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Characterisation of radioactive particles in fly ash via electron microscopy and synchrotron-based techniques

To assess the health risks, fate, transport and long-term environmental impact of Naturally Occurring Radioactive Materials (NORM), information on the mode of occurrence, size, morphology and species is essential. This work assessed NORM in fly ash via scanning electron microscopy (SEM) coupled with energy dispersive spectroscopy (EDS) and synchrotron-based techniques (μ-XRF, μ-XRF tomography and μ-XANES).
Results from the SEM-EDS analysis revealed discrete uraninite and monazite particles (with sizes between 10 μm and 80 μm) dispersed within the fly ash samples. The uraninite particles were found to contain 30% mass fraction of U, and the monazite particles were found to contain about 2% and 4% mass fractions of U and Th, respectively. The weathered, pitted and cracked surface morphologies of these radioactive particles indicate their susceptibility for disintegration into more harmful and readily inhalable PM2.5 aerosol particles, with the potential to deliver localised radiation dose and cause chronic respiratory diseases.
While μ-XRF analysis revealed U to be homogeneously distributed in the uraninite particles, U alongside Th were found to exist strongly co-localised in the interior of the monazite particles in a core-shell pattern. μ-XRF tomography confirmed the existence of U and Th in the interior of the monazite particles, with the implication that leaching of U and Th into the environment from these resistate monazite particles would be insignificantly very low. Results of μ-XANES analysis of the uraninite and monazite particles showed that U existed in the IV oxidation state. Though less mobile, uraninite (U(IV) species) is potentially leachable and can be remobilised during weathering processes.

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