Microbial Impacts on Colloid-Radionuclide Interactions

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Abstract

Microorganisms can play an important role on the behaviour of colloids in natural and engineered environments, which in turn can control the mobility of associated metals and radionuclides. This is especially true in the nuclear fuel cycle, where radionuclides (including uranium) can interact with a broad range of inorganic colloids. This is relevant to the legacy spent nuclear fuel ponds at Sellafield, which house a diverse inventory of waste from the early Magnox reactors. These reactors used uranium metal as a fuel encased in a magnesium non-oxide cladding. Corrosion of the cladding results in the release of radionuclides, primarily uranium, and the formation of brucite ($Mg(OH)_2$) phases which are present both in the corroded Magnox sludge at the base of the pond and suspended in the water column as colloids (Gregson et al. 2011). These brucite colloids have the potential to mobilise insoluble phases providing an important pathway for radionuclide migration. The spent nuclear fuel ponds are maintained at high pH to minimise corrosion of the cladding, however significant corrosion has still occurred.

Despite the seemingly inhospitable conditions in spent nuclear fuel ponds, numerous studies have found microorganisms capable of surviving in spent nuclear fuel ponds (Dekker et al. 2014, Foster et al. 2020, Ruiz-Lopez et al. 2020). Previous work has demonstrated increased abiotic sorption of strontium to brucite in the presence of organic matter derived from *Pseudanabaena catenata* (Ashworth et al. 2018), which dominates algal blooms in the ponds. In this study we focus on uranium interactions with colloidal brucite in the presence of microbes adapted to high pH environments under conditions relevant to the spent nuclear fuel ponds at Sellafield.

Keywords

legacy spent nuclear fuel pond, alkaliphile, colloid

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Conflicts of interest

The authors have declared that no competing interests exist.

References

- Ashworth H, Abrahamsen-Mills L, Bryan N, Foster L, Lloyd J, Kellet S, Heath S (2018) Effect of humic acid & bacterial exudates on sorption–desorption interactions of ⁹⁰Sr with brucite. Environmental Science: Processes & Impacts 20 (6): 956-964. https://doi.org/10.1039/c8em00073e
- Dekker L, Osborne T, Santini J (2014) Isolation and identification of cobalt- and caesium-resistant bacteria from a nuclear fuel storage pond. FEMS Microbiology Letters 359 (1): 81-84. https://doi.org/10.1111/1574-6968.12562
- Foster L, Boothman C, Ruiz-Lopez S, Boshoff G, Jenkinson P, Sigee D, Pittman J, Morris K, Lloyd J (2020) Microbial bloom formation in a high pH spent nuclear fuel pond. Science of The Total Environment 720 https://doi.org/10.1016/j.scitotenv.2020.137515
- Gregson C, Goddard D, Sarsfield M, Taylor R (2011) Combined electron microscopy and vibrational spectroscopy study of corroded Magnox sludge from a legacy spent nuclear fuel storage pond. Journal of Nuclear Materials 412 (1): 145-156. https://doi.org/10.1016/j.jnucmat.2011.02.046
- Ruiz-Lopez S, Foster L, Boothman C, Cole N, Morris K, Lloyd J (2020) Identification of a Stable Hydrogen-Driven Microbiome in a Highly Radioactive Storage Facility on the Sellafield Site. Frontiers in Microbiology 11 https://doi.org/10.3389/fmicb.2020.587556