Health Effects of Radon

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Radon is one of the "noble" gases (such as neon and argon). It is a naturally occurring element that is produced from radium which is part of the uranium decay series. Radon has a half-life of 3.82 days and during decay produces particles called radon daughters. These particles are solid, short-lived radioisotopes that emit alpha particles. When the radon daughters release these alpha particles into the lungs, the alpha particles penetrate cells and cause DNA damage.

Exposure to Radon

Radon is measured in Becquerel's/cubic meter (Bq/m^3). Concentrations may also be reported in picocuries/liter (pCi/L) or picograms per cubic meter (pg/m^3). One Bq represents the activity of a radioactive material in which one nucleus decays per second. One Bq/m^3 is equal to 0.02 pCi/L and 0.0002 pg/m^3.

Approximations of the dose of radiation received are reported as millirems (mrem) and "effective dose" as milliSieverts (mSv). A millirem of radiation carries the risk of a 1 in 8 million chance of dying of cancer (assuming one can extrapolate from very large to very small doses linearly). The mSv represents 100 mrem. Another measure for dose of radiation is the Working Level Month (WLM) or an average concentration of 1 Working Level (WL) for 170 hours. One WL = 8000 Bq/m^3 or 200 pCi/L.

Radiation doses from radon progeny comprise more that 50% of the US population's exposure to radiation. Medical X rays provide the second highest exposure (11%). Typical indoor residential exposure is normally less than 400 Bq/m^3 (generally about 100 Bq/m^3) and between 10 and 20 Bq/m^3 outdoors. In houses built on soils with a high uranium content, very high radon concentrations (>1000 Bq/m^3) have been found.

Radon is also found in the ground, soil, rock and water. Homes that rely on well water may be exposed to some additional radon if the concentration in the well is high. However, the greatest health effect from this source is inhalation of the radon that transfers from the water to the air, and only a very small fraction of the radon in water enters the air. The EPA has recommended a standard for drinking water of 11Bq/L.

Lung cancer

The primary health effect of radon is lung cancer. When the radon daughters release these alpha particles into the lungs, the alpha particles penetrate cells and cause DNA damage. The damage is cumulative and can eventually cause cancer. Animal studies have shown that radon can cause cancer without the contribution of other pollutants (e.g., tobacco smoke).

The fact that radon exposure causes lung cancer was recognized first in uranium miners. One

study evaluated American Indian miners who were non-smokers, and found a threefold increase in lung cancer over that experienced by non smokers who were not miners in the same community.

Smoking increases the risk of lung cancer dramatically. Early evidence for the role of smoking is the fact that before manufactured cigarettes were available, lung cancer was considered a rare disease (in spite of ongoing exposure to radon). Following the introduction of manufactured cigarettes, the incidence of lung cancers rose quickly to the point where it is now one of the most common cancers. For lifelong non-smokers, absolute risks (as opposed to excess risk due only to radon) of lung cancer (for those still alive) are 0.4%, 0.5% and 0.7% respectively at radon concentrations of 0, 100 and 400 Bq/m^3. In cigarette smokers exposed to the same radon concentrations, these risks are 10%, 12% and 16% (Darby et al., 2005).

The EPA is strongly focused on the reduction of radon exposure primarily because of the enormous public health impact of its role in lung cancer in smokers. Mendez et al. (2009) analyzed smoking trends in the US and concluded that a better approach would be to concentrate on programs to reduce smoking.

Radon and Childhood Leukemia

There is some evidence that excessive radon exposure can increase the risk of acute lymphoblastic leukemia in children. One study demonstrated a 56% increase in the rate of this type of leukemia per 1000 Bq/m^3-years increase in exposure (Raaschou-Nielsen et al., 2008; Harley & Robbins 2009).

Radon and Pancreatic Cancer

Radon exposure may be a significant risk factor for pancreatic cancer in African Americans, American Indians, and Asian Americans. Testing and mitigating homes for indoor radon may decrease the incidence of pancreatic cancer in these groups (Reddy & Bhutani 2009).

Radon and Other Cancers

One study of miners revealed some evidence for a relationship between other pulmonary cancers and cumulative radon exposures, but unknown factors could have influenced their results either negatively or positively (Kreuzer et al. 2008).

Protective Effect of Radon

There is some evidence that exposure to very low levels of radon may be protective, especially in smokers. Samet (2009) suggests that a non-threshold linear response is indicated by studies showing that a single alpha particle hit can permanently damage a cell. However, modeling of data from miners' studies indicate that the excess risk for lung cancer at 100 Bq/m^3 is 0.l6, indicative of a protective effect. Note that risk estimates relate to 1 (no change), with estimates greater than 1 indicating increased risk and estimates less than 1 indicating decreased risk (Bogen 1998).

Standards and Guidelines

An indoor air radon concentration of 200-400 Bq/m^3 has been adopted as an action or reference level by many countries. Levels less than 160 Bq/m^3 indicate that no further action is necessary. **The USEPA recommends remedial action if radon levels exceed4 pCi/L** (200 Bq/m^3). The World Health Organization recommends a reference level of 100 Bq/m^3 for radon. An acceptable radon concentration in the workplace is set at 1/3 of a WL or about 1200 Bq/m^3. In September 2009, the World Health Organization released a comprehensive global initiative on radon that recommended a reference level of 100 Bq/m^3 for radon and urged member countries to establish or strengthen radon measurement and mitigation programs, as well as develop building codes that require radon prevention measures in homes under construction.