Plasticised PVC fuels nitrate reduction at high pH: Implications for nuclear waste disposal

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Safe disposal of nuclear waste necessitates a thorough understanding of the role microbiology plays on the fate of waste forms over long time periods. Despite their significant volumetric contribution, relatively little is known about the bioavailability and fate of organic nuclear wastes under the high pH conditions of a geological disposal scenario. To address this, we conducted microcosm experiments to assess whether plasticised PVC, a significant waste form in the nuclear industry, is available to a high-pH adapted microbial consortium to fuel microbial nitrate reduction at pH 10. A non-plasticised powder form of PVC was also tested. In order to assess the effect of radiation in bioavailability, samples of both PVC forms were subject to 1MGy gamma irradiation using a 60Co source at pH 12.4. The plasticised and pure forms of PVC, both irradiated and non-irradiated, were supplied as the sole source of carbon and electron donors to nitrate-amended freshwater microcosms buffered to pH 10, and inoculated with sediment from a high-pH environment known to contain nitrate-reducing microorganisms.

Plasticised PVC film was found to fuel nitrate reduction at high pH, whether subject to irradiation or not, though non-irradiated PVC film led to greater nitrate reduction. In contrast, pure PVC powder supported minor nitrate reduction and only in irradiated form. Scanning electron microscopy indicated that radiation led to pitting of the PVC film surface, though pyrolysis-GC-MS analysis suggested that radiation had little overall effect on organic composition. Analysis of 16S rRNA gene sequences indicate that common soil microbial lineages not previously known to operate at high pH were enriched during the experiments. Results suggest that PVC additives can fuel microbial metabolism under conditions relevant to nuclear waste disposal, and future work should seek to characterise the impact of these process on radionuclide mobility and ultimately the geological disposal safety case.