Plutonium Health Effects: Basics

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Plutonium in Livermore:
Ethical Decision Making
Livermore, CA
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Ionizing Radiation: Health Effects

- **Deterministic (Non-stochastic):** Appear if minimum radiation dose is exceeded, severity increasing with dose. Single radiation doses over about 1 sievert: radiation sickness (nausea, vomiting, diarrhea), radiation burns

- **Random (Stochastic):** Radiation doses less than 1 sievert. Cancer, genetic damage: may appear decades after exposure
Radiation

- **Alpha Particles**: Stopped by a sheet of paper.
- **Beta Particles**: Stopped by a layer of clothing or by a few millimeters of a substance such as aluminium.
- **Gamma Rays**: Stopped by several feet of concrete or a few inches of lead.

- Organic Tissue
Plutonium

- Solid under normal conditions
- Pu-239 present only in trace amounts in nature
- Over 1,200 metric tons produced since WWII in military and commercial programs
- DOE: 100 million gallons high level waste
Plutonium

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Half Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pu-236</td>
<td>2.87 years</td>
</tr>
<tr>
<td>Pu-237</td>
<td>45.2 days</td>
</tr>
<tr>
<td>Pu-238</td>
<td>87.7 years</td>
</tr>
<tr>
<td><strong>Pu-239</strong></td>
<td><strong>24100.0 years</strong></td>
</tr>
<tr>
<td>Pu-240</td>
<td>6560.0 years</td>
</tr>
<tr>
<td>Pu-241</td>
<td>14.4 years</td>
</tr>
<tr>
<td>Pu-242</td>
<td>375000.0 years</td>
</tr>
<tr>
<td>Pu-243</td>
<td>4.95 hours</td>
</tr>
<tr>
<td>Pu-244</td>
<td>8.0E7 years</td>
</tr>
<tr>
<td>Pu-245</td>
<td>10.5 hours</td>
</tr>
<tr>
<td>Pu-246</td>
<td>10.85 days</td>
</tr>
</tbody>
</table>
Plutonium 239: Health Dangers

- Greatest health danger from inhalation, especially in form of insoluble Pu-239 oxide
- Absorption into bloodstream from cuts and abrasions
- Risk from absorption into body via ingestion generally much lower than inhalation
- In general, larger particles produce smaller amount of biological damage and pose smaller risk of disease
Plutonium: Alpha Tracks
Ionizing Radiation: Cancer

- Genetic damage can occur in any cell, so cancer can occur in many sites
- Effects depend in part on route of exposure: x-Rays or gamma radiation can effect DNA in blood-forming cells or various organs with delayed effects
- Many pathways: solubility, specific organ accumulation
Organ doses of ingested Pu-239

Drawn by Abel Russ, Community-Based Hazard Management Program at Clark University

(values from ICRP publication 67 (1993)).
Organ doses of inhaled Pu-239 Oxides, 1 μm diameter

Drawn by Abel Russ, Community-Based Hazard Management Program at Clark University

(values from RAC report No. 5-CDPHE-RFP-1998-FINAL(Rev.2) (2000): Assessing Risks of Exposure to Plutonium)
The Evolution of Health Protection Standards for Nuclear Workers

No dose standards existed between 1896 and 1925.

A new law institute of the damage caused by human tissue by a device of institutions.
Linear No-Threshold Hypothesis

![Linear No-Threshold Hypothesis](image)
Threshold Hypothesis
Supralinear Hypothesis
Plutonium in Livermore Parks

- Big Trees Park: Discovered in 1993 when EPA checking background plutonium values in the vicinity of LLNL
- Plutonium found at greater concentration than what would have been expected from global fallout alone
- Issue of elevated levels of plutonium at Sycamore Grove and Sunflower Parks
- Potential Exposure Pathways: Inhalation and Ingestion (children)
Radiation-Genetic Damage
PRECAUTIONARY PRINCIPLE

“When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.”

Wingspread Statement