Radionuclides (including Radon, Radium and Uranium)

Hazard Summary

Uranium, radium, and radon are naturally occurring radionuclides found in the environment. No information is available on the acute (short-term) noncancer effects of the radionuclides in humans. Animal studies have reported inflammatory reactions in the nasal passages and kidney damage from acute inhalation exposure to uranium. Chronic (long-term) inhalation exposure to uranium and radon in humans has been linked to respiratory effects, such as chronic lung disease, while radium exposure has resulted in acute leukopenia, anemia, necrosis of the jaw, and other effects. Cancer is the major effect of concern from the radionuclides. Radium, via oral exposure, is known to cause bone, head, and nasal passage tumors in humans, and radon, via inhalation exposure, causes lung cancer in humans. Uranium may cause lung cancer and tumors of the lymphatic and hematopoietic tissues. EPA has not classified uranium, radon or radium for carcinogenicity.

Please Note: The main sources of information for this fact sheet are EPA's Integrated Risk Information System (IRIS) (5), which contains information on oral chronic toxicity and the RfD for uranium, and the Agency for Toxic Substances and Disease Registry's (ATSDR's) Toxicological Profiles for Uranium, Radium, and Radon. (1)

Uses

- Uranium is used in nuclear power plants and nuclear weapons. Very small amounts are used in photography for toning, in the leather and wood industries for stains and dyes, and in the silk and wood industries. (2)
- Radium is used as a radiation source for treating neoplastic diseases, as a radon source, in radiography of metals, and as a neutron source for research. (3)
- Radon is used for treating malignant tumors and for experimental studies. (4)

Sources and Potential Exposure

- Uranium-238, a radioactive metal, is present in rocks, soil, and throughout the environment. Uranium-238 decays to form radium-226, which has a half-life of 1,600 years. Radium-226 then decays to form radon-222 gas, which has a half-life of 3.8 days. (1)
- Exposure to uranium can occur through the air, with an average daily intake estimated to be 0.0007 to 0.007 picocuries per day (pCi/d.). Higher levels of exposure generally occur through food consumption, with average levels of 0.6 to 1.0 pCi/d, or through the drinking water, with average levels of 0.6 to 1.0 pCi/d. (3)
- Radium is found in soil, water, plants, and food at low concentrations. The greatest potential for human exposure to radium is through drinking water, where levels are usually less than 1 picocurie per liter (pCi/L) but higher levels (>5 pCi/L) have been detected. (3)
- The major source of radon exposure is through inhalation, with background levels in ambient air of approximately 0.1 to 0.4 pCi/L. Higher levels of radon are frequently present in indoor locations, such as homes, schools, or office buildings. Indoor radon levels measured in one study showed a mean level of 1.6 pCi/L. Studies have shown that 1-3% of single-family homes may exceed 8 pCi/L. (4)
- People who work at factories that process uranium, work with phosphate fertilizers, or live near uranium mines have a greater chance of being exposed to higher levels of uranium, radium, and radon than the

general population. (2)

Assessing Personal Exposure

- Uranium, radium, and radon can be measured in the urine, and there is a test to measure the total amount of radioactivity in the body. In addition, there is a test that measures the rate of elimination of radium and radon in exhaled breath. (2-4)

Health Hazard Information

Acute Effects:

- No information is available on the acute effects of uranium, radium, or radon in humans. (2-4)
- Animal studies have reported inflammatory reactions in the nasal passages and kidney damage from acute inhalation exposure to uranium. (2)
- Acute animal tests in rats, mice, and guinea pigs, have shown uranium to have low to moderate toxicity from inhalation exposure and high toxicity from oral exposure. (2)

Chronic Effects (Noncancer):

- Several studies have found no increased deaths in uranium workers due to kidney disease, however, one study of uranium mill workers chronically exposed to uranium showed kidney disfunction. (2)
- Animal studies have reported effects on the kidney from chronic inhalation and oral exposure to uranium. (2)
- EPA has not established a Reference Concentration (RfC) for uranium (soluble salts or natural). (5,6) ATSDR
- has established a chronic inhalation minimal risk level (MRL) of 0.0003 milligrams per cubic meter (mg/m^3) for uranium (soluble salts) based on renal tubule lesions in dogs. The MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure. Exposure to a level above the MRL does not mean that adverse health effects will occur. The MRL is intended to serve as a screening tool. (2)
- The Reference Dose (RfD) for uranium (soluble salts) is 0.003 milligrams per kilogram body weight per day (mg/kg/d) based on body weight loss and moderate nephrotoxicity in rabbits. The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious noncancer effects during a lifetime. It is not a direct estimator of risk but rather a reference point to gauge the potential effects. At exposures increasingly greater than the RfD, the potential for adverse health effects increases. Lifetime exposure above the RfD does not imply that an adverse health effect would necessarily occur. (6)
- EPA has medium confidence in the study on which the RfD was based since it was well designed, but used a small number of experimental animals; medium confidence in the database because there are adequate studies on the effects of uranium in various species; and, consequently, medium confidence in the RfD. (6)
- Chronic exposure to radium in humans, by inhalation, has resulted in acute leukopenia, while oral exposure has resulted in anemia, necrosis of the jaw, abscess of the brain, and terminal bronchopneumonia. (3)
- Chronic exposure to radon in humans and animals via inhalation has resulted in respiratory effects (chronic lung disease, pneumonia, fibrosis of the lung, decreased lung function), while animal studies have also reported effects on the blood and a decrease in body weights. (4)
- EPA has not established an RfC or an RfD for radium or radon. (7,8)

Reproductive/Developmental Effects:

- Limited evidence from epidemiological studies suggests that uranium or radon exposure may result in a decreased ratio of live male to female births in humans. However, it is not certain if the effect is from uranium or radon exposure because the workers were also exposed to other compounds (2,4)

- Animal studies have reported reduced number of offspring, reduced fetal body weight and length, and an increase in skeletal malformations from oral exposure to uranium in animals. (2)
- No information is available on the developmental or reproductive effects of radium in humans or animals. (3)

Cancer Risk:

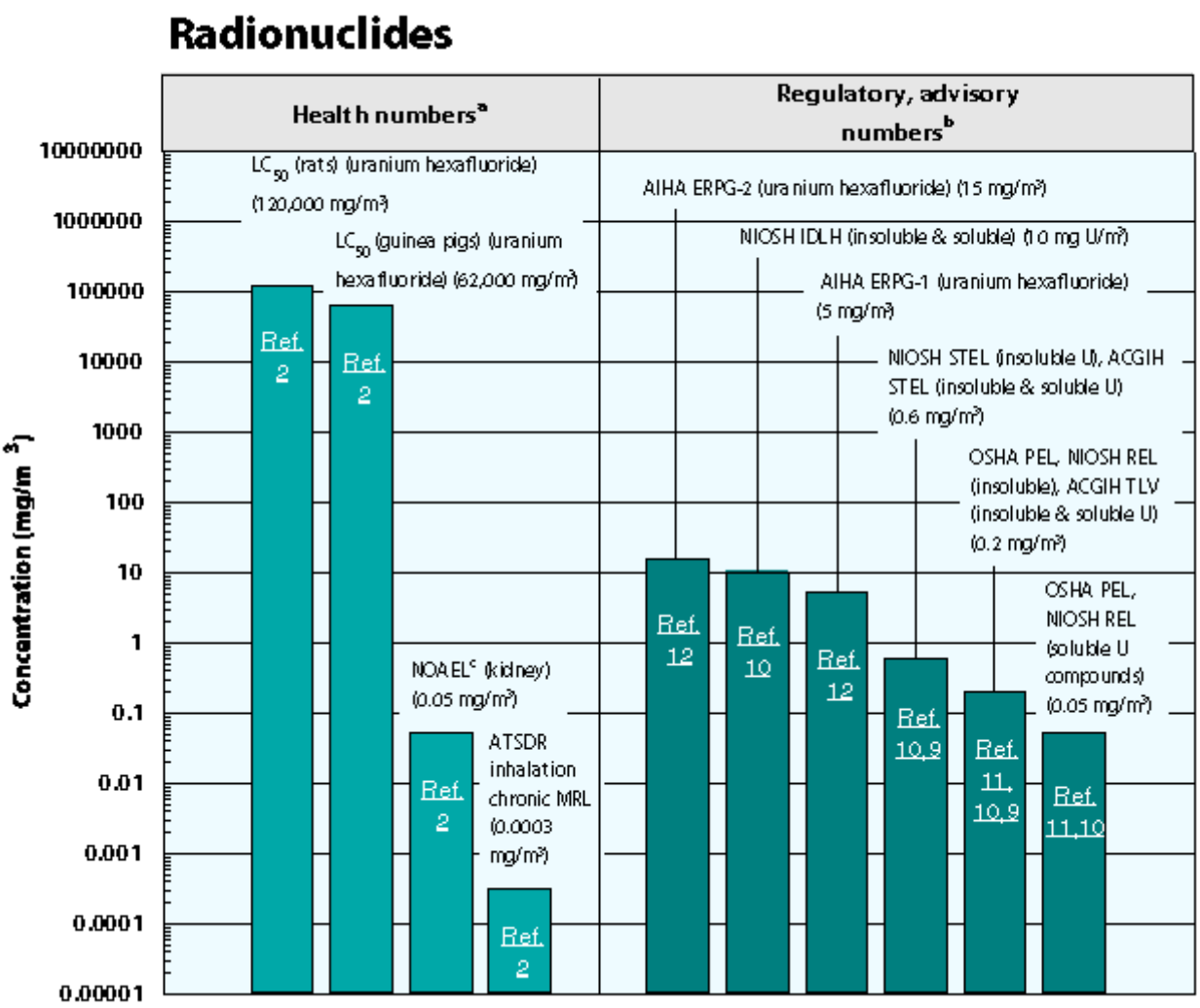
- Radium and radon are potent human carcinogens. Radium, via oral exposure, is known to cause lung, bone, head (mastoid air cells), and nasal passage tumors. Radon, via inhalation exposure, causes lung cancer. (3,4)
- Smokers exposed to radon are at greater risk for lung cancer (approximately 10 to 20 times) than are nonsmokers similarly exposed. (1)
- Studies in uranium miners have shown an increase in lung cancer and tumors of the lymphatic and hematopoietic tissues from inhalation exposure. However, it is not known whether the cancer risk is from uranium itself, or from radon or other confounding factors. (2)
- EPA has not classified radium, radon or uranium for carcinogenicity. (2-4)

Physical Properties

- Natural uranium is a silver-colored radioactive metal that contains three forms (isotopes) of uranium: uranium-234, uranium-235, and uranium-238. The amount of uranium-238 in natural uranium is more than 99 percent, but the uranium-234, present at 0.005 percent in natural uranium, accounts for half of the radioactivity. (2)
- The chemical symbol for uranium is U, and it has an atomic weight of 238.03 g/mol. (2)
- Radium is a naturally occuring silvery-white radioactive metal formed when uranium decays in the environment. (3)
- The chemical symbol for radium is Ra, and it has an atomic weight of 226.03 g/mol. (3)
- Radon is a colorless, odorless, tasteless, radioactive gas that is formed from the radioactive decay of uranium. (1,4)
- The chemical symbol for radon is Rn, and it has an atomic weight of 222 g/mol. (4)

Conversion Factors:
For uranium: 1 µg = 0.72 pCi.

Health Data from Inhalation Exposure from Uranium



ACGIH STEL--American Conference of Governmental and Industrial Hygienist's threshold limit value short-term exposure limit; a 15-minute TWA exposure which should not be exceeded at any time during a workday.
ACGIH TLV--ACGIH's threshold limit value expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effects.
AIHA ERPG--American Industrial Hygiene Association's emergency response planning guidelines. ERPG 1 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor; ERPG 2 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed up to one hour without experiencing or developing irreversible or other serious health effects that could impair their abilities to take protective action.
LC_{50} (Lethal Concentration$_{50}$)--A calculated concentration of a chemical in air to which exposure for a specific length of time is expected to cause death in 50% of a defined experimental animal population.
NIOSH IDLH--National Institute of Occupational Safety and Health immediately dangerous to life and health; NIOSH concentration representing the maximum level of a pollutant from which an individual could escape within 30 minutes without escape-impairing symptoms or irreversible health effects.
NIOSH REL--NIOSH's recommended exposure limit; NIOSH-recommended exposure limit for an 8- or 10-h time-weighted-average exposure and/or ceiling.
NIOSH STEL--NIOSH's recommended short-term exposure limit; a 15-minute TWA exposure which should not be exceeded at any time during a workday.
OSHA PEL--Occupational Safety and Health Administration's permissible exposure limit expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effect averaged over a normal 8-h workday or a 40-h workweek.

The health and regulatory values cited in this factsheet were obtained in December 1999.

[a] Health numbers are toxicological numbers from animal testing or risk assessment values developed by EPA.

[b] Regulatory numbers are values that have been incorporated in Government regulations, while advisory numbers are nonregulatory values provided by the Government or other groups as advice. OSHA numbers are regulatory, whereas NIOSH, ACGIH, and AIHA numbers are advisory.

[c] This NOAEL is from the critical study used as the basis for ATSDR's inhalation chronic MRL.

Summary created in April 1992, updated in January 2000

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1. * A picocurie (pCi) is a unit of measurement for radionuclides that measures the number of disintegrations per second.