Contribution ID : **131** Type : **Oral Presentation**

Development of an optimised method for analysis of strontium-90 in decommissioning wastes by triple quadrupole inductively coupled plasma mass spectrometry

Monday, 26 September 2016 14:40 (0:20)

Content

Inductively coupled plasma mass spectrometry (ICP-MS) has traditionally been applied to measurement of long-lived radionuclides, as the slow decay rate means ICP-MS offers a higher sample throughput and improved limits of detection compared to alpha and beta counting techniques. As instrumental capabilities have improved, ICP-MS is at a stage where it is capable of measuring shorter-lived radionuclides at activities rivalling radiometric techniques. In the case of 90Sr (half-life 28.8 years), this has the potential to offer significant economic benefits to nuclear sites, as the sample throughput is significantly improved over liquid scintillation counting techniques, the current routine approach for the majority of nuclear sites.

The critical factor affecting ICP-MS measurement of 90Sr is removal of multiple stable interferences prior to measurement, namely isobaric overlap from 90Zr, peak tailing from 88Sr, and multiple polyatomic interferences that form by reactions of elements with gases in the plasma and/or instruments with a reaction cell e.g. 58Ni16O2 and 74Ge16O. The latest generation triple quadrupole ICP-MS (ICP-QQQ-MS) offers an advance in removal of interferences affecting 90Sr compared to alternative instrumental setups. The two quadrupoles either side of a collision-reaction cell effectively removes peak tailing from 88Sr, whilst the introduction of oxygen as a reactive gas into the cell removes the mass overlap of 90Zr through the formation of 90Zr16O. Additionally, the quadrupole positioned in front of the cell prevents the formation of secondary oxide-based polyatomic interferences in the cell. This instrumental setup can be used in combination with or instead of radiochemical separation, reducing the total procedural time and further improving sample throughput.

This work presents the results from a Nuclear Decommissioning Authority (NDA)-funded project for the development of robust, reproducible procedures for low-level measurement of 90Sr in decommissioning samples (soils, sediments and cement) by ICP-QQQ-MS. Results are presented for the performance of multiple sample digestion (acid leaching, microwave and lithium borate fusion) and radiochemical separation techniques, with a focus on achieving complete 90Sr recovery and decontamination of interferences. This is combined with optimisation of ICP-QQQ-MS for both 90Sr sensitivity, and removal of interferences using the triple quadrupole setup. The results from liquid scintillation counting measurement of the same samples will also be presented, allowing direct comparison of the two techniques with regards to procedural time, sample throughput, and limits of detection achievable.

About the Presenter

Ben Russell completed his PhD at the University of Southampton in 2014, investigating the application of sector field inductively coupled plasma mass spectrometry (ICP-SFMS) for low-level nuclear waste characterisation, focussing on measurement of caesium-135/caesium-137 isotopic ratios and strontium-90. The project combined novel and efficient chemical separation techniques with high sensitivity ICP-SFMS quantification, resulting in three lead-author peer-reviewed papers with a invited ICP-MS review paper in draft. Ben now works in the radioactivity group at the National Physical Laboratory, London, with his primary role being to assess the radioanalytical capability of a novel ICP-MS/MS instrument.

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Session Classification : Non-radiometric Measurements

Track Classification : Non-radiometric Measurements