Radioactivity in the Risø District July-December 2012

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Radioactivity in the Risø District July-December 2012

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Abstract (max. 2000 char.): The environmental surveillance of the Risø environment was continued in July - December 2012. The mean concentrations in air were: 0.32±0.31 μBq m⁻³ of ¹³⁷Cs, 3.04±0.99 mBq m⁻³ of ⁷Be and 0.22±0.18 mBq m⁻³ of ²¹⁰Pb (±1 S.D.; N = 26). The depositions by precipitation at Risø in the second half of 2012 were: 0.039 Bq m⁻² of ¹³⁷Cs, 615 Bq m⁻² of ⁷Be, 40.3 Bq m⁻² of ²¹⁰Pb and < 0.6 kBq m⁻² of ³H. The average background dose rate (TLD) at Risø (Zone I) was 54 nSv h⁻¹ compared with 58 ± 8 nSv h⁻¹ (±1 S.D.; N = 3) in the four zones around Risø.
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<table>
<thead>
<tr>
<th>Date</th>
<th>$^7$Be</th>
<th>$^{137}$Cs</th>
<th>$^{210}$Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>02-Jul-12 - 09-Jul-12</td>
<td>3006</td>
<td>0.131</td>
<td>159</td>
</tr>
<tr>
<td>09-Jul-12 - 16-Jul-12</td>
<td>2315</td>
<td>0.103</td>
<td>82</td>
</tr>
<tr>
<td>16-Jul-12 - 23-Jul-12</td>
<td>3656</td>
<td>0.103</td>
<td>103</td>
</tr>
<tr>
<td>23-Jul-12 - 30-Jul-12</td>
<td>5139</td>
<td>0.271</td>
<td>264</td>
</tr>
<tr>
<td>30-Jul-12 - 06-Aug-12</td>
<td>3990</td>
<td>0.117</td>
<td>168</td>
</tr>
<tr>
<td>06-Aug-12 - 13-Aug-12</td>
<td>5266</td>
<td>0.318</td>
<td>244</td>
</tr>
<tr>
<td>13-Aug-12 - 20-Aug-12</td>
<td>3330</td>
<td>0.244</td>
<td>202</td>
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<tr>
<td>20-Aug-12 - 27-Aug-12</td>
<td>3683</td>
<td>0.147</td>
<td>164</td>
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<tr>
<td>27-Aug-12 - 04-Aug-12</td>
<td>4645</td>
<td>0.142</td>
<td>227</td>
</tr>
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<td>04-Sep-12 - 10-Sep-12</td>
<td>3041</td>
<td>0.117</td>
<td>118</td>
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<tr>
<td>10-Sep-12 - 17-Sep-12</td>
<td>3913</td>
<td>0.161</td>
<td>271</td>
</tr>
<tr>
<td>17-Sep-12 - 24-Sep-12</td>
<td>2550</td>
<td>0.242</td>
<td>168</td>
</tr>
<tr>
<td>24-Sep-12 - 01-Oct-12</td>
<td>2554</td>
<td>0.140</td>
<td>151</td>
</tr>
<tr>
<td>01-Oct-12 - 08-Oct-12</td>
<td>2014</td>
<td>0.161</td>
<td>84</td>
</tr>
<tr>
<td>08-Oct-12 - 15-Oct-12</td>
<td>2734</td>
<td>0.176</td>
<td>234</td>
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<td>15-Oct-12 - 22-Oct-12</td>
<td>2761</td>
<td>0.362</td>
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<tr>
<td>22-Oct-12 - 29-Oct-12</td>
<td>1421</td>
<td>0.264</td>
<td>152</td>
</tr>
<tr>
<td>29-Oct-12 - 05-Nov-12</td>
<td>2021</td>
<td>0.320</td>
<td>292</td>
</tr>
<tr>
<td>05-Nov-12 - 12-Nov-12</td>
<td>2114</td>
<td>0.175</td>
<td>418</td>
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<tr>
<td>12-Nov-12 - 19-Nov-12</td>
<td>2848</td>
<td>0.398</td>
<td>955</td>
</tr>
<tr>
<td>19-Nov-12 - 26-Nov-12</td>
<td>2608</td>
<td>0.694</td>
<td>88</td>
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<tr>
<td>26-Nov-12 - 03-Dec-12</td>
<td>3352</td>
<td>0.382</td>
<td>146</td>
</tr>
<tr>
<td>03-Dec-12 - 10-Dec-12</td>
<td>1900</td>
<td>0.494</td>
<td>88</td>
</tr>
<tr>
<td>10-Dec-12 - 17-Dec-12</td>
<td>3035</td>
<td>0.698</td>
<td>321</td>
</tr>
<tr>
<td>17-Dec-12 - 24-Dec-12</td>
<td>1858</td>
<td>1.628</td>
<td>93</td>
</tr>
<tr>
<td>24-Dec-12 - 31-Dec-12</td>
<td>3372</td>
<td>0.251</td>
<td>190</td>
</tr>
</tbody>
</table>

| Mean        | 3043   | 0.317      | 223        |
| SD         | 986    | 0.313      | 177        |
### Table 2.1. Radionuclides in precipitation in the 10 m$^2$ rain collector at Risø (cf. Fig. 1), July - December 2012. (Unit: Bq m$^{-3}$)

<table>
<thead>
<tr>
<th>Month</th>
<th>$^7$Be</th>
<th>$^{137}$Cs</th>
<th>$^{210}$Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>4967</td>
<td>0.497</td>
<td>321</td>
</tr>
<tr>
<td>August</td>
<td>2387</td>
<td>0.155</td>
<td>136</td>
</tr>
<tr>
<td>September</td>
<td>1712</td>
<td>0.059</td>
<td>106</td>
</tr>
<tr>
<td>October</td>
<td>1230</td>
<td>0.056</td>
<td>92</td>
</tr>
<tr>
<td>November</td>
<td>1243</td>
<td>0.044</td>
<td>52</td>
</tr>
<tr>
<td>December</td>
<td>1613</td>
<td>0.122</td>
<td>131</td>
</tr>
</tbody>
</table>

### Table 2.2. Radionuclides in precipitation in the 10 m$^2$ rain collector at Risø (cf. Fig. 1), July - December 2012. (Unit: Bq m$^{-2}$)

<table>
<thead>
<tr>
<th>Month</th>
<th>Precipitation (m)</th>
<th>$^7$Be</th>
<th>$^{137}$Cs</th>
<th>$^{210}$Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>0.029</td>
<td>144</td>
<td>0.0144</td>
<td>9.3</td>
</tr>
<tr>
<td>August</td>
<td>0.039</td>
<td>93</td>
<td>0.0060</td>
<td>5.3</td>
</tr>
<tr>
<td>September</td>
<td>0.067</td>
<td>114</td>
<td>0.0040</td>
<td>7.1</td>
</tr>
<tr>
<td>October</td>
<td>0.072</td>
<td>89</td>
<td>0.0040</td>
<td>6.6</td>
</tr>
<tr>
<td>November</td>
<td>0.045</td>
<td>56</td>
<td>0.0020</td>
<td>2.3</td>
</tr>
<tr>
<td>December</td>
<td>0.074</td>
<td>119</td>
<td>0.0090</td>
<td>9.7</td>
</tr>
<tr>
<td>Sum</td>
<td>0.326</td>
<td>615</td>
<td>0.0394</td>
<td>40.3</td>
</tr>
</tbody>
</table>
Table 2.3. Tritium in precipitation collected at Risø (cf. Figs. 1, 2.3.1 and 2.3.2). July - December 2012. (Unit: kBq m$^{-3}$)

<table>
<thead>
<tr>
<th>Month</th>
<th>10 m$^2$ rain collector*</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>2.2</td>
</tr>
<tr>
<td>August</td>
<td>&lt; 1.7</td>
</tr>
<tr>
<td>September</td>
<td>&lt; 1.7</td>
</tr>
<tr>
<td>October</td>
<td>&lt; 1.7</td>
</tr>
<tr>
<td>November</td>
<td>&lt; 1.7</td>
</tr>
<tr>
<td>December</td>
<td>&lt; 1.7</td>
</tr>
</tbody>
</table>

Double determinations*.

Table 2.4. Tritium in precipitation collected at Risø (cf. Fig. 1). July - December 2012. (Unit: kBq m$^{-2}$)

<table>
<thead>
<tr>
<th>Month</th>
<th>Precipitation (m)</th>
<th>10 m$^2$ rain collector</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>0.029</td>
<td>0.064</td>
</tr>
<tr>
<td>August</td>
<td>0.039</td>
<td>&lt; 0.066</td>
</tr>
<tr>
<td>September</td>
<td>0.067</td>
<td>&lt; 0.114</td>
</tr>
<tr>
<td>October</td>
<td>0.072</td>
<td>&lt; 0.122</td>
</tr>
<tr>
<td>November</td>
<td>0.045</td>
<td>&lt; 0.077</td>
</tr>
<tr>
<td>December</td>
<td>0.074</td>
<td>&lt; 0.126</td>
</tr>
<tr>
<td>Sum</td>
<td>0.326</td>
<td>&lt; 0.569</td>
</tr>
</tbody>
</table>
Table 3.1. Radionuclides in sediment samples collected at Bolund in Roskilde Fjord (cf. Fig. 3.1) July - December 2012. (Unit: Bq kg\(^{-1}\) dry)

<table>
<thead>
<tr>
<th>Date</th>
<th>(^{137})Cs</th>
<th>K*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 July</td>
<td>2.4</td>
<td>16.6</td>
</tr>
</tbody>
</table>

*Unit: g kg\(^{-1}\) dry

Table 4.1. Radionuclides in seawater collected in Roskilde Fjord (cf. Fig. 4.1) July - December 2012. (Unit: Bq m\(^{-3}\))

<table>
<thead>
<tr>
<th>Date</th>
<th>(^{137})Cs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 July</td>
<td>10.9</td>
</tr>
</tbody>
</table>

Table 4.2. Tritium in seawater collected in Roskilde Fjord (Risø pier) (cf. Fig. 4.2) July - December 2012.

<table>
<thead>
<tr>
<th>Month</th>
<th>kBq m(^{-3})</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>&lt; 1.7 *</td>
</tr>
<tr>
<td>August</td>
<td>&lt; 1.7 *</td>
</tr>
<tr>
<td>September</td>
<td>1.7 *</td>
</tr>
<tr>
<td>October #</td>
<td>-</td>
</tr>
<tr>
<td>November #</td>
<td>-</td>
</tr>
<tr>
<td>December</td>
<td>&lt; 1.7 *</td>
</tr>
</tbody>
</table>

* Double determinations

* starting autumn 2012, tritium in seawater is measured quarterly.
Table 5.1. Radionuclides in grass (* snow) collected at Risø (near the Waste Treatment Station (cf. Fig. 1)), July - December 2012. (**Measured on bulked ash samples)

<table>
<thead>
<tr>
<th>Week no. or month</th>
<th>Date</th>
<th>K (g kg(^{-1}) fresh)</th>
<th>(^{137})Cs (Bq kg(^{-1}) fresh)</th>
<th>(^{137})Cs (Bq m(^{-2}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>2 July</td>
<td>5.0</td>
<td>&lt;0.3</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>16 July</td>
<td>5.3</td>
<td>&lt;0.5</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>30 July</td>
<td>4.8</td>
<td>&lt;0.3</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>13 August</td>
<td>9.9</td>
<td>&lt;1.1</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>27 August</td>
<td>3.9</td>
<td>&lt;0.6</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>10 September</td>
<td>6.4</td>
<td>&lt;0.5</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>24 September</td>
<td>5.7</td>
<td>&lt;0.8</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>8 October</td>
<td>5.5</td>
<td>&lt;0.9</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>22 October</td>
<td>4.7</td>
<td>&lt;0.4</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>5 November</td>
<td>4.4</td>
<td>&lt;0.4</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>19 November</td>
<td>2.8</td>
<td>&lt;0.2</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>3 December *</td>
<td>&lt; 0.1</td>
<td>&lt;0.2</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>17 December *</td>
<td>&lt; 0.1</td>
<td>&lt;0.2</td>
<td></td>
</tr>
</tbody>
</table>

**July 5.4 0.039 0.018**

**August 6.4 0.121 0.022**

**September 6.3 0.103 0.029**

**October 5.2 0.063 0.011**

**November 3.6 0.044 0.020**

**December 2.1 0.220 0.046**
Table 5.2. Radionuclides in Fucus vesiculosus collected at Bolund in Roskilde Fjord. July - December 2012. (Unit: Bq kg\(^{-1}\) dry)

<table>
<thead>
<tr>
<th>Date</th>
<th>(^{137})Cs</th>
<th>K*</th>
<th>% dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 July</td>
<td>3.4</td>
<td>29</td>
<td>18</td>
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</table>

*Unit: g kg\(^{-1}\) dry
Table 7.1. Waste water collected at Risø (cf. Fig. 1), July - December 2012.

<table>
<thead>
<tr>
<th>Week number</th>
<th>eqv. mg KCl l(^{-1})</th>
<th>(^{137})Cs (Bq m(^{-3}))</th>
<th>(^{131})I (Bq m(^{-3}))</th>
<th>(^{226})Ra (Bq m(^{-3}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
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<td>&lt; 72</td>
<td>&lt; 71</td>
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<td>&lt; 101</td>
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<td>&lt; 107</td>
<td>&lt; 109</td>
<td>&lt; 209</td>
</tr>
<tr>
<td>52</td>
<td>79</td>
<td>&lt; 83</td>
<td>&lt; 175</td>
<td>&lt; 239</td>
</tr>
</tbody>
</table>

| Mean        | 129.4                  |
| SD          | 34.8                   |
Table 8.1. Background dose rates around the border of Risø (cf. Fig. 8.1) measured with thermoluminescence dosimeters (TLD) in the period May - October 2012. (Results are normalized to nSv h⁻¹)

<table>
<thead>
<tr>
<th>Location</th>
<th>nSv h⁻¹</th>
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<tr>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>2</td>
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<tr>
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Table 8.2. Background dose rates around Risø (cf. Fig. 8.2 and Fig. 1) measured with thermoluminescence dosimeters (TLD) in the period May – October 2012. (Results are normalized to nSv h\(^{-1}\))

<table>
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<th>nSv h(^{-1})</th>
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Table 8.3. Terrestrial dose rates at the Risø zones (cf. Fig. 8.2 and Fig. 1) July - December 2012. Measured with a NaI(Tl) detector. (Unit: nSv h⁻¹)

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Fig. 1. Locations for measurements of gamma-background radiation Zone I and II (cf. Tables 8.2 and 8.3)
Fig. 1.1. Caesium-137 in ground level air collected at Risø in July-December 2012. (Unit: $\mu$Bq m$^{-3}$)

Fig. 1.2. Beryllium-7 and lead-210 in ground level air collected at Risø in July-December 2012. (Unit: $\mu$Bq m$^{-3}$)
Fig. 2.3.1. Tritium in precipitation collected at Risø (1 m² rain collector) 1980 - 2012. (Unit: kBq m⁻³; DL = detection limit)

Fig. 2.3.2. Tritium in precipitation collected at Risø (10 m² rain collector) 1980 - 2012. (Unit: kBq m⁻³; DL = detection limit)
Fig. 3.1. Caesium–137 in sediment samples collected at Bolund in Roskilde Fjord. 1980 – 2012. (Unit: Bq kg$^{-1}$ dry matter)
Fig. 4.1. Caesium–137 in seawater collected in Roskilde Fjord 1980 - 2012. (Unit: Bq m$^{-3}$)

Fig. 4.2. Tritium in seawater collected in Roskilde Fjord 1980 - 2012. (Unit: kBq m$^{-3}$; DL = detection limit)
Fig. 7.1. Total-beta radioactivity in waste water collected at Risø 1994 - 2012. (Unit: eqv. mg KCl l⁻¹)
Fig. 8.1. Locations (1-6) for TLD measurements around the border of Risø (cf. Table 8.1).
Fig. 8.2. Locations for measurements of background radiation around Risø in Zones III, IV and V.
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