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Implications of bentonite bacterial community in selenite reduction: advances in the biogeochemical processes of the Deep Geological Disposal

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The most internationally accepted high-level radioactive waste (HLW) disposal system is the Deep Geological Repository (DGR), in which nuclear waste canisters are surrounded by compacted bentonites, and placed in a stable geological formation. Natural occurring microorganisms in bentonite could disturb the migration of radionuclides through processes such as biomineralization, and biotransformation. ^{79}Se is one of the most critical radionuclides in HLW. Therefore, the aim of this work was to describe the impact of microbial diversity in the immobilization of Se(IV) through its reduction and transformation in bentonites.

Water-saturated bentonite was treated with Se(IV), and spiked with a bacterial consortium (*Pseudomonas*, *Stenotrophomonas*, *Shewanella*, *Bacillus* and *Amycolatopsis*). Microcosms were incubated anaerobically for six months. DNA extractions and Next Generation 16S rRNA gene sequencing were performed to study the shifts in microbial diversity after 6 months of anoxic incubation. The results showed that bacteria such as *Pseudomonas*, *Stenotrophomonas*, and *Desulfosporosinus*, were highly enriched in Se(IV) microcosms, indicating the potential to produce Se(0) through Se(IV) bioreduction. Precipitates from orange to black were observed in Se(IV)-treated microcosms. Microscopic and spectroscopic techniques (VP-FESEM, STEM/HRTEM, EDX, Raman, and XAS analyses) were performed to characterize the Se(0) nanostructures (SeNS) produced. Different allotropic forms of these SeNS were identified: amorphous/monoclinic (a-/m-Se), and trigonal (t-Se) corresponding to orange, and black precipitates, respectively.

These results highlight the direct or indirect potential impact of bacterial communities in bentonite on the immobilization of Se(IV), through a reduction process to Se(0), and its subsequent biotransformation from unstable a-/m-Se to more stable and less biologically toxic t-Se.