Comparative analysis of the radionuclide composition in fallout after the Chernobyl and the Fukushima accidents

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Tasks

Chernobyl and Fukushima

1) Analysis of the ratios of $q(R_i)/q(^{137}\text{Cs})$ decay-corrected to the date of the main fallout.

   \[q(R_i)\text{ is ground deposition density of radionuclide } R_i\]

2) Analysis of the dependence of $q(^{131}\text{I})/q(^{137}\text{Cs})$ vs $q(^{137}\text{Cs})$ decay-corrected to the date of the main fallout.
Areas considered

Chernobyl

- Near zone – Central spot (up to 60 km)
- Far zone – Gomel-Mogilev spot (centered ~200 km)

Fukushima

- Near zone – circle (up to ~60 km)
Chernobyl: Map of $^{137}$Cs deposition
Fukushima: Map of $^{137}$Cs deposition
Input data

**Chernobyl**

- Spectrometrical measurements of soil samples. For $^{131}$I – only measurements conducted up to 2 months following accidents (up to June 23, 1986).
- Units – kBq m$^{-2}$
- Measurements were carried out by the specialists from: Institute of Nuclear energy (Minsk, Belarus) and Institute of Biophysics (Moscow, Russia)
Input data

**Fukushima**

- Spectometrical measurements of soil samples. For $^{131}$I – only measurements conducted up to 2.5 months following accidents (up to May 31, 2011).
- Units – Bq kg$^{-1}$
- Measurements were carried out by Japanese specialists and placed at the website of MEXT (Ministry of Education, Culture, Sports, Science and Technology)
Task

Chernobyl and Fukushima

1) Analysis of the ratios of $q(R_i)/q(^{137}\text{Cs})$ decay-corrected to the date of the main fallout.

$[q(R_i)$ is ground deposition density of radionuclide $R_i]$
# Average ratio of $R_i$ to $^{137}$Cs in soil

<table>
<thead>
<tr>
<th>Area</th>
<th>95\text{Zr}, 95\text{Nb}, 141\text{Ce}, 144\text{Ce}</th>
<th>106\text{Ru}, 103\text{Ru}</th>
<th>140\text{Ba}, 140\text{La}</th>
<th>132\text{Te}</th>
<th>134\text{Cs}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central spot</td>
<td>2-5</td>
<td>1-3</td>
<td>3</td>
<td>20</td>
<td>0.5</td>
</tr>
<tr>
<td>Gomel-Mogilev spot</td>
<td>0.06-0.11</td>
<td>0.7-2</td>
<td>0.7</td>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td>Fukushima (northwest zone)</td>
<td>ND</td>
<td>ND</td>
<td>traces</td>
<td>5-9</td>
<td>0.8-0.9</td>
</tr>
</tbody>
</table>
Range of ratio of $^{131}\text{I}/^{137}\text{Cs}$ in soil

**Chernobyl (two spots)**

$^{131}\text{I}/^{137}\text{Cs} = 3-50$

**Fukushima (near zone)**

$^{131}\text{I}/^{137}\text{Cs} = 5-80$
Task

Chernobyl and Fukushima

2) Analysis of the dependence of $q(^{131}\text{I})/q(^{137}\text{Cs})$ vs $q(^{137}\text{Cs})$ decay-corrected to the date of the main fallout.
Chernobyl: Central spot

![Graph showing the relationship between $^{131}$I/$^{137}$Cs and $^{137}$Cs, kBq m$^{-2}$]
Chernobyl: Gomel-Mogilev spot
Fukushima: 24 km north

$^{131}I/^{137}Cs$

$^{137}Cs$, Bq kg$^{-1}$
Fukushima: 33 km north-west
Fukushima: 62km north-west
Fukushima: 30km west-northwest

$^{137}\text{Cs}, \text{Bq} \text{kg}^{-1}$

$^{131}\text{I}/^{137}\text{Cs}$
Fukushima: 32km west

![Graph showing 
$^{137}$Cs, Bq kg$^{-1}$ vs. unknown y-axis.

13-18 May 2012 Glasgow Scotland
Fukushima: 22 km west-southwest
Fukushima: 23 km south

![Graph showing the ratio of 131I/137Cs against 137Cs concentration in Bq kg⁻¹.](image)
Discussion

**Deposition velocity**

- $^{131}\text{I}$
  - (a) aerosols, $V_g \sim 1 \text{ mm s}^{-1}$;
  - (b) reactive gaseous (elemental iodine), $V_g \sim 10 \text{ mm s}^{-1}$;
  - (c) non-reactive gaseous (organic compounds), $V_g \sim 0.1 \text{ mm s}^{-1}$.

- $^{137}\text{Cs}$
  - (a) aerosols, $V_g \sim 1 \text{ mm s}^{-1}$.

**Scavenging processes from the air to the ground**

- Wet deposition
- Dry deposition
Conclusions

1) Fukushima – volatile and intermediate (I, Cs, Te)
   Chernobyl – all radionuclides (I, Cs, Te, Ru, Ba(La), Zr(Nb), Ce)

2) Fukushima and Chernobyl
   fallout – $^{131}$I/$^{137}$Cs decreases with increase of level of the $^{137}$Cs ground deposition

3) Revealed tendency can be used in dose reconstruction
Thank you for your attention