ENVIRONMENTAL
Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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Radium, Radon, and Uranium: Health Information Summary

Radium, radon and uranium are grouped together because they are radionuclides, unstable elements that emit ionizing radiation. Ionizing radiation can cause toxicity when the particles pass into or through the body at high speed. If a collision occurs with the molecules of living cells, they may be damaged. These particular radionuclides emit radioactivity primarily in the form of alpha particles. Alpha radiation cannot pass through the dead outer layers of the skin. Therefore, these substances are a health risk only if taken into the body by ingestion or inhalation.

Each of these three elements exists in multiple forms, called "isotopes." For example, radium isotopes measured by drinking water analyses include radium-228, radium-226 and radium-224. As they emit radioactivity, these substances either change into a different isotope, or into a completely different element. The emission of radioactivity and transformation into another substance is known as radioactive "decay." Uranium, the first element in the decay chain, is the "parent" substance. Radium and radon are formed later in the decay chain and are "progeny." Uranium-238 decays through 16 radioactive progeny until the stable and non-radioactive element lead-206 is reached.

Uranium, radium and radon occur naturally in the environment, uranium and radium as solids in rock while radon exists as a gas. The radioactive half-life is the time it takes for a substance to lose one-half of its radioactivity. While the half–life of radon is only about four days, the half lives of the most common isotopes for radium and uranium, radium-226 and uranium-238, are approximately 1,600 years and 4.5 billion years, respectively.

Uranium is used in the nuclear power industry, for military ammunition, radiation shielding, and weighting balances for aircraft. Naturally occurring uranium has a smaller amount of radioactivity than the uranium used in nuclear reactors, in which the uranium-235 isotope has been concentrated or "enriched."

Radium has been used as a source of radiation to treat certain cancers and, until the 1960s, was used in paint to illuminate clock and watch dials. Many of the toxic effects of radium are known because of the high exposures to workers who used radium-containing paint. It was a common practice of radium dial painters to tip the paintbrushes with their lips.

Radon gas can be found in the soil because of decay from the parent element uranium. Radon can also migrate from soil into groundwater, which can become another route of exposure if the groundwater is used as a water supply source.

Being present in the soil, uranium and radium accumulate in food in small amounts. Radon can be found in the air or dissolved in water, but it is not generally present in food. Radon is not found at any appreciable concentration in surface water. Picocuries per liter (pCi/L) is a unit commonly used to measure radioactivity in water and air. The background level of radon naturally present in outdoor air is approximately 0.4 pCi/L. Openings between the soil and buildings, such as foundation cracks and where pipes enter, provide conduits for radon to move into structures. The difference in air pressure, caused by heated indoor air moving up and out of buildings, results in a flow of soil gas toward the indoors, allowing radon to potentially accumulate in structures.

Radionuclides are undetectable by the human senses, so only analytical testing can determine if they are present in water. Because they are associated with rock, wells drilled into bedrock are more likely to contain elevated levels of radionuclides than shallow or dug wells.

Health Effects

Absorption/Metabolism

Only about 1-5 percent of uranium is absorbed by ingestion. Measurements of workers exposed to uranium-containing dusts indicated that about 1-2 percent of inhaled uranium was absorbed. Uranium, radium, and radon are not absorbed through the skin to any significant degree. It has been estimated that while approximately 95-99 percent of uranium does not stay in the body for more than several days, the rest may remain in the kidney and bone for several years. Radium can also be incorporated in bone and remain for a long time.

Short-Term (Acute) Effects

There are no known short-term effects from environmental exposures to uranium, radium or radon.

Long-Term (Chronic) Effects

Although natural uranium is weakly radioactive, it's more significant impact on human health is through acting as a "heavy" metal, accumulating in the kidneys where sufficient exposure results in toxicity. High radium exposure, as formerly occurred in its occupational use, caused radiation-induced effects including immune system depression, anemia, cataracts, and teeth that are more easily broken. The effects seen from workplace radium exposure would be extremely unlikely to occur at the much lower environmental exposure levels.

Carcinogenic (Cancer-Causing) Effects

Each of these three radionuclides were Group A or "known human carcinogens" under the old US Environmental Protection Agency cancer classification system and would be classified as "carcinogenic to humans" under the new cancer guidelines. Uranium and radium exposures are primarily associated with an increased risk of bone cancer, although cancer of other organs is possible. Radon exposure is the second leading cause of lung cancer, although far behind smoking cigarettes. Radon is the number one cause of lung cancer for non-smokers. During typical residential water uses, an overall average of approximately 50 percent of the waterborne radon vaporizes into the air. There is a much smaller risk of stomach or other internal cancers from the radon remaining in water that is ingested. Radon exposed individuals who also smoke have a much higher risk of lung cancer than the sum of the risks from each exposure separately, referred to as a "synergistic" effect.

Reproductive/Developmental Effects

There is no information on reproductive or developmental effects of uranium, radium, or radon on humans. In animal studies, uranium exposure has increased developmental effects, but only at very high concentrations not likely to be found in drinking water

Health Standards and Criteria

The EPA has established Maximum Contaminant Level Goals (MCLGs) of zero parts per billion (ppb = micrograms per liter or ug/l) for uranium and zero PCi/L for radium's –226 and –228 isotopes combined in public drinking water systems. MCLGs are health-based non-enforceable guidelines and have traditionally been set at zero for "known" and "probable" human carcinogens. The radium-224 isotope is measured under the "gross alpha" drinking water standard along with other elements in the decay chain that produce alpha radiation, but do not have separate drinking water standards.

The EPA has also established Maximum Contaminant Levels (MCLs) for uranium and radium. MCLs are enforceable drinking water standards determined by balancing the adverse health effects of a particular substance against the feasibility and costs of treating contaminated water. There is a provisional MCL for radon, which has draft status and is, therefore, non-enforceable. The MCL for uranium is 30 ppb based on its potential to accumulate in the kidney and damage it. The MCL for radium is 5 pCi/L based on its potential to cause cancer. The provisional MCL for radon is 300 pCi/L based on its potential to cause lung cancer. Because the EPA realizes that an individual's risk from radon exposure is actually the sum of exposures from both indoor air, originating primarily from radon in soil gas migrating into homes, and from drinking water, the EPA has also proposed an Alternative Maximum Contaminant Level (AMCL). The AMCL would allow up to 4,000 pCi/L of radon in drinking water if radon exposure from indoor air was also considered and reduced, if necessary.

While the EPA decides on an appropriate MCL for radon, New Hampshire uses a guideline of 2,000 pCi/L for radon in drinking water. If this guideline is exceeded, we recommend that you consider taking action to reduce exposure. Because the total risk from radon includes exposure from radon in drinking water and also radon that migrates from the soil to indoor air, both exposure pathways should be taken into account when making decisions about reducing radon exposure.

Because these three radionuclides are considered human carcinogens, there may be some degree of carcinogenic risk even below their MCLs. Based upon EPA calculations, the EHP estimates that drinking water containing either uranium, radium, or radon at its MCL (provisional for radon) would be associated with an increased lifetime risk of cancer approximating one in 10,000 (one excess cancer case in 10,000 people exposed). The risk estimate for each substance is based on a daily intake of two liters of water per day for essentially a lifetime exposure duration of 70 years.

Suggested Reading and References

Casarett and Doull's Toxicology: The Basic Science of Poisons, Sixth Edition. Klaassen, C.D., ed. McGraw-Hill Publishing Co., Inc., New York, 2001.

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Case Studies in Environmental Medicine: Radon Toxicity. Agency for Toxic Substances and Disease Registry (ATSDR). Atlanta, GA. March, 2000.

Risk Assessment of Radon in Drinking Water. Committee on Risk Assessment of Exposure to Radon in Drinking Water; National Research Council. National Academy Press, Washington, D.C. 1999.