Radiochemical Measurements of Actinides in Biological Samples: Guide for Research Laboratories for a MARLAP-based Approach to Uncertainty and Quality Management (PEP course)

Daniel J. Strom and George Tabatadze

US Transuranium and Uranium Registries, Washington State University, 1845 Terminal Drive, Suite 201, Richland, Washington

The United States Transuranium & Uranium Registries (USTUR) is a U.S. Department of Energy funded research program at the Washington State University that studies deposition, biokinetics, dosimetry, and possible biological effects of actinides such as plutonium, americium, and uranium. Other radionuclides of interest for analysis at the USTUR include thorium, radium, curium, and neptunium. USTUR registrants are former nuclear workers with measurable, documented exposures to TRU elements who voluntarily donated their organs and tissues to science for post-mortem study.

Systemic plutonium and americium concentrate in the liver and skeleton, while uranium primarily concentrates in the skeleton. Inhalation and wound intakes are most common routes of intake. Lungs, thoracic lymph nodes, liver, skeleton, and, for a wound intake, wound site and axillary lymph nodes are collected and analyzed. For “whole body donors,” many more tissues and organs are included.

Our measurands (the quantities intended to be measured) are activity and activity concentration in tissues and organs. To illustrate how we estimate these measurands from measurement results, we present the entire radiochemistry program, from sample collection at autopsy to the inference of activity and activity concentration in tissues and organs. Sample preparation by dry ashing, microwave digestion, chemical separation of elements, addition of tracers for estimation of radiochemical recovery, and electrodeposition are shown.

The program is presented in a MARLAP framework of measurement quality objectives (MQOs) and data quality objectives (DQOs) with a focus on uncertainty propagation and data management. To demonstrate compliance with MQOs, we calculate the predicted “activity-on-a-planchet” that would be expected 50 years after an intake of 74 Bq (2 nCi) for lung, liver, and skeleton to demonstrate that our radiochemical methods provide data of usable quality. Uncertainties in activity are calculated as a function of background counts and various other uncertain parameters. Methods used in calculations of counting efficiencies and radiochemical recovery are presented. Data and measurement system performance indicators, such as critical value (SC), p-value, minimum detectable activity (MDA), and minimum quantifiable activity (MQA), are calculated and recorded. Calculations are done with the “N+1” option presented in MARLAP. The overall Quality Assurance program is cast in numerical terms with control levels and tolerance limits.

USTUR-0683-24A