Health Physics Society
Specialists in Radiation Safety

Fact Sheet
Adopted: February 2011

Uranium

Adopted from "A Citizen's Guide to Uranium"
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What is uranium?

Uranium is a naturally occurring metallic element that has always been present, since the formation of the earth. Like many other minerals, it has been deposited on land by volcanic action, dissolved by rainfall and, in some places, carried into underground formations. Sometimes chemical conditions resulted in its concentration into "ore bodies." It is a fairly common element in Earth's crust (soil, rock) and in sea and groundwater.

Uranium has exactly 92 protons in its nucleus. It also has approximately 146 neutrons, for a total atomic weight of approximately 238, giving it the highest atomic weight of any naturally occurring element. It is not the densest element, but its density is almost twice that of lead.

Uranium is radioactive and in nature has three primary *isotopes** or states with different numbers of neutrons. The major isotope is uranium-238, with a little uranium-235, and a very small amount of uranium-234.

The process of radioactive material emitting radiation is called radioactive decay. Uranium decays by emitting *alpha particles*, eventually becoming nonradioactive lead. Each new radionuclide along the decay chain is called a *progeny* (or decay product). Uranium progeny also emit *beta particles* and some *gamma and x rays*. Typically, the radioactivity of the uranium progeny contributes about seven times more to the total radioactivity of soil than that of the uranium itself.

The *half-life* is how long it takes for one-half of a radionuclide to decay. The abundance and half-life of a uranium isotope determine its contribution to the radioactivity of natural uranium. The table below lists the relative mass (weight), half-life, and radioactivity of the three primary isotopes of uranium (U.S. Public Health Service 1999).

Uranium Mass, Half-Life, and Radioactivity

Isotope	% Mass	Half-Life (years)	% Radioactivity
U-238	99.3	4.5 billion	48.9
U-235	0.72	704 million	2.2
U-234	0.005	245,000	48.9

How much uranium is there in our environment?

<u>Uranium in soil</u>

The concentration of uranium in soil varies widely, but typically contains about 3 parts per million (ppm), or about 2 *picocuries* per gram (pCi/g). A picocurie is a small amount of radioactivity where approximately two atoms decay per minute. A square mile of earth, one foot deep, will typically contain over a ton of uranium. The radioactivity of uranium ore in the United States is about 0.1 percent by weight, or 700 pCi/g.

<u>Uranium in groundwater</u>

The average concentration of uranium in the groundwater of the United States is about 2 pCi per liter (pCi/L). The U.S. Environmental Protection Agency's (EPA) drinking water standard for uranium is 30 micrograms per liter (µg/L, 30 millionths of a gram per liter), which is about 20 pCi/L (EPA 2009).

However, concentrations can vary considerably from place to place, depending on local geology and other factors. Numerous studies that have been conducted in the United States indicate that the levels in groundwater

*Words in italics are defined in the Glossary on page 3.

used for domestic purposes, including drinking water, are sometimes many times higher than the EPA's drinking water standard.

Uranium in food

Typical annual uranium intakes from a few example foods include (Welford 1967):
Whole-grain products: 10 pCi/yr
Fruit: 30-51 pCi/yr
Meat: 50-70 pCi/yr

The radiation that we are exposed to from sources like soil, water, and food is referred to as background radiation. *Radon*, a progeny of uranium, is one of the largest contributors to our background radiation. Radon is a gas, so can escape from the ground. We are exposed to various concentrations of radon depending on a number of factors, including the amount of uranium in the soil.

Figure 1 illustrates the variability of uranium concentration in soil across the United States and parts of Canada in parts per million of equivalent uranium (ppm eU). Equivalent uranium means that the amount of uranium isotopes that were actually detected were adjusted to account for the other uranium isotopes (i.e., all of the uranium present is included). One ppm eU is equal to about 0.67 pCi/g (U.S. NRC 1992). The U.S. Geological Survey has compiled other aerial radiation survey data to illustrate the variability in the annual background exposure based on where one chooses to live, eat, and drink, available at http://pubs.usgs.gov/of/2005/1413/.

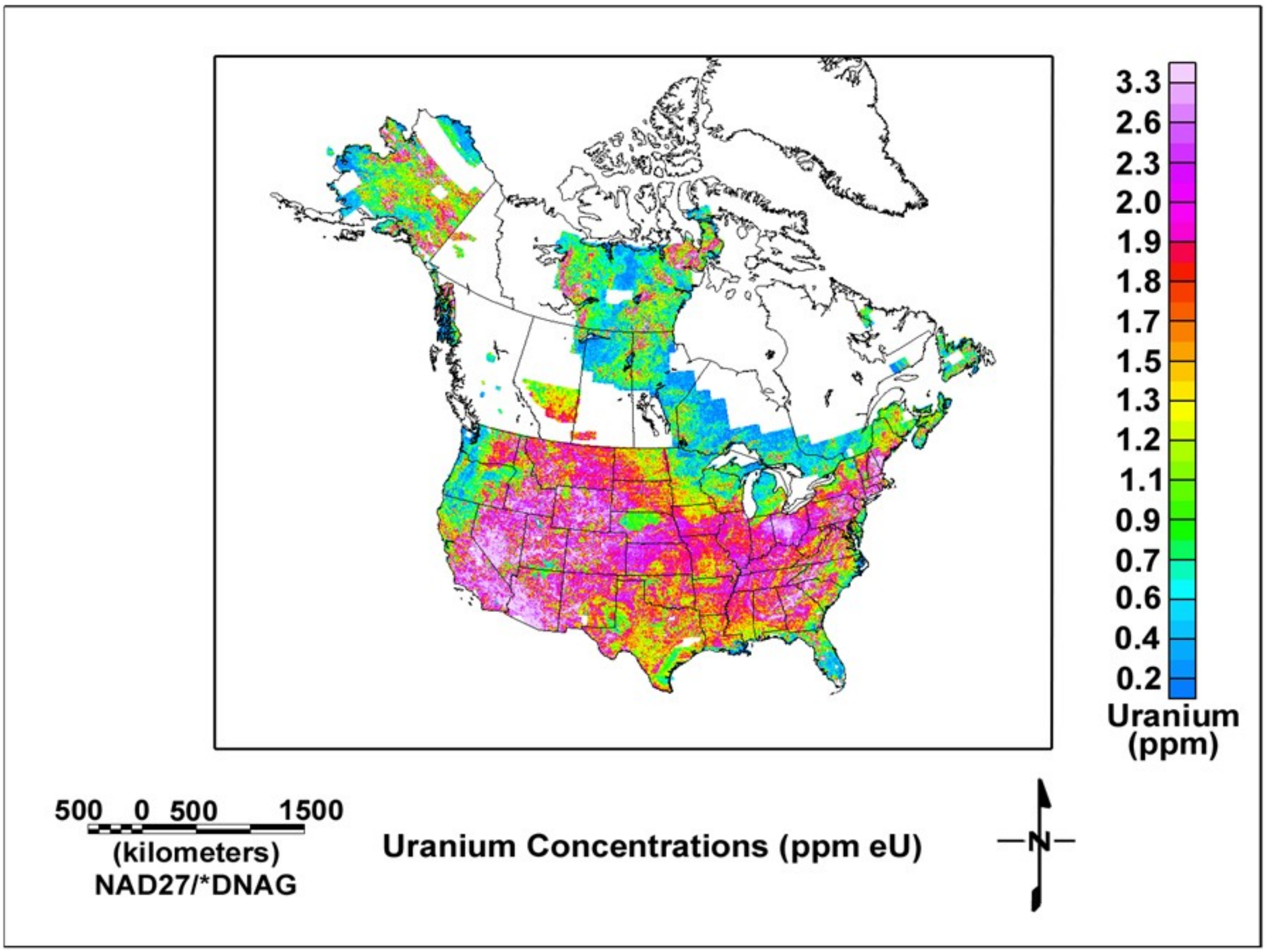

Figure 1: Uranium concentration in soil in the United States (U.S. Geological Survey 2005)

What is uranium used for?

Uranium is primarily used as fuel for electrical generation in nuclear reactors. Approximately 20 percent of U.S. base load electricity is generated by uranium fuel in nuclear power plants (approximately 100 plants in the United States, over 400 currently worldwide). In addition to electricity production, nuclear reactors are used to generate radioactive material needed for radiopharmaceuticals used extensively in medicine.

The uranium used in nuclear reactors typically has been enriched, meaning it has been processed to increase its abundance of uranium-235 from the natural level of less than 1 percent to around 4 percent. The remaining uranium is referred to as depleted uranium because it is depleted in this isotope. Since it is an extremely dense and heavy metal but relatively malleable, depleted uranium is used in military armor and armament as well as counterweights on ships and aircraft (HPS 2010b). Uranium has also been used for many years as a coloring agent in ceramics and glass (HPS 2010a).

What are the potential health effects from uranium?

Uranium is a heavy metal and acts similarly to other heavy metals in the body (like molybdenum, lead, or mercury) (Kathren and Burklin 2008). Accordingly, uranium exposure standards are based on the possible chemical toxicity of uranium, not on its radioactivity (NCRP 1989; U.S. NRC 1992). Despite the prevalence of uranium production and use in the United States, there has never been a documented death or permanent injury to a human from uranium poisoning (U.S. Public Health Service 1999).

The health effects from ionizing radiation exposure are well understood. No health effects have been observed in human populations at the exposure levels within the range and variability of natural background exposures in the United States.

The official position of the Health Physics Society is that for cumulative doses below 5-10 *rem* (which includes the range of both occupational and environmental exposures to uranium), the risks of health effects are either too small to be observed or nonexistent (HPS 2010c).

Possible health effects in populations living near uranium mines, mills, and nuclear power plants have been well studied. "No human cancer of any type has ever been seen as a result of exposure to natural or depleted uranium" (U.S. Department of Health and Human Services 1999).

Although some might question these conclusions, the vast majority of scientists agree with them. The information presented here represents "consensus science," that is, the generally agreed-upon positions of national and international bodies of experts, many of whom are appointed to these positions by their peers or by their governments from around the world.

Would you like to know more about uranium?

If you have further questions about uranium or radiation, please visit another Web site sponsored by the Health Physics Society, www.radiationanswers.org, which is dedicated to public education. This site contains objective, scientific information about radiation in a friendly, easy-to-read format. You can also visit the HPS "Ask the Experts" site to receive answers to your questions about uranium or read the answers given to others who submitted questions.

Glossary

This fact sheet may use nuclear terms that are unfamiliar. Many of these are denoted in italics in the text and are defined in this glossary. More can be found on the Radiation Terms and Definitions page on the Health Physics Society Web site at http://hps.org/publicinformation/radterms.

Alpha Particles

Positively charged, containing two neutrons and two protons, so relatively large and easily stopped.

Beta Particles

Negatively charged, high-energy electrons with a medium ability to be stopped.

Gamma and X Rays

Can be more energetic than alpha and beta particles and, having no mass or charge, harder to stop.

Half-Life
The time it takes for one-half of the atoms in a radioactive isotope to decay.

Isotope
An atom of an element with the same number of protons but with different numbers of neutrons in the nuclei.

Picocurie
A measure of the amount of radioactivity where approximately two atoms decay per minute. A picocurie is 10^{-12} curie.

Progeny
Those elements that a radionuclide decays into.

Radon
A naturally occurring radioactive gas that is released into the atmosphere at the earth's surface. Radon is a progeny of uranium.

Rem
A unit of effective radiation dose. A rem is related to the amount of energy absorbed by human tissue and other factors. 1,000 millirem = one rem. There are 100 millirem in a millisievert (mSv).

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Resources for more information

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The Health Physics Society is a nonprofit scientific professional organization whose mission is excellence in the science and practice of radiation safety. Formed in 1956, the Society has approximately 5,500 scientists, physicians, engineers, lawyers, and other professionals. Activities include encouraging research in radiation science, developing standards, and disseminating radiation safety information. The Society may be contacted at 1313 Dolley Madison Blvd., Suite 402, McLean, VA 22101; phone: 703-790-1745; fax: 703-790-2672; email: HPS@BurkInc.com.