RADON MEASUREMENTS IN INDOOR AIR

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INTRODUCTION

Exposures to radon and daughters due to natural background in indoor air have been estimated by a number of authors (Unscear, 1977 and 1982). Measurements in Australian buildings were reported by Wong (1983) and Kennedy et al (1984). Elevated activity concentrations were found in various types of buildings including terratecture and lithotecture (Baggs and Wong 1987; Hines, Wong and Taylor 1987). In this paper, an attempt to assess the effects of these activities is made.

EXPERIMENTAL

Calibrated nuclear track detectors were used for the survey of radon in indoor air. They were positioned at various exposure sites in selected buildings for periods up to one year. The detectors were processed and the average radon concentrations were determined as described elsewhere (Hines, Wong and Taylor 1987). Further calibrations were made with the radon chamber at the Australian Radiation Laboratory (ARL). In order to assess the effects of these radon activities, the working levels were calculated using the following equation (Straden 1979)

$$mWL = F \times \langle Rn \rangle / 3.7 \qquad ..(1)$$

where $\langle Rn \rangle$ = radon concentration in Bg m^{-3}, and
F = equilibrium factor for radon daughters.

The equilibrium factor for radon daughters may vary considerably with the atmospheric conditions. The mean value value obtained in the survey of private dwellings (Unscean 1977 nd 1982) was 0.5 and the deviation from the mean was found to be within 40%. In this paper the mean value was adopted for the calculation of the working levels.

RESULTS

The results of ten areas which have been surveyed (Hines, Wong and Taylor, 1987) were given in Table 1. These results of the working levels have been compared to those obtained by the air-sampling method. The system was calibrated in the radon chamber at ARL. Reasonably good agreements between these data suggested that the validity of the methods used in the present survey.

TABLE 1. WORKING LEVEL AND ANNUAL EFFECTIVE DOSE EQUIVALENT

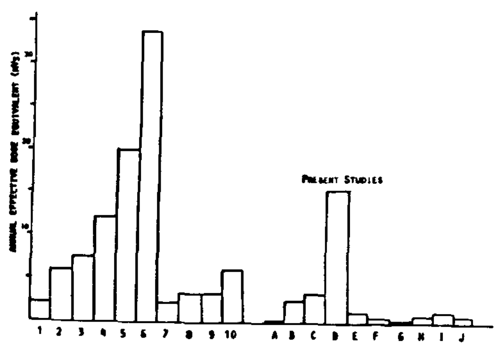
Area*	Mean Activity Concentration (Bg m^{-3})	Mean Working Level (mWL)	Mean Annual Effective Dose Equivalent (mSv)
Wooden Home	17	2	0.23
Sewerage Room	174	24	2.3
Area adjacent to Radon Laboratory	243	33	3.3
Radon Laboratory Radium Safe and Radon Plant Radon Laboratory	1230	166	16
Radon Laboratory - Measuring Area	122	17	1.6
Office 1	34	5	0.6
Office 2	21	3	0.23
Control Room for LINAC	64	9	0.92
Material Store	110	15	1.4
Geology Store	81	11	1.2

*See ref. (Hines, Wong and Taylor 1987) for details.

The lung dose due to the inhalation of airborne alpha emitting nuclides has been calculated by several authors (Jacobi, 1964; Harley, 1982; Hofmann, 1982). An important consideration in the dose-assessment is the mix of attached and unattached radon progeny. The unattached radon daughters, which amount to about 7% in indoor air, deposit all their energies in the respiratory tract, while the attached particles only deposit a fraction of their energies. The dosimetric calculations yielded an average value of 2 Sv J^{-1} for effective dose equivalent per unit of inhaled potential alpha energy intake of radon daughters (UNSCEAR, 1982). Using this figure, the annual effective dose equivalent for exposure in a building (ICRP, 32, 1981) was estimated to be 0.056 mSv per Bq m^{-3}. The values given in the third column of Table 3 were calculated using this conversion factor taking into account the fraction of the time used for occupational exposures.

DISCUSSION AND CONCLUSION

It would be difficult to assess hazards caused by airborne alpha-emitting nuclides, radon and thoron, because of the problems associated with accurate determination of some important parameters such as the equilibrium ratio and the unattached fraction during the prolonged periods of exposure. The results presented in Table 1 were calculated using the mean values of published data as explained previously. If we believe in these figures then the data given in Table 1 may serve as a guideline for the assessment of health hazards from these sources. There is a good reason to adopt these values as the estimates used in this paper are close to lower limits of published results, and consequently they would not overstate the effets. Consistency of track density measured in various detectors exposed at the same site and the comparison of the results to that obtained by the air sampling method supported these assumptions. The cancer risk for inhalation of radon and thoron daughters had been estimated by several international organizations (UNSCEAR, 1977; NAS, 1980; ICRP 31 1981; Cross, 1985) using uranium-mining data. The lifetime risk estimates for lung cancer attributable to radon progeny expsoure range from 1 x 10^{-4} per WLM to 14 x 10^{-4} per WLM, where WLM is the working level month. Using the lowest estimate, the highest lifetime risk in the area surveyed was found to be about 2 x 10^{-4} (Table 1), provided that the required condition of life time exposure is met. It should be pointed out that the estimation of the mean annual effective dose equivalent in areas such as the radon laboratory may not be realistic because the actual occupancy in this area could be lower than 170 hours for a working month used in the estimation. A comparison (Figure 1) of the mean annual effective dose equivalent with that obtained for other occupational exposures could be useful. It is interesting to note that the activity concentration in some of the areas surveyed could deliver a dose which is even higher than those obtained for the coal mines and private dwellings but is lower than those for the uranium mines. In view of the results obtained from this survey, it is apparent that the survey of radon in indoor air could give interesting and useful results for radiation protection. A passive dosimeter would be most suitable for this purpose.



1 Mean in private dwellings
2 Canadian uranium mines (1979)
3 Highest in private dwellings
4 French uranium mines (1979)
5 Indian uranium mines, underground (1979)
6 U.S. uranium mine (1977)
7 U.K. coal mines (1981)
8 Finland coal mines (1977)
9 Norway coal mines (1980)
10 Swedish coal mines (1980)

Fig. 1. Mean Annual Effective Dose Equivalent

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