Optimisation of microbial phosphate biomineralisation for radionuclide remediation

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Phosphate minerals, such as apatites have the potential to be used in permeable reactive barriers (PRBs) for the remediation of groundwater and waste waters contaminated by radionuclides [1]. This is due to their ability to sorb a range of relevant contaminants and stability towards degradation by geochemical processes and ionising radiation [1]. Microorganisms are able to induce phosphate biomineralisation through the action of phosphatase enzymes. These enzymes hydrolyse organic phosphate (P_o) compounds and release inorganic phosphate (P_i) into solution, which can then form precipitates with other ions present, such as radionuclides in the local environment [2,3]. This process possesses several advantages over chemically induced formation including superior contaminant uptake capacities [2], greater control over the localisation of mineralisation [4], and avoiding the need for a direct source of P_i minerals over which there are concerns regarding future supply and price stability [1]. The requirement for an inexpensive and readily available source of P_o may be met by phytate, a common constituent of plant tissues [3]. This research focuses on phytate-hydrolysing organisms and investigates the factors influencing biomineral formation, composition, and characteristics (e.g. enzyme production and activity, secretion of microbial metabolites, other chemical species present, pH, redox potential). Knowledge of these factors can then be used to tailor conditions to promote the manufacture of a biomineral with optimal physicochemical properties for deployment in a PRB (large, reactive surface area with a high capacity for contaminant sorption while remaining hydraulically permeable). Select biominerals will be tested in flow-through column experiments designed to simulate PRB conditions and, from this, challenges relating to scale-up and field-scale deployment of the process will be considered.

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