BACKGROUND EXPOSURE AND DOSE TO SMALL MAMMALS
IN RADON-RICH SOILS

by

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ABSTRACT

Protection of non-human species from radionuclide releases requires knowledge of the normal background levels of radiation exposure in the exposed biotic community and an estimate of the detriment with the increased exposure. This study modelled the exposure and dose to the lungs of small burrowing mammals from $^{222}$Rn in artificial burrows in radon-rich soils at a site in southeastern Manitoba. Radon-222 was measured in soil gas using E-PERM ionizing chambers. The chambers showed good reproducibility of measurement, with an average coefficient of variation (CV) of about 10%. Preliminary field tests gave geometric mean (GM) $^{222}$Rn concentrations of 5490 Bq•m$^{-3}$ (geometric standard deviation (GSD) = 1.57, $n = 7$) to 41 200 Bq•m$^{-3}$ (GSD = 1.02, $n = 5$). Radon levels in artificial burrows were monitored for one year to determine the influence of physical and environmental factors. Radon-222 concentrations varied markedly within and between burrows and did not show consistent variation with season, orientation of the burrow opening, or levels of $^{226}$Ra in the soil. Annual GM concentrations ranged from 7480 Bq•m$^{-3}$ (GSD = 1.60) in one burrow to 18 930 Bq•m$^{-3}$ (GSD = 1.81) in another burrow several metres away. Overall, the $^{222}$Rn concentration for single observations ranged from about 2000 Bq•m$^{-3}$ to almost 40 000 Bq•m$^{-3}$, with a grand GM of 9990 Bq•m$^{-3}$ (GSD = 1.81, $n = 214$) for the whole site over one year.

An exposure model was constructed for small mammals based on their respiration rates and the number of hours spent in the burrow, either active or hibernating, and the time spent out of the burrow. The highest levels of exposure occurred in animals with the highest respiration rates. A background dose of 2 mGy a' from atmospheric $^{222}$Rn (40 Bq•m$^{-3}$) was estimated for a large-bodied (80 kg), non-burrowing animal, living on the soil surface. For soil-dwelling mammals, hibernation in burrows accounted for a small fraction of total exposure (< 5%) because of very low respiration rates during hibernation. Using mean $^{222}$Rn concentrations from the field studies and an equilibrium factor (F) of 0.5, exposure in the five species was estimated to range from 0.22 mJ•h•m$^{-3}$ (star-nosed mole) to 8.30 mJ•h•m$^{-3}$ (badger). These exposures resulted in doses to the lung up to 11.6 mGy a', using a dose conversion factor of 1.4 mGy per mJ•h•m$^{-3}$ (5 mGy per working level month (WLM)) for whole lung. Higher published dose conversion factors for the upper bronchial pathways (2.5 mGy per mJ•h•m$^{-3}$) and terminal bronchioles (5.4 mGy per mJ•h•m$^{-3}$) result in potential doses up to 44.8 mGy a' in these areas of the lung under the same exposure conditions. Proportionately higher exposures and doses are estimated for higher F values and $^{222}$Rn concentrations. Although these doses to lung approach the levels at which effects have been observed in laboratory studies, published risk coefficients for small mammals (77 cancers per 10$^{6}$ individuals per mJ•h•m$^{-3}$) suggest that exposure to $^{222}$Rn does not pose a major risk for these animals relative to predation, disease and other environmental factors.

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1997