- FACTSHEETS

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CENTER FOR HUMAN RADIOBIOLOGY

Fact Sheet on

Determination of ^{228}Ra and ^{228}Th by Measurement of ^{220}Rn (Thoron)

The radium dial industry used both ^{226}Ra (radium, T 1/2 ~1600 yr) and ^{228}Ra (mesothorium, T 1/2~5.8 yr) in luminous paints. Initial activity ratios (228/226) varying from 7 to less than 0.01 have been reported. Both isotopes were also present in some preparations applied for supposed therapeutic effects, most notably in the case of the nostrum, "Radithor", which contained equal amounts (i.e., disintegration rates) of ^{226}Ra and ^{228}Ra. Thus, determination of residual amounts of both isotopes is necessary in order to estimate radiation doses in radium cases. Since radioactive decay reduces the amount of ^{228}Ra by a factor of 400 in 50 years, while ^{226}Ra decays hardly at all, there are few cases for which gamma-ray measurements can now be used to determine ^{228}Ra content. The procedure employed is to determine ^{228}Ra by radiochemical analysis of autopsy and exhumation specimens.

Samples of tissue are ashed and dissolved in nitric acid. ^{220}Rn (mean life 1.3 min), the gaseous decay product of ^{224}Ra (thorium-X), is continuously deemanated from the solution with nitrogen into a collection chamber, where the decay products of thoron are collected on a negatively-charged copper disc coated with zinc sulfide. After a collection period of 10 to 20 hr, the disc is removed and counted with 4-π geometry in an α-scintillation counter. The present system has an optimum efficiency of 0.4 count per disintegration of ^{224}Ra in the solution. For samples of sufficient age, the amounts of ^{228}Th (radiothorium) and ^{228}Ra can be calculated from the measured amount of ^{224}Ra.

The natural content of ^{228}Ra in one gram of human bone is typically an amount that undergoes an average of one disintegration every five hr. The ^{224}Ra content of 20 grams of the ash of such bone can be determined with a relative standard error of 30%. The residual ^{228}Ra activity concentration in the skeleton of a dial worker from an initial systemic activity of 1 μCi ^{228}Ra (2.22×10^6 disintegrations per min) acquired 50 yr earlier and delivering a 50-yr skeletal dose of 10 to 15 rad, is equal to the typical natural level. Therefore, detection of occupationally or iatrogenically acquired ^{228}Ra burdens is limited by the variability of natural levels of ^{228}Ra and by the size of bone sample available for analysis.

For measurement of ^{220}Rn in the breath, the subject exhales for about one hr into a large collection chamber via a face mask. The method of electrostatic collection and counting of active deposit is otherwise identical to that used for dissolved samples. When the average exhaled fraction of ^{220}Rn produced in vivo is known, small burdens of ^{224}Ra and ^{228}Th not detectable by γ-ray measurement can be estimated from measurements of exhaled thoron.

Prepared by A. T. Keane

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The average exhaled fraction of ^{220}Rn is about 0.08 for Thorotrast cases (ThO_2 in the reticuloendothelial system), about 0.05 for inhaled thorium, and about 0.001 for radium cases (^{228}Ra in bone).

When neither in-vivo nor radiochemical measurements can be made, the ratio of ^{228}Ra to ^{226}Ra and its variability are estimated from values obtained on a group of persons with similar exposure histories or from analysis of samples of the radium material to which the person was exposed.

Publication

Low-Level Determination of Skeletal ^{228}Ra and ^{228}Th in the Presence of Gross Amounts of ^{226}Ra

D. R. Kuchta, J. Rundo, and R. B. Holtzman in: Biological and Environmental Effects of Low-Level Radiation, Proceedings of a Symposium, Chicago, Illinois, 3—7 November 1975, International Atomic Energy Agency, Vienna, Vol II, 193—195 (1976).