RadoNorm
Managing risks from radon and NORM

Deliverable 3.2

Report on results of dosimetric calculations for epidemiological studies

Work Package 3

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Authors	**Augusto Giussani (BfS), Balázs Madas (HUN-REN EK), Vladimir Spielmann (BfS)**

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Executive Summary

This deliverable reports on Task 3.2 of the RadoNorm project, which aimed to provide harmonised dosimetric input for epidemiological studies of uranium miners. Annual absorbed doses to the lung and systemic organs were calculated for exposures to radon gas, radon progeny, long-lived radionuclides (LLR) in ore dust, and external gamma radiation. The calculations were based on the most recent ICRP biokinetic and dosimetric models from the Occupational Intakes of Radionuclides (OIR) series. A harmonised protocol was developed, and dose coefficients were derived for radon progeny (Gy per WLM) and for isotopes of the U-238, U-235 and Th-232 decay chains (Gy per Bq). These results, together with the calculation procedures, provide a consistent framework for dose assessment. After publication in a scientific paper, the data will be openly available through STORE^{DB}.

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1. Introduction

This deliverable summarises the results of Task 3.2 of RadoNorm. The aim was to calculate annual absorbed doses to the lung and systemic organs of uranium miners, based on exposures to radon gas, radon progeny, long-lived radionuclides (LLR) in ore dust, and external gamma radiation. Calculations were performed using the most recent ICRP biokinetic and dosimetric models published in the Occupational Intakes of Radionuclides (OIR) series (2017, 2015, 2009, 2008, ICRP, 2006). The following sections present the dose coefficients derived for radon progeny and LLR, which form the basis for application to miner cohorts.

2. Radon progeny

For radon progeny, annual absorbed dose coefficients were calculated in Gy per WLM. For each job type two cases were considered – a breathing rate of 1.2 m^3/h (standard worker) and 1.4 m^3/h (drillers).

Epidemiologists normally have annual exposure data (in WLM) for miners. Therefore, the doses (in Gy) from radon progeny can be calculated for each year. The procedure for calculating doses from radon progeny describes two methods (Marsh, 2022):

- Method 1: assumes all dose is delivered in the year of exposure (simple and sufficiently accurate for lung doses).
- Method 2: accounts for the contribution of earlier exposures to subsequent years (more accurate for systemic organs).

All parameter values used for the calculation of dose coefficients are consistent with those provided in the Dosimetry Protocol for Miners and Millers (Marsh and Task 3.2 members, 2024).

3. Long lived radionuclides (LLR)

For the LLR, annual absorbed dose coefficients were calculated in Gy per Bq for each isotope of the U-238, U-235 and Th-232 chains separately. For each isotope two cases were considered – breathing rates of 1.2 m^3/h and 1.4 m^3/h.

The dose coefficient of each decay chain was calculated as the sum of all isotopes in the chain. The total organ dose was then calculated as:

$$D_{organ} = D_{U\text{-}238chain} + (U\text{-}235/U\text{-}238)\, D_{U\text{-}235chain} + (Th\text{-}232/U\text{-}238)\, D_{U\text{-}235chain}$$

The assumed activity ratio of $^{235}U/^{238}U$ is 2.26/49.03, typical for natural uranium. For $^{232}Th/^{238}U$, different cohort-specific ratios can be used (Marsh and Task 3.2 members, 2024). These ratios and systemic model parameters are taken from the OIR series (ICRP, 2017).

Epidemiologists normally have annual exposure data for LLR in units of gross alpha activity exposure, G [h·Bq·m^{-3}]. The intake of ^{238}U, $I_{U\text{-}238}$ [Bq], can be calculated from G as follows:

$$I_{U-238} = \frac{G \times B}{U_\alpha}$$

where B is the breathing rate [$m^3 \cdot h^{-1}$], and U_α is the total number of alpha disintegrations from uranium ore dust per disintegration of ^{238}U.

4. Conclusions

Task 3.2 has established a harmonised protocol and calculated dose coefficients for radon progeny and LLR exposures of uranium miners. These coefficients allow the conversion of exposure data (WLM or gross alpha activity) into annual absorbed doses for specific organs. The methods are ready to be applied to cohort databases and can provide the dosimetric basis for epidemiological analyses. The data will be openly available in the STORE^{DB} (https://www.storedb.org/store_v3/index.jsp) after the publication of a scientific paper.

5. References

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