Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.25111

Visualization of dissolved CO_2 plume migration under hydraulic gradient conditions: proposal for large-scale experiments

DR. WON-TAK JOUN[1] AND KANG-KUN LEE[2]
[1]Korea Atomic Energy Institute
[2]Seoul National University

To understand the migration of dissolved CO_2 plumes through porous media under hydraulic gradient conditions, we strived to simulate visualization experiments using a Hele-Shaw cell, consisting of two transparent boards (50 by 50 cm) with a small gap (0.4 cm). Three hydraulic gradient conditions (i = 0, 0.1, and 0.01) were applied to examine the diffusive-advective transport of the dissolved CO_2 plume and to estimate the shape, area, and flow direction of the plume depending on the hydraulic gradient conditions. Under a high hydraulic gradient (0.1), advective flow dominated, causing the dissolved CO_2 plume to quickly migrate horizontally from the injection spot to the right side boundary. In contrast, under a low hydraulic gradient (0.01), the dissolved CO_2 plume gradually migrated diagonally toward the bottom right corner, driven by diffusive flow. The numerical model was able to simulate, to some extent, the migration of the dissolved CO_2 plume, capturing the complex influences acting simultaneously. As the hydraulic gradient condition decreased from 1.0E-02 to 1.0E-05, the diagonal flow angle increased from 10 to 40 degrees[1]. In addition, while previous studies have predicted changes in dissolved CO_2 concentration influenced by hydraulic gradients or density effects using numerical models, verifying these results with observed data has been challenging due to the limited size of the Hele-Shaw cell, which makes it difficult to collect water samples during visualization tests. To overcome these challenges, we developed an experimental system in large scale of Hele-Shaw cell and it can be performed to monitor the CO_2 concentration with real time scale and to take the images of dissolved CO_2 plume simultaneously. Moreover, this laboratory experiment system could be utilized to apply to the other experiment types and verify the empirical analysis equations such as single well push pull test, tracer test by comparing the plume migration images and the tracer concentration data.

[1]Joun and Lee (2024) *Journal of Environmental Management*, *357*, 120814

Acknowledgements

This study is supported by the Institute for Korea Spent Nuclear Fuel (iKSNF) and National Research Foundation of Korea (NRF) grant funded by Korean Government (Ministry of Science and ICT, MSIT) (2021M2E1A1085200 and NRF-2021R1C1C2093498)