Spatio-temporal soil CO_2 concentrations and fluxes after artificial CO_2 release in Korea

Hyun-jun Kim[1,2], Hyeon Min Yun[2], Seongjun Kim[2], Seung Hyun Han[2], and Yowhan Son[2]*
[1]BK21 Plus Eco-Leader Education Center, Korea University, Seoul 02841, Korea
[2]Department of Environmental Science and Ecological Engineering, Graduate School, Korea University, Seoul 02841, Korea
* Corresponding author: yson@korea.ac.kr

Introduction

- Carbon capture and storage (CCS) is a technical process to capture CO_2 from industrial and energy-based sources, transfer and sequestrate impressed CO_2 in geological formations, oceans, or mineral carbonates (IPCC 2005).
- However, potential CO_2 leakage may exist and cause environmental problems (Lewicki et al. 2010).
- This study was conducted to analyze the spatial and temporal variation in soil CO_2 concentrations and fluxes after artificial CO_2 release in Korea.

Materials and Methods

◆ Study site and experimental design

- A controlled artificial CO_2 release experiment site was established in Eumsung, Korea (36°57′44.2″N, 127°28′03.1″E), with perforated linear pipeline buried in the center at the depth of 2.5m.
- The site, called “Environmental Impact Evaluation Test Facility on Seepage of Geologically Stored CO_2 (EIT)”, consisted of the 5 treatment zones (Fig. 1).

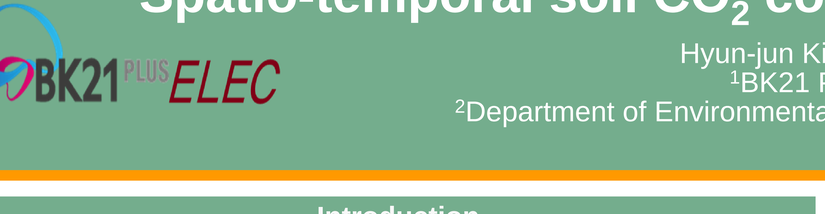

Fig. 1. Controlled artificial CO_2 release experiment site (EIT) in Eumsung, Korea, showing locations of soil CO_2 concentration (red circles) and flux (blue stars) measurements.

◆ Operation and measurements

- The CO_2 injection pipe was installed at 2.5m depth, and each zone had 2 CO_2 release wells with 1m in width (Fig. 2).
- From 26 to 30 October 2015, 34*kgCO_2 day^{-1} zone^{-1}* were released from each of the perforated wells in Zones 2, 3, and 4.
- Soil CO_2 flux was measured at the surface at 0m, 1.5m, 2.5m, and 10m from the CO_2 releasing well in Zone 3 using an automated soil CO_2 flux system (**Li-8100A**), and soil CO_2 concentration was measured at 15cm, 30cm, and 60cm depths at every 0m, 2.5m, 5m, and 10m distances from the well in Zones 2, 3, and 4 using a portable gas analyzer (**GA5000**).

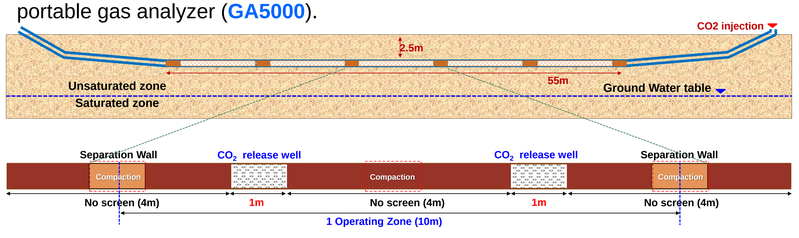

Fig. 2. Installation of CO_2 injection pipe in EIT.

Results and Discussion

◆ Soil CO_2 concentration

- Soil CO_2 leakage signal was shown as 38.4% at 60cm depth at 0m from the well in Zone 3 on the second day after CO_2 release (Fig. 3).
- Soil CO_2 was leaked more widely over time, and detected up to 5m away from the well at all zones through the CO_2 releasing period.
- Soil CO_2 was measured up to 89% at 60cm depth at 0m from the well, followed by 30cm depth (82.5%) and 15cm depth (55.4%) at the same distance in Zone 3.

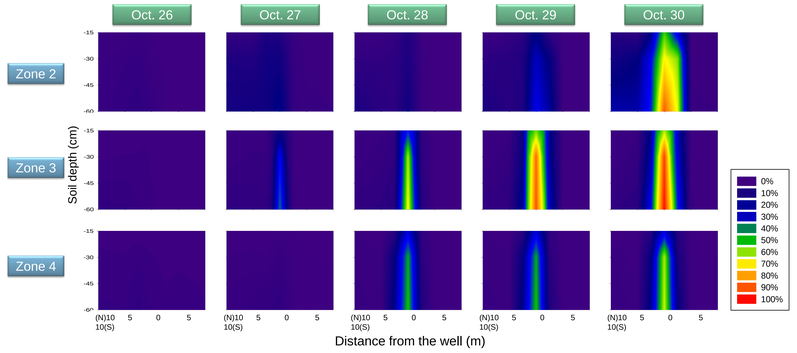

Fig. 3. Spatial distribution of soil CO_2 based on distance and soil depth

◆ Spatial and temporal variations of soil CO_2

- The spatial variation in soil CO_2 concentration was clearly observed, especially when presented by soil depth and observation date (Fig. 4).
- The observed soil CO_2 concentration was highest at Zone 3.
- The temporal variation of soil CO_2 showed the similar patterns at 30cm and 60cm depths.
- At all depths, soil CO_2 has increased for the first 4 days, after that, its increase rates were reduced.

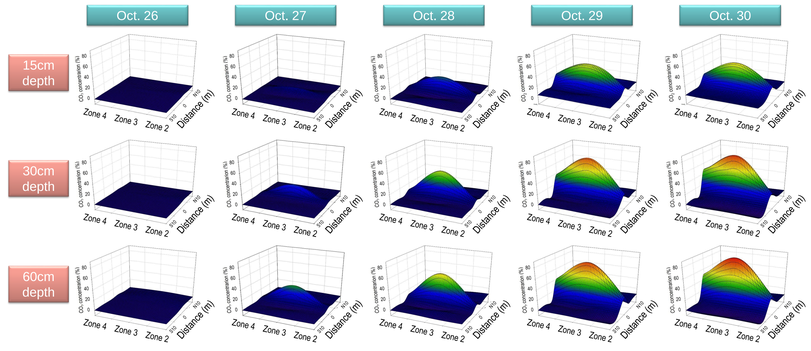

Fig. 4. Spatial and temporal variations of soil CO_2 in EIT, Korea.

◆ Soil CO_2 flux

- Soil CO_2 fluxes showed temporal and spatial variations due to its strong dependence on surrounding soil and meteorological conditions (Schloemer et al. 2013).
- Soil CO_2 fluxes were significantly affected by the climatic factors; negative relationship with relative humidity and atmospheric pressure and positive relationship with soil temperature and moisture (Fig. 5).
- Soil CO_2 leakage at the surface was detected at 0m distance from the well after 5 days, and soil CO_2 flux increased over 8 days until raining even though the artificial CO_2 release stopped.

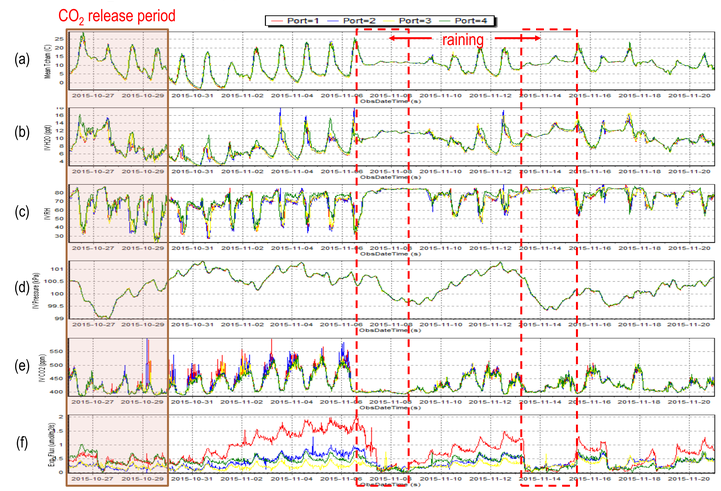

Fig. 5. Time series of (a) soil temperature, (b) soil moisture, (c) relative humidity, (d) atmospheric pressure, (e) CO_2 concentration, and (f) CO_2 flux.

Conclusions

- Soil CO_2 concentrations and fluxes after artificial CO_2 release were clear and varied by soil depth, distance from well, and observation time.
- Even the same amount of CO_2 gas was injected, the CO_2 releasing variations were detected differently in all zones.

Acknowledgments

- This subject was supported by Korea Ministry of Environment (2014001810002).

Reference

- IPCC. 2005. IPCC special report on carbon dioxide capture and storage. Cambridge University Press, New York.
- Lewicki JL, Hilley GE, Dobeck L, and Spangler L. 2010. Dynamics of CO_2 fluxes and concentrations during a shallow subsurface CO_2 release. Environmental Earth Sciences 60(2): 285-297.
- Schloemer S, Furche M, Dumke I, Poggenburg J, Bahr A, Seeger C, Vidal A, and Faber E. 2013. A review of continuous soil gas monitoring related to CCS – technical advances and lessons learned. Applied Geochemistry 30: 148-160.