Doses to Public Arising From the Use of Radioisotopes in Radionuclide Laboratories and Hospitals in Finland

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Purpose of the study

- The regulatory guide ST 6.2” Radioactive wastes and discharges” is set for renewal

  ![STUK guide ST 6.2](image)

  Radioactive Wastes and Discharges

- The desire to get a ”Bq to Sv” calculation chain
- No reason to suspect current limits are too high
- Estimates for both adults and children
- Real disposal activities were used
Exposure routes considered in the study

- Discharge
  - Waste incineration
    - Flue Gas
      - Internal Dose From Flue
    - Fly ash
      - Internal Dose From Contaminated Foodstuff
      - Internal dose to Landfill Site Worker
  - Sewage
    - Purified Water
      - Internal Dose From Contaminated Foodstuff
    - Sludge
      - Internal Dose From Contaminated Foodstuff
      - Internal and External Dose to Sewage Plant Worker
Selected locations

1. **Turku**
   - Waste incinerator plant
     - Flue gas
     - Ash deposited at landfill

2. **Tampere**
   - Liquid waste from laboratories, hospital
     - Purified water pumped to lake Pyhäjärvi
     - Sludge used in farming

3. **Seinäjoki**
   - Same as Tampere except cleaned water pumped to river Seinäjoki

City and site specific data used
- Stack height, river flow, ...
Example - Tampere

• Waste from radionuclide laboratory / hospital enters the sewage system
  – For hospital discharges, actual reported values for Tampere University Hospital were used
  – For laboratories, values for Turku were used

• Sewage is treated in the local sewage water treatment plant

• Radionuclides are divided between sludge and purified water based on nuclide specific distribution coefficient
  – If a coefficient was found in literature, it was used
  – If no coefficient was found, all radionuclides were assumed to go both sludge and purified water -> conservative result
Example – Tampere, contd.

- **Purified water** is pumped into the lake Pyhäjärvi, where it dilutes and is consumed for
  - Irrigation -> exposure through consumption of irrigated vegetables
  - Fishing -> exposure through consumption of fish

- **Sludge is used for soil improvement in farming**
  - Internal and external exposure from soil improvement
  - Internal exposure through consumption of
    - Meat, milk, grain

- **Consumption values were taken from literature**
  - E.g.

\[
C_{crops} = C_{final} \times CF_{crops} \times e^{-\lambda_{crops}} \times f_{red}
\]

\[
E_{crop} = C_{crops} \times IR_{crops} \times DF_{ing}
\]
# Results – Doses from Tampere University Hospital

<table>
<thead>
<tr>
<th>Nuclide:</th>
<th>Cr-51</th>
<th>F-18</th>
<th>I-123</th>
<th>I-131</th>
<th>In-111</th>
<th>P-32 (*)</th>
<th>Se-75</th>
<th>Tc-99m</th>
<th>Y-90</th>
<th>Total Dose: (Sv/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual Dose, (Sv/a)</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult, purified water</td>
<td>1,E-14</td>
<td>7,E-107</td>
<td>1,E-25</td>
<td>4,E-09</td>
<td>2,E-12</td>
<td>5,E-09</td>
<td>5,E-13</td>
<td>6,E-42</td>
<td>3,E-14</td>
<td>9,E-09</td>
</tr>
<tr>
<td>Child, purified water</td>
<td>4,E-14</td>
<td>2,E-106</td>
<td>4,E-25</td>
<td>1,E-08</td>
<td>4,E-12</td>
<td>1,E-08</td>
<td>9,E-13</td>
<td>1,E-41</td>
<td>9,E-14</td>
<td>3,E-08</td>
</tr>
<tr>
<td>Sewage treatment plant worker</td>
<td>9,E-10</td>
<td>7,E-20</td>
<td>6,E-08</td>
<td>6,E-06</td>
<td>2,E-07</td>
<td>2,E-07</td>
<td>2,E-10</td>
<td>2,E-07</td>
<td>7,E-08</td>
<td>7,E-06</td>
</tr>
<tr>
<td>Adult, sludge used as soil improvement</td>
<td>5,E-12</td>
<td>7,E-187</td>
<td>5,E-33</td>
<td>9,E-07</td>
<td>6,E-14</td>
<td>5,E-06</td>
<td>1,E-09</td>
<td>2,E-59</td>
<td>3,E-13</td>
<td>6,E-06</td>
</tr>
<tr>
<td>Child, sludge used as soil improvement</td>
<td>1,E-11</td>
<td>2,E-186</td>
<td>2,E-32</td>
<td>3,E-06</td>
<td>2,E-13</td>
<td>2,E-05</td>
<td>3,E-09</td>
<td>5,E-59</td>
<td>1,E-12</td>
<td>2,E-05</td>
</tr>
</tbody>
</table>

(* P-32: half life of 14 days)
Results – Doses from a hypothetical laboratory in Tampere

The ratio between a discharge that causes a 10 µSv annual dose and the exemption limit of the nuclide

![Graph showing ratios for different scenarios and nuclides.](image-url)
Summary

• A small study was performed to aid in the renewal of the regulatory guide ST 6.2: Radioactive wastes and discharges

• An Excel spreadsheet was developed that can be used in different scenarios for dose estimation

• For laboratory discharges the study confirmed that
  – The current discharge limits do not result in overexposure of the population, as expected
  – The use of nuclide specific exemption levels as a criteria for regulatory limits for annual discharges from radionuclide laboratories is justified

• The results are to be used in the renewal of the guide ST 6.2