

The Plains CO_2 Reduction (PCOR) Partnership, led by the Energy & Environmental Research Center (EERC) at the University of North Dakota, is working with Denbury Resources Inc. (Denbury) on an iterative approach to site characterization, modeling and predictive simulation, monitoring, and risk assessment at the Bell Creek oil field to evaluate the efficiency of a large-scale injection of carbon dioxide (CO_2) for simultaneous CO_2 enhanced oil recovery (EOR) and long-term CO_2 storage (Gorecki and others, 2012). Initial injection of approximately 50 MMscf/day of CO_2 into the Lower Cretacous Muddy Formation at a depth of 4,500 ft is anticipated to begin by mid-2013 as part of the combined CO_2 EOR and CO_2 storage project at the Denbury-operated Bell Creek oil field. The Bell Creek oil field covers approximately 22,000 acres and contains over 450 wellbores.

Denbury will carry out the injection and production operations in a phased approach. As part of the EERC's iterative approach to monitoring a combined CO_2 EOR and CO_2 storage project, a soil gas-monitoring program is being carried out as one component of a CO_2-monitoring and -accounting program assessing storage site security. The primary objectives of baseline soil gas monitoring at Bell Creek is to 1) establish preinjection concentrations and seasonal variations in soil gas chemistries across the Bell Creek Field, 2) provide a scientifically defensible data source to show that the near-surface environment remains unaffected by fluid or gas migration and to evaluate any deviation from baseline conditions, and 3) to aid in characterizing the source and location of an out-of-zone migration to guide remediation efforts should a significant anomaly be detected.

Near-surface vadose zone soil gas monitoring directly measures the characteristics of the soil atmosphere and is an indirect indicator of processes occurring in and below a sampling horizon. Soil gas sampling was accomplished using a mechanically driven probe. This method was chosen because of its cost-effectiveness, mobility, low environmental impact, and efficiency. The objective of the soil gas survey was to establish preinjection baseline values for several specific components naturally found in shallow subsurface. These components included CO_2, oxygen (O_2), nitrogen (N_2), hydrogen (H_2), carbon monoxide (CO), methane (CH_4), ethane (C_2H_6), and ethylene (C_2H_4). A sudden change in one or any combination of these components could be indicative of either naturally occurring processes or a potential out-of-zone fluid or gas migration.

Soil gas samples were collected and analyzed at 124 active well locations, 52 plugged and abandoned well locations, and ten interspaced (between active wells) locations over the period from November 2011 through November 2012. Analyses consisted of both field determinations of soil gas concentrations using handheld instrumentation and laboratory determinations using gas chromatography.

Analyses indicated the presence of N_2, O_2, and CO_2 as the only detectable soil gases. CH_4, CO, C_2H_6, C_2H_4, and H_2 were not detected in any of the soil gas samples. CO_2 levels were generally higher near active well locations but never exceeded 4.5%, well within expected normal background levels. The highest CO_2 levels were associated with warmer-weather sampling events as is expected with natural biologic processes. Analysis of soil gas data using a process-based approach indicated that the shallow-vadose-zone soil gas composition is consistent with biological respiration. Methane oxidation did not appear to be a significant source of CO_2 in the sampling region. Carbon isotope analysis confirmed that soil gas CO_2 was a result of a mixture of soil decomposition and C3 photosynthetic respiration.

In addition to shallow soil gas samples, ten soil gas-profiling stations (SGPSs) were installed in October 2012 to assess changes in soil gas composition with depth. Each SGPS consisted of a shallow PVC (polyvinyl chloride) well with nested tubing individually screened at depths of 3.5, 9.0, and 14 feet below the ground surface. Preliminary data showed increasing levels of soil gas CO_2 with depth, accompanied by lower levels of O_2, consistent with biological processes.

A process-based approach in conjunction with isotope analysis has been utilized to characterize near-surface seasonal soil gas concentration changes throughout the Bell Creek oil field and surrounding area. The baseline soil gas characterization data will be utilized to guide monitoring efforts during the CO_2 injection phase of the project and to identify and scientifically evaluate the significance and source of anomalies (if present). Continued monitoring will continue to provide additional insight into interannual variations of soil gas concentration changes during drought/wet cycles and provide a valuable data set that can be utilized to enhance future CO_2 EOR- and CO_2 storage-monitoring efforts throughout the region.

Reference

Gorecki, C.D., Hamling, J.A., Klapperich, R.J., Steadman, E.N., and Harju, J.A., 2012, Integrating CO_2 EOR and CO_2 storage in the Bell Creek oil field, *in* 2012 Carbon Management Technology Conference, Orlando, Florida, February 7–9, 2012, Proceedings, CMTC 151476, DOI 10.7122/151476-MS.