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AN EVALUATION OF THORON (AND RADON) EQUILIBRIUM FACTOR CLOSE TO WALLS BASED ON LONG-TERM MEASUREMENTS IN DWELLINGS

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Thoron gas and its progeny behave quite differently in room environments, owing to the difference in their half-lives; therefore, it is important to measure simultaneously gas and progeny concentrations to estimate the time-integrated equilibrium factor. Furthermore, thoron concentration strongly depends on the distance from the source, i.e. generally walls in indoor environments. In the present work, therefore, the measurements of both thoron and radon gas and their progeny concentrations were consistently carried out close to the walls, in 43 dwellings located in the Sokobanja municipality, Serbia. Three different types of instruments have been used in the present survey to measure the time-integrated thoron and radon gas and their progeny concentrations simultaneously. The equilibrium factor for thoron measured 'close to the wall', F^{W}_{Tn}, ranged from 0.001 to 0.077 with a geometric mean (GM) [geometric standard deviation (GSD)] of 0.006 (2.2), whereas the equilibrium factor for radon, F_{Rn}, ranged from 0.06 to 0.95 with a GM (GSD) of 0.23 (2.0).

INTRODUCTION

Simultaneous measurements of radon, thoron and their progeny in indoor environments have indicated that the effective doses due to exposure to radon and thoron are similar in specific cases[1, 2]. Dose is mainly attributable to radon and thoron progenies. However, radon and thoron measurements have been usually preferred to progeny measurements due to their higher simplicity and lower cost. In these cases, progenies are estimated by means of the *equilibrium factor* (F), which is the ratio of the equilibrium-equivalent concentration to the actual activity concentration of radon or thoron in air. The equilibrium factor for radon is generally assumed to have a typical value of 0.4[3, 4], with considerable variability due to its sensitivity to room conditions (ventilation, humidity, surface/volume ratio, etc.). Besides its variability under different room conditions, F_{Rn} is quite uniform within each room because both radon and its progeny are essentially uniformly distributed over the room.

In the case of thoron, the equilibrium factor F_{Tn} is not uniform within a room due to the high inhomogeneity of thoron concentration. Even if the last United Nations Scientific Committee on the Effects of Atomic Radiation report[4] assumes a typical thoron equilibrium factor of 0.02, it also underlines its high variability. In fact, due to its short half-life thoron has a distinctly decreasing concentration profile away from the exhaling surface (generally walls in indoor environments), and it is relatively independent of air exchange rate[5]. On the other hand, thoron progenies are sufficiently long lived such that advective and turbulent mixing can be assumed to lead to an approximately uniform or homogeneous distribution in the room, but very sensitive to air exchange. As a result, the F factor has a spatial gradient and depends on air exchange[6, 7].

Data of the thoron equilibrium factor are scarce, and often based on progeny measurements performed with short-term active methods[8]. A central estimate of the equilibrium ratio between thoron and its progeny (measured away from walls) is reported to be on the order of 0.02, both in studies carried out in US homes[8] and dwellings in China[9, 10]. However, short-term active sampling methods for progeny measurements introduce substantial uncertainties in exposure assessment because both gas and progeny have strong temporal variation on diurnal to seasonal scales. Only recently, with the availability of passive time-integrated decay product measurement techniques[11], a long-time

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