Assessment of CO$_2$ discharge in a spring using time-variant stable carbon isotope data as a natural analogue study of CO$_2$ leakage

Sooenyoung Yu (1), Gitak Chae (2), Minki Jo (2), Jeong-Chan Kim (2), and Seong-Taek Yun (3)

(1) Research Institute for Social Criticality, Pusan National University, Busan, 609-735, Korea (s7yu.iamysy@gmail.com), (2) CO$_2$ sequestration research team, Korean Institute of Geoscience and Mineral Resources, Daejeon, 305-350, Korea (gtchae@kigam.re.kr), (3) Department of Earth and Environmental Sciences and K-COSEM Research Center, Korea University, Seoul, 136-701, Korea (styun@korea.ac.kr)

CO$_2$-rich springs have been studied as a natural analogue of CO$_2$ leakage through shallow subsurface environment, as they provide information on the behaviors of CO$_2$ during the leakage from geologic CO$_2$ storage sites. For this study, we monitored the $\delta^{13}$C values as well as temperature, pH, EC, DO, and alkalinity for a CO$_2$-rich spring for 48 hours. The water samples (N=47) were collected every hour in stopper bottles without headspace to avoid the interaction with air and the CO$_2$ degassing. The $\delta^{13}$C values of total dissolved inorganic carbon (TDIC) in the water samples were analyzed using a cavity ring-down spectroscopy (CRDS) system (Picarro). The values of $\delta^{13}$C$_{TDIC}$, temperature, pH, EC, DO, and alkalinity were in the range of $-9.43$ to $-8.91 \%\delta$, $12.3$ to $13.2^\circ$C, $186$ to $189 \mu$S/cm, $1.8$ to $3.4$ mg/L, and $0.74$ to $0.95$ meq/L, respectively. The concentrations of TDIC calculated using pH and alkalinity values were between $22.5$ and $34.8$ mmol/L. The $\delta^{13}$C$_{TDIC}$ data imply that dissolved carbon in the spring was derived from a deep-seated source (i.e., magmatic) that was slightly intermixed with soil CO$_2$. Careful examination of the time-series variation of measured parameters shows the following characteristics: 1) the $\delta^{13}$C$_{TDIC}$ values are negatively correlated with pH ($r = -0.59$) and positively correlated with TDIC ($r = 0.58$), and 2) delay times of the change of pH and alkalinity following the change of $\delta^{13}$C$_{TDIC}$ values are $0$ and $-3$ hours, respectively; the pH change occurs simultaneously with the change of $\delta^{13}$C$_{TDIC}$, while the alkalinity change happens before $3$ hours. Our results indicate that the studied CO$_2$-rich spring is influenced by the intermittent supply of deep-seated CO$_2$. [Acknowledgment] This work was financially supported by the fundamental research project of KIGAM and partially by the "Geo-Advanced Innovative Action (GAIA) Project (2014000530003)" from Korea Ministry of Environment (MOE).