Microbe-radionuclide redox interactions: Extending the biobarrier concept from contaminated land to geodisposal

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Microorganisms are able to colonise some of the most exteme environments on Earth, including highly radioactive environments associated with the nuclear fuel cycle. In nuclear facilities, their proliferation as biofilms or planktonic "blooms" can help capture priority radionuclides (although in some settings their presence can also cause operational challenges). In contaminated land microorganisms can also have a controlling infleunce on the solubility of redox active radionuclides, and here microbial activity can be harnessed for non-invasive bioremediation applications, effectively forming "biobarriers" to prevent radionuclide migration. In the "far field" deep geosphere surrounding underground nuclear repositories, microorganisms can also immobilise redox active radionuclides via respiratory processes that either change directly the oxidation state of the element, or produce new biomineral phases for enhanced sorption. In the "near field" of the repository, where higher level wastes are located, the direct and indirect impacts of microbial metabolism are less well characterised but have the potential to have a significant impact on wasteform evolution and radionuclide mobility. The extension of the "biobarrier" concept to geodisposal scenarios can have a significant, and currently underrepresented, positive impact on safety case development for geological disposal facilities.

Recent work on the impact of microbial metabolism on various steps of the nuclear fuel cycle will be discussed. Focusing primarily on contaminated land and geodisposal scenarios, this talk will also discuss the biogeochemistry and redox cycling of priority radionuclides including U, Np, Pu and Tc, including reactions that build new insoluble phases that "lock" these radionuclides into subsurface sediments. Studies from a range of contrasting natural and engineered systems will highlight how microbial communities can respond to the radioactive inventory and the extreme (radio)chemistry of some disposed wasteforms, and ultimately control the biogeochemical fate of key radioactive elements via a range of mechanisms. A particular focus will be new work on the imact of microbial metabolism on the nuclear inventory of high pH cementitious intermediate level wasteforms.