Sources of Exposure

General Populations

- The primary route of exposure for the general population is ingestion of food and drinking water containing uranium.
- Uranium from soil is adsorbed onto plant roots. Thus, high levels of uranium can be found in root vegetables, particularly unwashed potatoes.
- Populations living near uranium mills or mines or other areas with elevated uranium in soil may be exposed to higher levels of uranium from locally grown vegetables.
- The general population can also be exposed to uranium in air; however, exposure to uranium from inhalation is small compared to exposure from food and drinking water.

Occupational Populations

- Workers engaged in the extraction and processing of uranium, such as uranium mining and milling, uranium conversion and enrichment, uranium fuel fabrication, and nuclear weapons production, are more likely to be exposed to higher uranium levels than the general population.
- Glass makers and potters using uranium-containing enamels may be exposed to higher levels of uranium.

Toxicokinetics and Normal Human Levels

Toxicokinetics

- Uranium is poorly absorbed following inhalation, oral, or dermal exposure and the amount absorbed is heavily dependent on the solubility of the compound.
- Following inhalation exposure, the more soluble uranium compounds are more likely to be absorbed into the blood at the alveolar level within days. The less soluble compounds are more likely to remain in the lung tissue and associated lymph nodes either for weeks or years, resulting in significant pulmonary retention and greater dose of alpha radiation.
- Following oral exposure, <0.1–6% of the uranium is absorbed, depending on the solubility of the uranium compound.
- Approximately 67% of uranium in the blood is filtered in the kidneys and leaves the body in urine within 24 hours; the remainder distributes to tissues, primarily the bone, liver, and kidney. The retention half-time for uranium in bone is 70–200 days.

Normal Human Levels

- The normal adult body burden is approximately 90 µg of which 66% is found in bone, 16% in the liver, 8% in the kidneys, and 10% in other tissues.
- The range of geometric mean levels of uranium in the urine of the U.S. population is 0.006–0.009 µg U/g creatinine or 0.005–0.010 µg/L urine.

Biomarkers/Environmental Levels

Biomarkers

- The primary biomarker of exposure to uranium is the chemical or radiological detection of total uranium or individual uranium isotopes in the urine.

Environmental Levels

Air

- Very low levels of uranium, in the attocurie/m^3 range, are detected in air.

Sediment and Soil

- The average concentration of uranium in U.S. soils is about 3 ppm (2 pCi/g)
- Some parts of the U.S., particularly the western portion, have higher-than-average uranium levels due to natural geological formations.

Water

- Uranium levels in drinking water vary widely, with a mean population-weighted average of 1.2 µg/L (0.8 pCi/L.)

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2013. Toxicological Profile for Uranium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Services.

ToxGuide™ for Uranium

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U.S. Department of Health and Human Services
Public Health Service
Agency for Toxic Substances and Disease Registry
www.atsdr.cdc.gov

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Chemical and Physical Information

Uranium is a Metal

- Uranium is an alpha-emitting, radioactive, heavy metal that occurs naturally in nearly all rocks and soils.
- The three naturally-occurring isotopes are ^{234}U, ^{235}U, and ^{238}U.
- Naturally occurring uranium is an isotopic mixture containing 99.284% ^{238}U, 0.711% ^{235}U, and 0.005% ^{234}U by mass and has a specific activity of 0.68 µCi/g.
- The industrial process of enrichment separates natural uranium into enriched uranium (increased percentage of ^{235}U) and depleted uranium (decreased percentage of ^{235}U). Uranium enrichment for commercial nuclear energy produces uranium that contains about 3% ^{235}U by activity. Uranium enrichment for other purposes, including nuclear weapons production, can produce uranium containing as much as 97.3% ^{235}U.
- Depleted uranium is the byproduct of the enrichment process. It has even less specific activity (0.33 µCi/g) than natural uranium.
- Natural uranium is used to make enriched uranium. Enriched uranium is used in the production of fuel for nuclear power plants. Depleted uranium is used as counterbalance on helicopter rotors and airplane control surfaces, radiation shield for high radioactivity sources, military armor, and armor piercing munitions.

Routes of Exposure

- Inhalation – Minor route of exposure for the general population. Major route for occupational population.
- Oral – Predominant route of exposure for general population through ingestion of food and drinking water.
- Dermal – Unlikely route of exposure for general population.

Uranium in the Environment

- Naturally occurring uranium isotopes have very long half-lives, 2.4×10^5, 7.0×10^8, and 4.5×10^9 years for ^{234}U, ^{235}U, and ^{238}U, respectively.
- Uranium is most commonly found in soil and water; very low levels have been detected in air.
- The highest levels of uranium in food are found in beef liver and kidneys, cow's milk, and root vegetables.

Relevance to Public Health (Health Effects)

Health effects are determined by the dose (how much), the duration (how long), and the route of exposure.

Minimal Risk Levels (MRLs)

Inhalation

- No acute-duration inhalation MRLs have been derived for soluble or insoluble uranium compounds
- Intermediate-duration inhalation MRLs (15–365 days):
  - 0.002 mg U/m³ for insoluble uranium compounds
  - 0.0001 mg U/m³ for soluble uranium compounds
- Chronic-duration inhalation MRLs (≥365 days):
  - 0.0008 mg U/m³ for insoluble uranium compounds
  - 0.00004 mg U/m³ for soluble uranium compounds

Oral

- An MRL of 0.002 mg U/kg/day has been derived for acute-duration oral exposure to soluble uranium compounds (≤14 days).
- An MRL of 0.0002 mg U/kg/day has been derived for intermediate-duration oral exposure to soluble uranium compounds (15–364 days).
- No chronic-duration oral MRL has been derived for soluble uranium compounds.
- No acute-, intermediate-, or chronic-duration oral MRLs have been derived for insoluble uranium compounds.

Health Effects

- *Natural Uranium.* The toxicity of natural uranium is mainly due to its chemical damage to kidney tubular cells following exposure to soluble uranium compounds and the respiratory tract following chronic inhalation exposure to insoluble uranium compounds. Other potential targets of toxicity include the reproductive system and the developing organism.
- *Depleted Uranium.* Depleted uranium is less radioactive than natural uranium. The health effects associated with exposure to depleted uranium will be the same as natural uranium because the toxicity of natural uranium is primarily due to chemical toxicity to uranium rather than uranium radiotoxicity.
- *Enriched Uranium.* The chemical toxicity of enriched uranium is the same as natural uranium; however, there is an increased risk of radiotoxicity. Animal studies have reported increased serum testosterone levels and decreased memory in rats exposed to enriched uranium, as compared to rats exposed to depleted uranium.

Children's Health

- Uranium is expected to affect children in the same manner as adults.
- Animal data suggest that there may be age-related toxicokinetic differences, such as changes in absorption efficiencies, skeletal development, or kidney development which may affect toxicity in different aged children.