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Feasibility study of a screening method for plutonium in urine by Q-ICP-MS

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ABSTRACT

The monitoring of personnel for exposure to radioactive elements is a regulatory requirement for any nuclear installation and due to the nature of the research, the need for a non-invasive procedure for the monitoring for exposure to plutonium has been identified at the South African Nuclear Energy Corporation (NECSA). Historically, analyses of short-lived radioactive elements were performed by α-spectrometry. But due to the well documented drawbacks of the older generation of α-spectrometer analysis, Quadrupole Inductively Coupled Mass Spectrometry (Q-ICP-MS) was suggested as an alternative technique.

A feasibility study was undertaken to determine whether sub-trace concentrations of plutonium in urine can be determined using a modern, standard Q-ICP-MS. A simplified One Variable at a Time (OVAT) approach was used to establish optimal analytical conditions starting from instrument setup and ending in sample preparation.

The optimum sample preparation determined required 50 mL urine which underwent co-precipitation, wet-ashing and solid phase extraction using Tetra Valent Actinide (TEVA)-resin. Calibration standards ranged from 5 to 100 pg L^{-1} and the optimised method produced LOD's of 0.2 pg L^{-1} and LOQ's of 0.5 pg L^{-1}. Sample intra-assay precision at 0.5- and 15 pg L^{-1} were 11.3% and 4.43% respectively, in the urine matrix. The bias was 8% and 0% at the same concentrations. The method was evaluated using samples from an international proficiency study and two out of the three tests that could be quantified passed specification. According to ISO 13528 a method is acceptable if two out of three tests pass.

The method has been verified and a modern, standard Q-ICP-MS has been proven to be a suitable alternative to α-spectrometry with respect to sub-trace plutonium analysis.