Nitrate-reducing bacterial activity under alkaline conditions in nuclear waste repositories for intermediate-level bituminous nuclear waste:

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Bitumen is used to embed low and intermediate radioactive waste because of its high impermeability and its great resistance to chemicals. This study focused on the bituminous wastes used for stabilisation of soluble and insoluble salts, mainly of nitrate and sulphate. Resaturation in the disposal cell after closure will modify the confinement properties and the presence of water will not only have significant physical impact (salt dissolution, pressure increase, organic matter solubilisation) but may also allow the development of microorganisms.

Particularly, the released of nitrate can influence the *redox* environment of the cell near-field and, then, oxidize radionuclides increasing their mobility. Nevertheless, other species released in the cell as organic matter and dihydrogen can induce nitrate reduction, both catalysed by microbial activity. Predicting the evolution of the nitrate concentration in the near field (concrete barrier and Excavation Damaged Zone of the Callovo-Oxfordian geological barrier) turns into a biogeochemical research endeavour.

One of the most critical aspect limiting bacterial activity is the high alkalinity prevailing in the barrier concrete system or at the interface concrete-clay rock (11-13.5). The objective of this work is to evaluate the possible activity of nitrate reducing bacteria under these alkaline conditions, as some alkaliphile bacteria are known to develop optimally at pH values above 9, often between 10 and 12, in some cases above 12 (Cao et al., 2008; Yang et al., 2008). They are likely to be predominant under alkaline conditions, but they will be replaced by neutrophilic bacteria as soon as local zones of near-neutral pH develop near the argillite or near the organic matter releasing bituminous waste. The identification of the final product of nitrate reduction, the kinetics of organic matter or dihydrogen oxidation, the optimum pH value of bacterial activity are studied here in order to integrate these unknown data in reactive transport modelling.

A mixed culture of alkaliphile bacteria has been used, coming from Ian Burke's group from the Leeds University. These bacteria originate from alkaline sediments of a man-made lake in Great Britain (Whittleston et al., 2009). These bacteria have been grown in different alkaline media with the goal to quantify nitrate reduction. These alkaline media contain alkaline buffer, Na_2CO_3 0.1 M + $NaHCO_3$ 0.1 M : pH=10, or $Ca(OH)_2$ 25 mM : pH = 12.5, sodium nitrate, organic matter (sodium acetate or lactate) or hydrogen. The evolution of pH, nitrates and nitrites concentration and other energetic nutrients (carbon source, hydrogen) is measured with time.

When organic matter is used as electron donor (acetate), the results show that, nitrite is the main reducing product of nitrate. This result is of primary interest as nitrogen is often used to model the final chemical specie of nitrate reduction. Significative activity is observed at pH=10 (assimilate to the optimum pH value) , but also at pH = 12,5 but with a decrease of the reduction rate. The bacterial reduction of nitrites in the same experiments is very low, indicating the possible accumulation of nitrites rather than nitrates in pore water coming from concrete system into the COx environment. The second part of the experimental work will focus on the microbiological influence on the nitrate consumption by dihydrogen oxidation.

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