Sources of Exposure

General Populations

- The main sources of plutonium in the environment are releases from research facilities, atmospheric nuclear weapons testing, waste disposal, nuclear weapons production facilities, and accidents.
- Atmospheric testing of nuclear weapons, which ended in 1980, is the source of most of the plutonium in the environment worldwide.
- Humans may be exposed to plutonium by breathing air, drinking water, or eating food containing plutonium; however, the levels of plutonium in air, water, soil, and food are generally very low, and of little health consequence.

Occupational Populations

- Workers may be exposed at facilities where plutonium is used or stored; however, plutonium is highly contained and strictly regulated.
- Accidental releases at facilities where plutonium is used or stored could result in levels of exposure higher than those experienced by the general population.

Toxicokinetics and Normal Human Levels

Toxicokinetics

- The absorption of inhaled plutonium from the lung is slow and follows a two-phase model, with respective half-times of months and years. The portion that absorbs more quickly increases with chemical solubility and is greater for ^{238}Pu than ^{239}Pu compounds due to radiolytic fragmentation of high specific activity particles. Plutonium is poorly absorbed from the gastrointestinal tract or intact skin, but a fraction is readily absorbed from skin wounds.
- Once absorbed, plutonium is distributed throughout the body, but concentrates in bone and liver.
- Plutonium is not metabolized. Following exposure there is an initially high fecal excretion period after which it is only slowly eliminated via the urine and feces.

Normal Human Levels

- Background urinary levels of 8.5×10^{-7} Bq/day (2.3×10^{-5} pCi/day) have been reported.

Biomarkers

- Plutonium is a radioactive element. Plutonium within the body can be inferred from radioassays of urine, feces, or tissue samples or from external measurements of x-rays emitted from the body.

Biomarkers/Environmental Levels

Environmental Levels

Air

- In general, plutonium concentrations in air are low. Baseline ^{239}Pu concentrations in air ranging from 1.6×10^{-6} to 3.8×10^{-6} pCi/m^3 have been reported on locations close to facilities known to release plutonium.

Sediment and Soil

- Average plutonium levels in surface soil from fallout range from about 0.01 to 0.1 pCi/g.

Water

- Average $^{239,240}Pu$ concentration in water samples collected upstream from a contaminated site was 9.5×10^{-6} and 2.7×10^{-5} pCi/L in the particulate and dissolved fractions, respectively.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2010. Toxicological Profile for Plutonium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Services.

ToxGuide™ for Plutonium

Pu

CAS# 7440-42-8

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U.S. Department of Health and Human Services
Public Health Service
Agency for Toxic Substances and Disease Registry
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ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Chemical and Physical Information

Plutonium is a radioactive element

- Most plutonium is not naturally occurring; however, trace amounts are found in naturally occurring uranium ores.
- Isotopes with mass numbers 228–247 have been identified for plutonium; all are radioactive.
- The principal plutonium isotopes used in military and nonmilitary applications are ^{238}Pu and ^{239}Pu.
- ^{238}Pu is used as a heat source in nuclear batteries to produce electricity in devices such as unmanned spacecraft, and interplanetary probes.
- ^{239}Pu and ^{240}Pu are produced in nuclear power plants as a product of nuclear fission as well as in production facilities for use in nuclear weapons.
- Plutonium is a carefully regulated material under government control.

Routes of Exposure

- Inhalation – The exposure route of primary concern for workers and the general population.
- Oral – Minor route of exposure.
- Dermal – Minor route of exposure.

Plutonium in the Environment

- The half lives of the most common plutonium isotopes are 87.7, 24,100, 6,560, and 14.4 years for ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Pu, respectively.
- Plutonium enters the environment primarily through releases to the atmosphere or direct discharge to ponds, streams, or oceans. Approximately one-fifth of the plutonium released to the atmosphere during atmospheric weapons testing before 1980 was estimated to fall on the test site; the rest was carried in the atmosphere, adsorbed to particulate matter and is transported back to earth via dry or wet deposition.
- Once plutonium is deposited either on the land or surface water, sorption to soils or sediments is the primary environmental fate of plutonium.
- A small fraction of plutonium reaching the soil will become solubilized either through chemical or biological processes, depending upon its chemical form. In soluble form, plutonium can either migrate in groundwater or surface water or be available for uptake into plants.

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-, intermediate-, or chronic-duration inhalation MRLs were derived for plutonium.

Oral

- No acute-, intermediate-, or chronic-duration oral MRLs were derived for plutonium.

Health Effects

- The main health effect from exposure to plutonium is cancer which may occur years after exposure. Cancer risks are strongly dependent on radiation doses received by specific tissues and organ systems. The types of cancers humans would most likely develop are cancers of the lung, bones, and liver where most of the body burden resides. These types of cancers have occurred in workers who were exposed to plutonium in air at much higher levels than those found in the air that most people breathe.
- IARC has assigned ^{239}Pu and its decay products as aerosols to group 1 human carcinogens. DHHS, and the EPA Office of Air and Radiation consider plutonium to be a known human carcinogen.

Children's Health

- There is no information regarding health effects of plutonium in children.
- Since a large portion of the plutonium in the body of adults is in bone, it is possible that plutonium in the bones of a pregnant woman may move to the fetus, when the calcium from the mother's bone is being used to build the bones of the fetus.
- Epidemiological studies of ionizing radiation exposures have found higher cancer risks associated with exposures of infants and children compared to adults.
- Studies in animals suggest that immature animals may be more vulnerable to plutonium as a result of higher deposition of absorbed plutonium on bone surfaces and higher turn-over of bone.