

“most exposure to radon and terrestrial gamma rays results from living indoors because the average person in the UK spends only 8% of their time out of doors”

Many atoms are unstable and will change quite naturally into atoms of another element accompanied by the emission of ionising radiation. This process is called radioactivity and the change is called radioactive decay. Unstable atoms that change through radioactive decay are referred to as radionuclides. Radon is the main radionuclide of concern to people and provides about 50% of the total radiation dose to the average person (*see below*). Radon is a natural radioactive gas that you cannot see, smell or taste and can

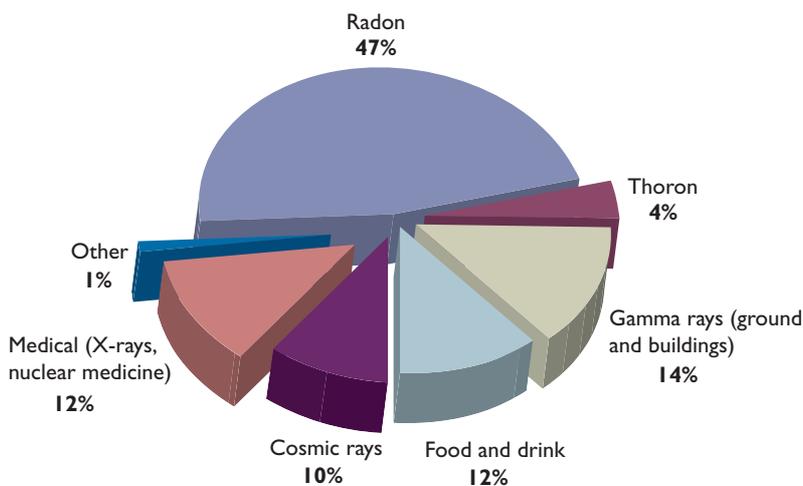
Building materials are the main source of another radioactive gas called thoron, which is derived from the radioactive decay of thorium. The other principal geological source of radiation is terrestrial gamma radiation, which originates chiefly from the radioactive decay of natural potassium, uranium and thorium. These elements are widely distributed in terrestrial materials including rocks, soils and building materials extracted from the Earth. Most exposure to radon and terrestrial gamma rays results from living indoors because

Natural radioactivity and health

The risks posed by exposure to ionising radiation by Don Appleton

only be detected with special equipment. It is produced by the radioactive decay of radium, which in turn is derived from the radioactive decay of uranium. Uranium is found in small quantities in all soils and rocks, although the amount varies from place to place.

the average person in the UK spends only 8% of their time out of doors. Most gamma radiation is received from building materials, whereas most radon comes from the ground underneath a building. Geology is the most important factor controlling the source and distribution of radon and gamma radioactivity so areas of high radon potential and gamma radioactivity can be mapped using geological and geophysical information. However, the resultant dose to the population depends on additional factors such as soil type, house construction and life style.



Sources of radiation exposure contributing to the average annual dose to the UK population (Source: NRPB data; Other = Occupation 0.3%, Fallout 0.2%, Nuclear discharges <0.1%, Products <0.1%).

Natural radioactive materials also occur in food. The radionuclide potassium-40 is a major source of internal irradiation. Shellfish concentrate radioactive materials so that people who consume large quantities of mussels, cockles or winkles can receive a dose from natural radioactivity in food that is about 50% higher than average.

The radiation dose from cosmic rays increases with latitude and altitude so that polar and mountain dwellers, as well as aircrew and frequent air travellers receive higher doses of cosmic radiation.

X-rays and radioactive materials used to diagnose disease are the largest source of artificial exposure to people. The average dose due to anthropogenic sources (radioactive fallout, fuel cycle and so on) is less than 1% of the total annual dose.

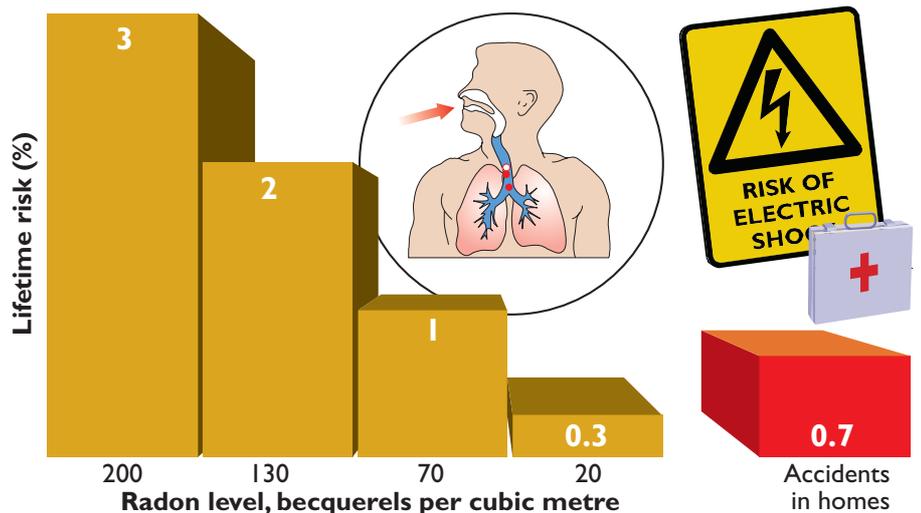
Health effects

Radiation can alter important molecules in human tissue and can also produce chemical changes in DNA, the basic material that controls the structure and function of the cells that make up the human body. This can lead to biological effects, including abnormal cell development, some of which may not be seen for some time after radiation exposure.

Most of the radon gas that is inhaled is exhaled again before it has time to decay and irradiate tissues in the respiratory tract. However, radon decays to form very small solid radioactive particles, including polonium-218, that become attached to natural aerosol, dust, smoke and moisture particles. These solid decay products of radon may become trapped in the lungs and irradiate the cells of mucous membranes, bronchi, and other pulmonary tissues. It is believed that the ionising radiation from the solid decay products of radon gas affect the bronchial epithelial cells and may initiate cancers of the respiratory tract, especially the lungs. The effects of the relatively low doses of natural radiation from radon (that is, lung cancer) usually occur a long time after exposure.

Evidence linking the exposure to high levels of radon and an increase in the risk of lung cancer is becoming overwhelming. Indeed, more is known about the health risks of radon exposure than about most other human carcinogens. High death rates from lung cancer recorded in the Middle Ages amongst miners in Germany and the Czech Republic are now recognised as radon-induced. Studies involving a total of more than 60 000 miners have been conducted in uranium, iron, tin, and fluorspar mines in Australia, Canada, China, Europe and the USA. These studies clearly indicate a correlation between excess mortality from lung cancer and radon exposure.

Residential epidemiological case-control studies examining the



Inhaled radioactive particles derived from radon expose the lungs to alpha radiation and increase the risk of developing lung cancer. The National Radiological Protection Board (NRPB) has estimated that the risk of lung cancer from lifetime exposure to radon at the UK Action Level (200 Bq m⁻³) is 3% (i.e. 30 in 1000 people) compared with 0.3% at the national average radon level (20 Bq m⁻³) and 0.7% (7 in 1000 people) for accidental death in the home.

relationship between contemporary radon gas concentrations in homes and lung cancer have been performed in Canada, China, Finland, Germany, Sweden, the UK, and the USA. These studies indicate that higher lung cancer rates occur in people exposed to higher levels of radon. Apart from lung cancer, there is no epidemiological proof of radon causing any other type of cancer.

The estimated number of deaths attributable to radon constitutes a significant public-health problem and makes indoor radon the second leading cause of lung cancer after cigarette smoking. Risk models have been used to estimate that 2000 to 3500 fatal lung cancers in the UK are attributable to the average domestic radon concentration and that the risk could be up to 50 times higher from lifetime residence in the worst affected areas, including parts of south-west England and Derbyshire. To put this in perspective, the total number of deaths from lung cancer in the UK is about 38 000, most of them due directly to smoking.

The overall hazard to human health from gamma-radiation, either indoors or outdoors is negligible compared with the hazard associated with radon. Visit the National Radiological Protection Board web site (www.nrp.org/radiation_topics/) for further information. ■

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