Determining $^{238}$U/$^{235}$U, $^{236}$U/$^{238}$U and Uranium Concentration in Urine using SF-ICP-MS and MC-ICP-MS: An Inter-laboratory Comparison.

Paper


Parrish, Randall R.; Thirlwall, Matthew F.; Pickford, Chris; Horstwood, Matthew; Gerdes, Axel; Anderson, James; Coggon, David

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 $^{235}$U/$^{238}$U and $^{236}$U/$^{238}$U 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 $^{236}$U, 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 $^{238}$U/$^{235}$U with precisions of $\sim$0.5% to $\sim$4%, but only selected MC-ICP-MS methods were capable of consistently analyzing $^{236}$U/$^{238}$U to reasonable precision at the $\sim$20 fg L$^{-1}$ level of $^{236}$U abundance. Isotope dilution using a $^{233}$U 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 $\sim$1% precision the $^{238}$U/$^{235}$U 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.

© 2006 Health Physics Society