5

Human Exposure

GEOFFREY G. EICHHOLZ

5.1 INTRODUCTION

Human exposure to radon results from several sources. Those exposures due to technologically enhanced causes such as mining and milling activities will be discussed first and indoor air exposures last.

Since radon is a decay product of uranium and radium, the distribution of these two elements in the lithosphere and in our bodies is important. The kinds of aerosols or particulates to which the radon progeny are attached and the relation to cigarette smoke are also important.

5.1.1 Dietary Uptake of Radium

Radium is a bone seeker, and an appreciable fraction is deposited on bone surfaces and in areas of active tissue turnover. After high intakes, approximately half the initial activity in man is deposited in critical organs and half in the diffuse component. About 70–90% of the radium in the body is contained in bone, the remainder being distributed fairly uniformly in soft tissues. In areas of normal radiation background, \(^{226}\text{Ra}\) concentrations in bone range from 2 to 20 pCi kg\(^{-1}\) (74–740 mBq kg\(^{-1}\)) with an average value of about 8 pCi kg\(^{-1}\) (0.3 Bq
kg$^{-1}$). The biological half-life of radium in the body has been estimated to be of the order of ten years.

Dose rates in bone lining cells and bone marrow have been calculated with the aid of the following assumptions: (a) an average retention factor in the skeleton and in soft tissues for $^{222}$Rn of 0.33 and 1.0, respectively, and (b) a uniform concentration of radium and its progeny over the total mass of the mineral bone. This leads to total doses of 0.072 mrad y$^{-1}$ (720 nGy y$^{-1}$) to the red marrow and 0.45 mrad y$^{-1}$ (4500 nGy y$^{-1}$) to the bone lining cells from radon and its progeny. Organ doses of this order form only a minor contribution to the natural background exposure: the same conclusion can be drawn for most other food pathways involving the uptake of radium.

5.1.2 Uptake of Radon Progeny

Although the typical concern with human exposure to radon arises from its mobility in the environment and the subsequent deposition and decay of its progeny in the lung, there are certain scenarios where radon progeny appears in its own right due to the pervasive character of the atmospheric radon background as discussed in Chapter 4. Lead-210, with its 22.3- y half-life, can accumulate on plants or soils and be ingested or inhaled without the immediate intervention of its radon precursor. If $^{210}$Pb is taken up by humans, ingrowth of its progeny can occur. Lead is a bone seeker; it is found in bone mineral with a 70% higher level in cancellous bone than in compact bone. The effective biological half-life of $^{210}$Pb, due both to inhalation and ingestion, is about 3300 d. The sum of the contributions from inhalation and ingestion is about 400 pCi (15 Bq).1

The main source of $^{210}$Pb and $^{210}$Po in the atmosphere is $^{222}$Rn emanation from the ground. The amount of atmospheric $^{210}$Pb produced in this way has been estimated to be 0.6 MCi y$^{-1}$ (22.2 PBq y$^{-1}$). After precipitation scavenging is allowed for, the average airborne concentrations in the middle latitudes of the Northern hemisphere have been estimated to be 14 fCi m$^{-3}$ (0.5 mBq m$^{-3}$) for $^{210}$Pb and 3.3 fCi m$^{-3}$ (0.12 mBq m$^{-3}$) for $^{210}$Po.1 Assuming that an adult inhales 20 m$^3$ of air daily, the intakes of nonsmokers are estimated to be 0.3 pCi d$^{-1}$ (11 mBq d$^{-1}$) of $^{210}$Pb and 0.07 pCi d$^{-1}$ (2.6 mBq d$^{-1}$) of $^{210}$Po.

Tobacco leaves have been known to contain appreciable amounts of these radionuclides, though there seems to be some disagreement whether this arises from surface deposition from atmospheric precipi-