Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35783

Hydrogen-Driven Fe(III), Sulfate, and Se(IV) Reduction by Anaerobic Microbial Communities from Deep Groundwater and Tidal-Flat Sediments in South Korea

YUMI KIM, HYOSEON KIM AND YUL ROH
Chonnam National University

Microbially driven redox reactions are increasingly recognized as critical factors influencing the long-term geochemical evolution and safety of deep geological repositories for high-level radioactive waste (HLW). In particular, hydrogen—continuously produced through radiolysis and corrosion processes—can serve as a key electron donor supporting anaerobic metabolisms that reduce redox-sensitive metals and radionuclides [1]. This study investigates hydrogen-oxidizing microbial communities enriched from deep groundwater within granitic bedrock and tidal-flat sediments, with a focus on their Fe(III), sulfate, and Se(IV) reduction capacities under geochemically relevant conditions.

Deep groundwater enrichments yielded hydrogen-oxidizing iron-reducing bacteria (KURT_IRB) dominated by *Paludirhabdus*, and sulfate-reducing communities (KURT_SRB) dominated by *Desulforamulus*. In contrast, tidal-flat enrichments (MA_IRB) consisted of a mixed consortium including *Citrobacter*, *Terrisporobacter*, *Paraclostridium*, and *Shewanella*, while the corresponding sulfate-reducing enrichment (MA_SRB) comprised *Romboutsia*, *Methanosarcina*, *Lacrimispora*, and *Desulforamulus*. All enrichments showed active growth and Fe(III)/sulfate reduction at pH 8–9, but activities were strongly inhibited at pH 10, suggesting that highly alkaline zones near cementitious barriers may limit microbial processes, whereas surrounding regions with pH < 10 may still support active hydrogen-driven metabolisms. To evaluate microbial attenuation of selenium—one of the key redox-sensitive radionuclides potentially mobilized around HLW repositories—we examined Se(IV) immobilization in media containing bentonite. After 30 days, Se immobilization efficiencies were 53.8% for KURT_IRB and 79.8% for MA_IRB. Both sulfate-reducing enrichments (KURT_SRB and MA_SRB) achieved complete (100%) Se immobilization. When equilibrated groundwater was used instead of nutrient medium, Se immobilization decreased to roughly half, confirming that active microbial growth substantially enhances Se-reducing and immobilization processes.

These results suggest that hydrogen-oxidizing Fe- and sulfate-reducing microorganisms—such as *Paludirhabdus*, *Desulforamulus*, and *Shewanella*—may play beneficial roles in HLW repository environments where pH remains below 10. Their combined abilities to consume hydrogen, reduce Fe(III) and sulfate, and precipitate Se species could contribute to long-term geochemical stabilization and retardation of radionuclide migration in deep geological disposal systems.

[1] Haynes et al. (2021), *Chemical Geology* 581, 120353.