Determination of 238U/235U, 236U/238U and Uranium Concentration in Urine using SF-ICP-MS and MC-ICP-MS: An Inter-laboratory Comparison.

Paper

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Abstract:

Accidental exposure to depleted or enriched uranium may occur in a variety of circumstances. There is a need to quantify such exposure, with the possibility that the testing may post-date exposure by months or years. Therefore, it is important to develop a very sensitive test to measure precisely the isotopic composition of uranium in urine at low levels of concentration. The results of an inter-laboratory comparison using sector field (SF)-inductively coupled plasma-mass spectrometry (ICP-MS) and multiple collector (MC)-ICP-MS for the measurement of uranium concentration and 235U/238U and 236U/238U isotopic ratios of human urine samples are presented. Three urine samples were verified to contain uranium at 1-5 ng L-1 and shown to have natural uranium isotopic composition. Portions of these urine batches were doped with depleted uranium (DU) containing small quantities of 236U, and the solutions were split into 100 mL and 400 mL aliquots that were subsequently measured blind by three laboratories. All methods investigated were able to measure accurately 238U/235U with precisions of ~0.5% to ~4%, but only selected MC-ICP-MS methods were capable of consistently analyzing 236U/238U to reasonable precision at the ~20 fg L-1 level of 236U abundance. Isotope dilution using a 233U tracer demonstrates the ability to measure concentrations to better than +/-4% with the MC-ICP-MS method, though sample heterogeneity in urine samples was shown to be problematic in some cases. MC-ICP-MS outperformed SF-ICP-MS methods, as was expected. The MC-ICP-MS methodology described is capable of measuring to ~1% precision the 238U/235U of any sample of human urine over the entire range of uranium abundance down to <1 ng L-1, and detecting very small amounts of DU contained therein.