

The Mayak Worker Dosimetry System (MWDS-2013): A Bayesian Analysis to Quantify Pulmonary Binding of Plutonium in Lungs Using Historic Beagle Dog Data

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The revised human respiratory tract model, published in Part 1 of the International Commission on Radiological Protection's (ICRP) report on Occupational Intakes of Radionuclides (OIR), includes a bound fraction, fb , to represent radionuclides that have become chemically bound in the lungs following dissolution of particulates in lung fluid. Bound radionuclides are not subject to particle transport clearance but can be absorbed to blood at a rate, sb . The occurrence of long-term binding of plutonium can greatly increase lung doses, particularly if it occurs in the bronchial and bronchiolar regions. However, there has been little evidence that currently supports the existence of a long-term bound state for plutonium. The present work describes the analysis of measurements of lung data obtained from a life span study of Beagle dogs that were exposed by inhalation to different concentrations of plutonium-239 (^{239}Pu) nitrate aerosol at Pacific Northwest Laboratories, USA. The data have been analysed to assess whether a bound state was required to explain the data. A Bayesian approach was adopted for the analysis that accounts for uncertainties in model parameter values, including uncertainties in the rates of particle transport clearance. Furthermore, it performs the analysis using two different modelling hypotheses: a model based on the current ICRP human respiratory tract model and its treatment of alveolar particle transport clearance; and a model of particle transport clearance that is based on the updated model developed by ICRP to calculate dose coefficients for the OIR. The current model better represents clearance in dogs at early times (up to 1 year following intake) and the latter better represents retention at greater times (>5 years following intake). The results indicate that a long-term bound fraction of between 0.16 and 1.1%, with a mean value of between 0.24 and 0.8% (depending on the model) is required to explain the data.

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