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Deposition of ¹²⁵Sb, ¹⁰⁶Ru, ¹⁴⁴Ce, ¹³⁴Cs and ¹³⁷Cs in Finland after the Chernobyl accident

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In this study the deposition characteristics of ¹²⁵Sb, ¹⁰⁶Ru, ¹⁴⁴Ce, ¹³⁴Cs and ¹³⁷Cs in Finland after the Chernobyl accident was investigated based on gamma spectrometric analysis of 97 lichen, peat and surface soil samples. The aim of this study was to determine the fallout pattern of ¹²⁵Sb, ¹⁰⁶Ru, ¹³⁴Cs, and ¹⁴⁴Ce in Finland, to verify the fallout pattern of ¹³⁷Cs reported in earlier works, and to obtain an estimate of the total amounts of these nuclides deposited in Finland. The highest deposition values of ¹⁴⁴Ce were found in a zone extending from southwestern Finland to Kuhmo area close to the Russian border. The deposition pattern of ¹⁴⁴Ce resembled the deposition patterns of refractory nuclides, such as ⁹⁵Zr and transuranium elements. The regional deposition of cesium isotopes 134 and 137 differed from that of ¹⁴⁴Ce owing to the different volatility properties of these nuclides. Our results confirm the earlier observations of high deposition values of ¹³⁷Cs in southwestern Finland, Varkaus-Kuopio region, Kuhmo region and Kotka-Kouvola region. A comparison of previous results to our results suggests an overestimated deposition in the Oulu region in this study due to the lack of samples in the region. The observed average ¹³⁴Cs to ¹³⁷Cs activity ratio, 0.527 ± 0.010 decay-corrected to 1 May 1986, is in agreement with earlier studies and corresponds to a burnup of 13 GWd tU⁻¹. Although ruthenium is a refractory element, the behaviour of ¹⁰³Ru and ¹⁰⁶Ru has been shown to resemble the behaviour of volatile elements. This has been explained by the formation of volatile ruthenium oxides. The deposition pattern of ¹²⁵Sb resembled those of cesium isotopes. This suggests that antimony behaved like volatile nuclides in the destroyed reactor. It was calculated that depending on the nuclide, 0.017%–1.5% of the reactor core inventory and 0.6%–13% of the atmospheric emissions were deposited in Finland. These percentages were proportional to the volatility of the nuclides.

Introduction

The worst ever peace-time nuclear accident happened in the former Soviet Union on 26 April 1986. An accident destroyed the Chernobyl number four reactor, leading to a rapid loss of over 30 human lives and to a significant radioactive contamination of the environment.

According to the Soviet estimates, all the radioactive noble gases of the reactor core inventory were liberated during the accident. 10%–20% of the volatile nuclides, e.g. ¹³¹I and ¹³⁷Cs, were distributed into the environment. A fraction (2%–6%) of refractory nuclides, such as ⁹⁵Zr and transuranium elements, was released as well (USSR State Committee on the Utilization of Atomic Energy 1986). Dose calculations relating to the accident have been published by Aarkrog (1988) and Bouville (1995).

The energy released in the hydrogen explosion and the heat produced by burning graphite and decaying fission products caused the radioactive debris to reach considerable altitudes with correspondingly high wind speeds. This, in turn, caused the debris to spread quickly in the atmosphere. At first the emissions were transported northwestwards to Poland, the Baltic states, Sweden, Norway and Finland. During 27 April, emissions spread to eastern-central Europe, southern Germany, Italy and Yugoslavia. During the next week the plume was transported southwards from Chernobyl to Romania, Bulgaria, the Balkans, the Black Sea and Turkey. The emissions of 5 May arrived again over central Europe, Scandinavia and Finland during 6-9 May (Persson et al. 1987). Most of the Chernobyl-originated activity remained in the troposphere. Jaworowski and Kownacka (1988) reported that the stratospheric activities were only 1%-6% of those found in the surface air. Eventually the plume was distributed practically all over the northern hemisphere, its advance being monitored both by measurements and by air mass trajectory calculations.

According to the calculations of Valkama *et al.* (1995), the air parcel trajectories originating from Chernobyl at the time of the accident arrived at Finland from the south-west at the release heights of 1500 and 2500 metres. Their arrival time in south-west Finland was 12:00 UTC on 27 April 1986 for the release height of 2000 m and the arrival height of 1500 m, and 15:00 UTC on 27 April for the release height of 1500 m and the arrival height of 1000 m. Aircraft measurements made over the southern Finland daily starting on 28 April are in agreement with these arrival heights (Sinkko *et al.* 1987). Paatero et al. • BOREAL ENV. RES. Vol. 12

After the first few days no significant amount of radioactivity was deposited in Finland, even though somewhat higher values were observed on 11 and 13 May in southern Finland. In Nurmijärvi, southern Finland, the concentration of ¹³⁷Cs in the ground-level air decreased by four orders of magnitude between 28 April and 16 May, 1986, starting from the value of 10⁴ mBq m⁻³ (Finnish Centre for Radiation and Nuclear Safety 1986a, 1986b).

In the present study a number of ¹²⁵Sb, ¹⁰⁶Ru, ¹⁴⁴Ce, ¹³⁴Cs and ¹³⁷Cs deposition values following the Chernobyl accident were collected. They are based on a gamma-spectrometric analysis of peat, lichen and soil samples. The regional distribution of these deposition values was studied. The aims of this study was (1) to find out the fallout patterns of ¹²⁵Sb, ¹⁰⁶Ru, ¹³⁴Cs and ¹⁴⁴Ce after the Chernobyl accident, (2) to verify the fallout pattern of ¹³⁷Cs reported in the earlier works and (3) to obtain an estimate of the total amount of these nuclides deposited in Finland.

Experimental and computational methods

In May 1986, the National Public Health Institute collected 62 peat samples from peatlands in production. The sampling areas had been untouched since the peat harvesting season of 1985. A detailed description of the sampling procedure and the results of gamma spectrometric analyses have been published by Jantunen *et al.* (1987) and Jantunen *et al.* (1991). At the Department of Radiochemistry, University of Helsinki, the peat samples were analysed again using the gamma spectrometry followed by radiochemical separations to analyse their contents of transuranium nuclides (Reponen *et al.* 1993, Paatero *et al.* 1994a, Salminen *et al.* 2005).

Most of the lichen samples analyzed in this study were collected in 1986 by the staff of the Department of Radiochemistry, University of Helsinki. The sampling of lichen was usually performed by collecting all the lichen from a definite area. These lichen-carpet profile samples were air-dried in the laboratory and usually divided into four fractions: the upper and lower parts of the lichen, litter and underlying soil. One sample was collected in 1987. Some additional lichen samples were obtained from the Finnish Centre for Radiation and Nuclear Safety.

The peat and lichen samples were analysed using the HPGe gamma spectrometry. The lichen samples were analysed in 1986 and the peat samples were analysed in 1989. Thus the gamma emitters with a half life less than a few months had already decayed from the peat samples. The spectra were handled with the MicroSAMPO peak fit program (Aarnio *et al.* 1988).

Finnish Centre for Radiation and Nuclear Safety collected about 10 surface soil samples around Finland in 1986 and analysed them with the semiconductor gamma-spectrometry. The activity concentrations of the radionuclides were calculated using the computer program GAMMA-83 (Saxén *et al.* 1987).

The cases of missing results owing to concentrations below minimum detectable activity were treated in the subsequent analysis as follows: The missing values were replaced with a value that was one fourth of the lowest observed value within the corresponding sample type (peat, soil, lichen). It was assumed that the lowest deposition was twice the minimum detectable activity. In atmospheric sciences it is a common practice to replace the below-detection-limit values with one half of the detection-limit value. Altogether this yielded 97 deposition values, mainly in southern and central Finland.

The deposition values were extrapolated over Finland by taking into account the amount of precipitation causing wet deposition. The sums of daily precipitation amounts between 27 April and 17 May 1986 were calculated at 591 meteorological and hydrological monitoring stations in Finland. This time period was chosen to cover the occurrence of most of the Chernobyl fallout based on daily total beta activity deposition (Paatero et al. 1994b). The deposition values were divided by the amount of precipitation at the sampling site in order to get the concentration values in precipitation. The precipitation estimates were interpolated from all the 591 precipitation amounts using inverse distance weighing (IDW):

$$\hat{C}_{j} = \frac{\sum_{i=1}^{n} w_{i} C_{i}}{\sum_{i=1}^{n} w_{i}}.$$
(1)

Here \hat{C}_j denotes the estimated quantity (precipitation amount in this case) at the location of interest *j*, C_i the observed quantity at the location *i*, *n* is the number of observations and w_i is the weight factor related to the distance $d_{i,j}$ between the locations *i* and *j* and is given by

$$w_i = \frac{1}{d_{i,i}^3}$$
 (2)

The distances d_{ij} were calculated using the following equation:

$$d_{i,j} = R \arccos[\sin\phi_j \times \sin\phi_i + \cos\phi_j \\ \times \cos\phi_i \times \cos(\lambda_i - \lambda_j)].$$
(3)

Here *R* is the radius of the Earth (6371 km), and ϕ and λ are the latitude and longitude of the location, respectively, when assuming a spherical Earth (Bonham-Carter 1996). The use of weights that are inversely proportional to the third power of the distance strongly enhances the significance of the closest observations.

Next a concentration value grid between the latitudes 60°N and 70°N and the longitudes 20°E and 31°E was calculated using the IDW method. The resolution of the calculated grid was 0.5 degrees in the north–south direction and 1.0 degree in the east–west direction. A similar grid was calculated for the precipitation amounts. A deposition estimate was calculated at each grid node by multiplying the concentration value by the precipitation amount (Paatero *et al.* 2002).

Results and discussion

Figure 1 shows the locations of the regions. The observed deposition values of ¹²⁵Sb, ¹⁰⁶Ru, ¹⁴⁴Ce, ¹³⁴Cs and ¹³⁷Cs based on peat and lichen samples are reported in Tables 1–4. The deposition values obtained with the soil samples have been reported in the work of Saxén *et al.* (1987). Statistical parameters of the interpolated deposition values are presented in Table 5.



Fig. 1. Studied locations.

The highest deposition values of ¹⁴⁴Ce were found in a zone extending from southwestern Finland to the Kuhmo area close to the Russian border (Fig. 2). The deposition pattern of ¹⁴⁴Ce resembled the deposition patterns of refractory nuclides such as ⁹⁵Zr and transuranium elements (Arvela *et al.* 1990, Paatero *et al.* 2002, Salminen *et al.* 2005). The highest ¹⁴⁴Ce deposition values

Fig. 2. Regional distribution of the ¹⁴⁴Ce deposition (Bq m⁻²) in Finland decay-corrected to 1 May 1986. The three classes of deposition represent the 0–50 (light grey, < 647 Bq m⁻²), 50–75 (dark grey, 647–2159 Bq m⁻²) and 75–100 (black, > 2159 Bq m⁻²) percentiles of the interpolated deposition values.

were found along the calculated trajectory of the air mass which was located in the Chernobyl region during the initial explosion of the reactor (Valkama *et al.* 1995). The deposition was high

Table 1. The observed deposition values (Bq m⁻² \pm 1 σ propagated counting error decay-corrected to 1 May 1986) of ¹³⁴Cs and ¹³⁷Cs based on peat samples.

No.	Community	Lat. (°N)	Long. (°E)	Cs-134		Cs-13	37
		()		(Bq m ⁻²)	\pm 1 σ	(Bq m ⁻²)	$\pm 1 \sigma$
4	Karvia	62.0	22.7	8300	200	15200	500
10	Kankaanpää	61.8	22.8	11500	150	19400	600
11	Kankaanpää	61.7	22.8	35800	500	59600	1900
14	Tampere	61.3	23.9	111900	1500	188000	7000
15	Punkalaidun	61.0	23.2	11900	140	20100	700
16	Köyliö	61.0	22.5	15900	200	26600	900
17	Hattula	60.7	24.2	13400	300	25200	800
18	Loimaan mlk	60.7	23.0	25300	300	43100	1400
							continued



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$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	No.	Community	Lat.	Long.	Cs-1	Cs-134		Cs-137	
19 Janakkala 60.8 24.7 12100 200 20300 700 20 Rihimäki 60.6 24.7 20100 300 33100 1100 21 Hankasalmi 62.2 25.3 7850 140 13300 500 22 Leivonmäki 61.7 25.8 5260 50 8900 300 26 Piltispasari 63.1 25.5 8040 140 13900 600 27 Heinolan milk 61.0 25.9 2690 60 4670 160 37 Juva 61.8 27.2 2530 50 4370 140 40 Joutseno 61.9 28.4 280 100 490 200 41 Rauljavi 61.2 28.0 840 20 1520 50 42 Purkharaju 61.7 27.2 410 11 720 30 43 Taplalsaari 61.2			(*N)	(°E)	(Bq m ⁻²)	\pm 1 σ	(Bq m ⁻²)	±1 <i>0</i>	
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Tomantsi Eac Tu	49	Tohmaiärvi	62.3	29.8	270	9	480	20	
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52 Pyhäselkä 62.4 29.7 411 12 720 30 53 Rääkkylä 62.2 29.5 429 12 760 30 54 Rautavaara 63.3 28.2 1390 20 2570 80 55 Suonenjoki 62.6 26.6 2640 60 4470 150 55 Suonenjoki 62.6 26.6 1860 40 3140 110 56 Suonenjoki 62.7 27.2 10200 110 17000 600 57 Pielavesi 63.1 26.8 2580 130 9900 300 60 Kiuruvesi 63.7 26.4 2540 90 8800 300 61 Kiuruvesi 63.5 26.3 2110 30 3630 120 62 Kiuruvesi 63.7 26.4 2540 40 4600 200 63 Kiuruvesi 63.1 24.0	51	Tuupovaara	62.5	30.0	213	7	670	20	
Sa Rääkkylä 62.2 29.5 429 12 760 30 54 Rautavaara 63.3 28.2 1390 20 2570 80 55 Suonenjoki 62.6 26.6 1390 20 2570 80 55 Suonenjoki 62.6 26.6 1860 40 3140 110 56 Suonenjoki 62.7 27.2 10200 110 17000 600 57 Pielavesi 63.1 26.8 5860 130 9900 300 60 Kiuruvesi 63.6 26.3 2110 30 3630 120 61 Kiuruvesi 63.7 26.4 2540 40 4600 200 63 Kiuruvesi 63.8 27.2 4120 80 8600 300 64 Sonkajärvi 63.8 27.2 4120 80 8600 300 65 Ilomantsi 62.9 3	52	Pvhäselkä	62.4	29.7	411	12	720	30	
Hautavaara 63.3 28.2 1390 20 2570 80 55 Suonenjoki 62.6 26.6 2640 60 4470 150 55 Suonenjoki 62.6 26.6 1860 40 3140 110 56 Suonenjoki 62.7 27.2 10200 110 17000 600 57 Pielavesi 63.1 26.8 7160 110 12300 400 58 Karttula 62.8 26.6 2540 90 8800 300 60 Kiuruvesi 63.7 26.4 2540 40 4600 200 63 Kiuruvesi 63.7 26.4 2540 40 4600 200 63 Kiuruvesi 63.7 26.4 2540 40 4600 200 63 Kiuruvesi 63.2 24.5 10700 190 28700 900 96 Halsua 63.2 24.5	53	Rääkkylä	62.2	29.5	429	12	760	30	
55 Suonenjoki 62.6 26.6 2640 60 4470 150 55 Suonenjoki 62.6 26.6 1860 40 3140 110 56 Suonenjoki 62.7 27.2 10200 110 17000 600 57 Pielavesi 63.1 26.8 7660 130 9900 300 60 Kiuruvesi 63.3 26.3 2540 90 8800 300 61 Kiuruvesi 63.6 26.3 2110 30 3633 120 62 Kiuruvesi 63.5 26.3 2440 70 7900 260 64 Sonkajärvi 63.8 27.2 4120 80 8600 300 65 Ilomantsi 62.9 30.6 105 4 434 15 95 Vimpeli 63.1 24.0 17700 300 18000 600 99 Jalasjärvi 62.3 <t< td=""><td>54</td><td>Rautavaara</td><td>63.3</td><td>28.2</td><td>1390</td><td>20</td><td>2570</td><td>80</td></t<>	54	Rautavaara	63.3	28.2	1390	20	2570	80	
Suonenjoki Sec.	55	Suonenioki	62.6	26.6	2640	60	4470	150	
Schnight Server Serve	55	Suonenioki	62.6	26.6	1860	40	3140	110	
57 Pielavesi 63.1 26.8 7160 110 12300 400 58 Karttula 62.8 26.8 5860 130 9900 300 60 Kiuruvesi 63.3 26.3 2540 90 8800 300 61 Kiuruvesi 63.6 26.3 2110 30 3630 120 62 Kiuruvesi 63.7 26.4 2540 40 4600 200 63 Kiuruvesi 63.5 26.3 4240 70 7900 260 64 Sonkajärvi 63.8 27.2 4120 80 8600 300 65 Ilomantsi 62.9 30.6 105 4 434 15 95 Vimpeli 63.1 24.5 10700 300 18000 600 99 Jalasjärvi 62.3 22.9 1330 200 22200 700 100 Peräseinäjoki 61.0 22.4 8330 110 14200 500 111 Loimaa	56	Suonenioki	62.7	27.2	10200	110	17000	600	
58 Karttula 62.8 26.8 560 130 9900 300 60 Kiuruvesi 63.3 26.3 2540 90 8800 300 61 Kiuruvesi 63.7 26.4 2540 40 4600 200 62 Kiuruvesi 63.5 26.3 4240 70 7900 260 64 Sonkajärvi 63.8 27.2 4120 80 8600 300 65 Ilomantsi 62.9 30.6 105 4 434 15 95 Vimpeli 63.1 24.0 17700 190 28700 900 96 Halsua 63.2 24.5 10700 300 18000 600 99 Jalasjärvi 62.3 22.9 13300 200 22200 700 100 Peräseinäjoki 61.0 22.4 8330 110 14200 500 111 Loimaa 61.3 25.9 12400 200 20800 700 115 Kerimäki	57	Pielavesi	63.1	26.8	7160	110	12300	400	
60 Kuruvesi 63.3 26.3 2540 90 8800 300 61 Kuruvesi 63.6 26.3 2110 30 3630 120 62 Kuruvesi 63.7 26.4 2540 40 4600 200 63 Kiuruvesi 63.5 26.3 4240 70 7900 260 64 Sonkajärvi 63.8 27.2 4120 80 8600 300 65 Ilomantsi 62.9 30.6 105 4 434 15 95 Vimpeli 63.1 24.0 17700 190 28700 900 96 Halsua 63.2 24.5 10700 300 18000 600 99 Jalasjärvi 62.3 22.9 13300 200 22200 700 100 Peräseinäjoki 61.0 22.4 8330 110 14200 500 111 Loimaa 60.7 23.1 7080 100 12300 400 117 Hartola <t< td=""><td>58</td><td>Karttula</td><td>62.8</td><td>26.8</td><td>5860</td><td>130</td><td>9900</td><td>300</td></t<>	58	Karttula	62.8	26.8	5860	130	9900	300	
61 Kiuruvesi 63.6 26.3 2110 30 3630 120 62 Kiuruvesi 63.7 26.4 2540 40 4600 200 63 Kiuruvesi 63.5 26.3 4240 70 7900 260 64 Sonkajärvi 63.8 27.2 4120 80 8600 300 65 Ilomantsi 62.9 30.6 105 4 434 15 95 Vimpeli 63.1 24.0 17700 190 28700 900 96 Halsua 63.2 24.5 10700 300 18000 600 99 Jalasjärvi 62.3 22.9 13300 200 22200 700 100 Peräseinäjoki 61.0 22.4 8300 110 14200 500 111 Loimaa 60.7 23.1 7080 100 12300 400 135 Kerimäki 61.9	60	Kiuruvesi	63.3	26.3	2540	90	8800	300	
62 Kiuruvesi 63.7 26.4 2540 40 4600 200 63 Kiuruvesi 63.5 26.3 4240 70 7900 260 64 Sonkajärvi 63.8 27.2 4120 80 8600 300 65 Ilomantsi 62.9 30.6 105 4 434 15 95 Vimpeli 63.1 24.0 17700 190 28700 900 96 Halsua 63.2 24.5 10700 300 18000 600 99 Jalasjärvi 62.3 22.9 13300 200 22200 700 100 Peräseinäjoki 62.4 23.2 3500 70 6100 200 111 Loimaa 61.3 25.9 12400 200 20800 700 135 Kerimäki 61.9 28.8 6100 100 10400 400 136 Mikkelin mlk 61.8 27.2 3520 80 6000 200 140 Lieksa	61	Kiuruvesi	63.6	26.3	2110	30	3630	120	
63 Kiuruvesi 63.5 26.3 4240 70 7900 260 64 Sonkajärvi 63.8 27.2 4120 80 8600 300 65 Ilomantsi 62.9 30.6 105 4 434 15 95 Vimpeli 63.1 24.0 17700 190 28700 900 96 Halsua 63.2 24.5 10700 300 18000 600 99 Jalasjärvi 62.3 22.9 13300 200 22200 700 100 Peräseinäjoki 62.4 23.2 3500 70 6100 200 111 Loimaa 60.7 23.1 7080 100 12300 400 117 Hartola 61.3 25.9 12400 200 20800 700 135 Kerimäki 61.9 28.8 6100 100 10440 400 136 Mikkelin mlk 61.8 27.2 3520 80 6000 200 140 Lieksa	62	Kiuruvesi	63.7	26.4	2540	40	4600	200	
64 Sonkajärvi 63.8 27.2 4120 80 8600 300 65 Ilomantsi 62.9 30.6 105 4 434 15 95 Vimpeli 63.1 24.0 17700 190 28700 900 96 Halsua 63.2 24.5 10700 300 18000 600 99 Jalasjärvi 62.3 22.9 13300 200 22200 700 100 Peräseinäjoki 62.4 23.2 3500 70 6100 200 111 Loimaa 60.7 23.1 7080 100 12300 400 117 Hartola 61.3 25.9 12400 200 20800 700 135 Kerimäki 61.9 28.8 6100 100 10400 400 136 Mikkelin mlk 61.8 27.2 3520 80 6000 200 140 Lieksa 63.3	63	Kiuruvesi	63.5	26.3	4240	70	7900	260	
65 Ilomantsi 62.9 30.6 105 4 434 115 95 Vimpeli 63.1 24.0 17700 190 28700 900 96 Halsua 63.2 24.5 10700 300 18000 600 99 Jalasjärvi 62.3 22.9 13300 200 22200 700 100 Peräseinäjoki 62.4 23.2 3500 70 6100 200 110 Köyliö 61.0 22.4 8330 110 14200 500 111 Loimaa 60.7 23.1 7080 100 12300 400 117 Hartola 61.3 25.9 12400 200 20800 700 135 Kerimäki 61.8 27.2 3520 80 6000 200 140 Lieksa 63.3 29.8 197 5 1010 30 143 Valtimo 63.7 28.4 2700 60 5100 200 144 Rautavaara <t< td=""><td>64</td><td>Sonkajärvi</td><td>63.8</td><td>27.2</td><td>4120</td><td>80</td><td>8600</td><td>300</td></t<>	64	Sonkajärvi	63.8	27.2	4120	80	8600	300	
95 Vimpeli 63.1 24.0 17700 190 28700 900 96 Halsua 63.2 24.5 10700 300 18000 600 99 Jalasjärvi 62.3 22.9 13300 200 22200 700 100 Peräseinäjoki 62.4 23.2 3500 70 6100 200 110 Köyliö 61.0 22.4 8330 110 14200 500 111 Loimaa 60.7 23.1 7080 100 12300 400 117 Hartola 61.3 25.9 12400 200 20800 700 135 Kerimäki 61.9 28.8 6100 100 10400 400 136 Mikkelin mlk 61.8 27.2 3520 80 6000 200 140 Lieksa 63.3 29.8 197 5 1010 30 143 Valtimo 63.7 28.4 2700 60 4820 160 144 Rautavaara	65	llomantsi	62.9	30.6	105	4	434	15	
96 Halsua 63.2 24.5 10700 300 18000 600 99 Jalasjärvi 62.3 22.9 13300 200 22200 700 100 Peräseinäjoki 62.4 23.2 3500 70 6100 200 110 Köyliö 61.0 22.4 8330 110 14200 500 111 Loimaa 60.7 23.1 7080 100 12300 400 117 Hartola 61.3 25.9 12400 200 20800 700 135 Kerimäki 61.9 28.8 6100 100 10400 400 136 Mikkelin mlk 61.8 27.2 3520 80 6000 200 140 Lieksa 63.3 29.8 197 5 1010 30 143 Valtimo 63.7 28.4 2700 60 5100 200 144 Rautavaara 63.5 27.6 2600 60 4820 160 146 Suonenjoki <td>95</td> <td>Vimpeli</td> <td>63.1</td> <td>24.0</td> <td>17700</td> <td>190</td> <td>28700</td> <td>900</td>	95	Vimpeli	63.1	24.0	17700	190	28700	900	
99 Jalasjärvi 62.3 22.9 13300 200 22200 700 100 Peräseinäjoki 62.4 23.2 3500 70 6100 200 110 Köyliö 61.0 22.4 8330 110 14200 500 111 Loimaa 60.7 23.1 7080 100 12300 400 117 Hartola 61.3 25.9 12400 200 20800 700 135 Kerimäki 61.9 28.8 6100 100 10400 400 136 Mikkelin mlk 61.8 27.2 3520 80 6000 200 140 Lieksa 63.3 29.8 197 5 1010 30 143 Valtimo 63.7 28.4 2700 60 5100 200 144 Rautavaara 63.5 27.6 2600 60 4820 160 146 Suonenjoki 62.4 27.1 16500 300 27200 900 148 Pielavesi	96	Halsua	63.2	24.5	10700	300	18000	600	
Observe Derive Derive <thderive< th=""> <thderive< th=""> <thderive< t<="" td=""><td>99</td><td>Jalasiärvi</td><td>62.3</td><td>22.9</td><td>13300</td><td>200</td><td>22200</td><td>700</td></thderive<></thderive<></thderive<>	99	Jalasiärvi	62.3	22.9	13300	200	22200	700	
110 Köyliö 61.0 22.4 8330 110 14200 500 111 Loimaa 60.7 23.1 7080 100 12300 400 117 Hartola 61.3 25.9 12400 200 20800 700 135 Kerimäki 61.9 28.8 6100 100 10400 400 136 Mikkelin mlk 61.8 27.2 3520 80 6000 200 140 Lieksa 63.3 29.8 197 5 1010 30 143 Valtimo 63.7 28.4 2700 60 5100 200 144 Rautavaara 63.5 27.6 2600 60 4820 160 146 Suonenjoki 62.4 27.1 16500 300 27200 900 148 Pielavesi 63.0 26.1 7400 70 12200 500 152 Keitele 63.2 26.1 2990 50 5200 200 168 Kauhava	100	Peräseinäioki	62.4	23.2	3500	70	6100	200	
111 Loimaa 60.7 23.1 7080 100 12300 400 117 Hartola 61.3 25.9 12400 200 20800 700 135 Kerimäki 61.9 28.8 6100 100 10400 400 136 Mikkelin mlk 61.8 27.2 3520 80 6000 200 140 Lieksa 63.3 29.8 197 5 1010 30 143 Valtimo 63.7 28.4 2700 60 5100 200 144 Rautavaara 63.5 27.6 2600 60 4820 160 146 Suonenjoki 62.4 27.1 16500 300 27200 900 148 Pielavesi 63.0 26.1 7400 70 12200 500 152 Keitele 63.2 26.1 2990 50 5200 200 168 Kauhava 63.0 23.5 14400 200 26200 900 201 Kitee	110	Kövliö	61.0	22.4	8330	110	14200	500	
117 Hartola 61.3 25.9 12400 200 20800 700 135 Kerimäki 61.9 28.8 6100 100 10400 400 136 Mikkelin mlk 61.8 27.2 3520 80 6000 200 140 Lieksa 63.3 29.8 197 5 1010 30 143 Valtimo 63.7 28.4 2700 60 5100 200 144 Rautavaara 63.5 27.6 2600 60 4820 160 146 Suonenjoki 62.4 27.1 16500 300 27200 900 148 Pielavesi 63.0 26.1 7400 70 12200 500 149 Keitele 63.0 26.1 2990 50 5200 200 152 Keitele 63.0 23.5 14400 200 26200 900 201 Kitee 62.2 29.6 343 7 720 20 202 Lieksa	111	Loimaa	60.7	23.1	7080	100	12300	400	
135 Kerimäki 61.9 28.8 6100 100 10400 400 136 Mikkelin mlk 61.8 27.2 3520 80 6000 200 140 Lieksa 63.3 29.8 197 5 1010 30 143 Valtimo 63.7 28.4 2700 60 5100 200 144 Rautavaara 63.5 27.6 2600 60 4820 160 146 Suonenjoki 62.4 27.1 16500 300 27200 900 148 Pielavesi 63.0 26.8 10300 160 17500 600 149 Keitele 63.0 26.1 7400 70 12200 500 152 Keitele 63.2 26.1 2990 50 5200 200 168 Kauhava 63.0 23.5 14400 200 26200 900 201 Kitee 62.2 29.6 343 7 720 20 202 Lieksa	117	Hartola	61.3	25.9	12400	200	20800	700	
136Mikkelin mlk61.827.23520806000200140Lieksa63.329.81975101030143Valtimo63.728.42700605100200144Rautavaara63.527.62600604820160146Suonenjoki62.427.11650030027200900148Pielavesi63.026.174007012200500149Keitele63.226.12990505200200152Keitele63.023.51440020026200900201Kitee62.229.6343772020202Lieksa63.230.0157454020	135	Kerimäki	61.9	28.8	6100	100	10400	400	
140 Lieksa 63.3 29.8 197 5 1010 30 143 Valtimo 63.7 28.4 2700 60 5100 200 144 Rautavaara 63.5 27.6 2600 60 4820 160 146 Suonenjoki 62.4 27.1 16500 300 27200 900 148 Pielavesi 63.0 26.8 10300 160 17500 600 149 Keitele 63.0 26.1 7400 70 12200 500 152 Keitele 63.2 26.1 2990 50 5200 200 168 Kauhava 63.0 23.5 14400 200 26200 900 201 Kitee 62.2 29.6 343 7 720 20 202 Lieksa 63.2 30.0 157 4 540 20	136	Mikkelin mlk	61.8	27.2	3520	80	6000	200	
143 Valtimo 63.7 28.4 2700 60 5100 200 144 Rautavaara 63.5 27.6 2600 60 4820 160 146 Suonenjoki 62.4 27.1 16500 300 27200 900 148 Pielavesi 63.0 26.8 10300 160 17500 600 149 Keitele 63.0 26.1 7400 70 12200 500 152 Keitele 63.2 26.1 2990 50 5200 200 168 Kauhava 63.0 23.5 14400 200 26200 900 201 Kitee 62.2 29.6 343 7 720 20 202 Lieksa 63.2 30.0 157 4 540 20	140	Lieksa	63.3	29.8	197	5	1010	30	
144 Rautavaara 63.5 27.6 2600 60 4820 160 146 Suonenjoki 62.4 27.1 16500 300 27200 900 148 Pielavesi 63.0 26.8 10300 160 17500 600 149 Keitele 63.0 26.1 7400 70 12200 500 152 Keitele 63.2 26.1 2990 50 5200 200 168 Kauhava 63.0 23.5 14400 200 26200 900 201 Kitee 62.2 29.6 343 7 720 20 202 Lieksa 63.2 30.0 157 4 540 20	143	Valtimo	63.7	28.4	2700	60	5100	200	
146Suonenjoki62.427.11650030027200900148Pielavesi63.026.81030016017500600149Keitele63.026.174007012200500152Keitele63.226.12990505200200168Kauhava63.023.51440020026200900201Kitee62.229.6343772020202Lieksa63.230.0157454020	144	Rautavaara	63.5	27.6	2600	60	4820	160	
148Pielavesi63.026.81030016017500600149Keitele63.026.174007012200500152Keitele63.226.12990505200200168Kauhava63.023.51440020026200900201Kitee62.229.6343772020202Lieksa63.230.0157454020	146	Suonenioki	62.4	27.1	16500	300	27200	900	
149Keitele63.026.174007012200500152Keitele63.226.12990505200200168Kauhava63.023.51440020026200900201Kitee62.229.6343772020202Lieksa63.230.0157454020	148	Pielavesi	63.0	26.8	10300	160	17500	600	
152 Keitele 63.2 26.1 2990 50 5200 200 168 Kauhava 63.0 23.5 14400 200 26200 900 201 Kitee 62.2 29.6 343 7 720 20 202 Lieksa 63.2 30.0 157 4 540 20	149	Keitele	63.0	26.1	7400	70	12200	500	
168Kauhava63.023.51440020026200900201Kitee62.229.6343772020202Lieksa63.230.0157454020	152	Keitele	63.2	26.1	2990	50	5200	200	
201 Kitee 62.2 29.6 343 7 720 20 202 Lieksa 63.2 30.0 157 4 540 20	168	Kauhava	63.0	23.5	14400	200	26200	900	
202 Lieksa 63.2 30.0 157 4 540 20	201	Kitee	62.2	29.6	343	7	720	20	
	202	Lieksa	63.2	30.0	157	4	540	20	

	No.	Community	Ru-106		Sb-125		Ce-144	
4 Karvia n.d. n.d. n.d. n.d. 10 Kankaanpää 19500 1200 620 20 2200 200 14 Tampere n.d. 5200 300 33000 7000 15 Punkaaladun 1400 400 625 14 5700 200 16 Köyliö 28000 1400 900 50 7400 600 17 Hatula n.d. n.d. n.d. n.d. 10 18 Loimaan mik 15000 2000 850 30 n.d. 20 21 Hainkaiki n.d. n.d. n.d. 104 20 200 <th>(Bq m⁻²)</th> <th>±1 σ</th> <th>(Bq m⁻²)</th> <th>±1<i>σ</i></th> <th>(Bq m⁻²)</th> <th>±1 σ</th>			(Bq m ⁻²)	±1 σ	(Bq m ⁻²)	±1 <i>σ</i>	(Bq m ⁻²)	±1 σ
10 Kankaanpää 19500 1200 620 20 200 200 14 Tampere n.d. 5200 300 33000 7000 15 Punkalaidun 14900 400 625 14 5700 200 16 Köyikö 28000 1400 900 50 7400 600 17 Hattula n.d. n.d. n.d. n.d. 10 18 Loimaa mik 15000 3000 1180 40 n.d. 120 20 Riikimäki 15000 2000 850 30 n.d. 120 21 Hankasalmi n.d. n.d. n.d. n.d. 140 140 140 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 300 200 300 200 n.d. <t< td=""><td>4</td><td>Karvia</td><td>n.d.</td><td></td><td>n.d.</td><td></td><td>n.d.</td><td></td></t<>	4	Karvia	n.d.		n.d.		n.d.	
11 Kankaanpää 40000 3000 1660 80 n.d. 14 Tampere n.d. 5200 300 33000 7000 15 Punkalaidun 14900 400 625 14 5700 200 16 Köyilö 28000 1400 900 50 7400 600 18 Loimaan mik 15000 3000 1180 40 n.d. 20 Riihimäki 15000 2000 850 30 n.d. 21 Hankasalmi n.d. n.d. n.d. n.d. 21 Heirolan mik n.d. 140 40 n.d. n.d. 22 Leironmäki n.d. n.d. n.d. n.d. 600 23 Juva n.d. n.d. n.d. n.d. 600 24 Heinolan mik n.d. n.d. n.d. n.d. 600 34 Juva n.d. n.d.	10	Kankaanpää	19500	1200	620	20	2200	200
14 Tampere n.d. 5200 300 33000 7000 15 Punkalaidun 14900 400 625 14 5700 200 16 Köyliö 28000 1400 900 50 7400 600 17 Hattula n.d. n.d. n.d. n.d. 18 Loimaa mik 15000 3000 180 40 n.d. 20 Riilimäki 15000 2000 850 30 n.d. 21 Hankasalmi n.d. n.d. n.d. n.d. 22 Viitasaari 7300 600 229 8 3500 200 24 Pirkhasari n.d. 1360 50 3000 600 37 Juva n.d. 1300 20 n.d. n.d. 44 Taipalsaari n.d. n.d. n.d. n.d. 42 Purkhahrju 100 300 300 2<	11	Kankaanpää	40000	3000	1680	80	n.d.	
15 Punkalaidun 14900 400 f25 14 5700 200 16 Köyliö 28000 1400 900 50 7400 600 17 Hatula n.d. n.d. n.d. n.d. n.d. 18 Loimaan mik 15000 2000 850 30 n.d. 20 Riihimäki 15000 2000 850 30 n.d. 21 Hankasalmi n.d. n.d. n.d. n.d. 120 21 Leivomäki n.d. 140 40 n.d. 126 26 Pithipudas 46000 3000 330 20 5400 500 27 Heinolan mik n.d. n.d. n.d. n.d. 140 Joutseno n.d. n.d. n.d. 40 Joutseno n.d. n.d. n.d. n.d. 144 Taipasaari n.d. n.d. 144 Taipasaari n.d.	14	Tampere	n.d.		5200	300	33000	7000
16 Köyliö 28000 1400 900 50 7400 600 17 Hattula n.d. n.d. n.d. n.d. n.d. 18 Loimaan mik 15000 3000 1180 40 n.d. 19 Janakkala n.d. 630 60 n.d. 20 Riihimäki 15000 2000 850 30 n.d. 21 Leivonmäki n.d. 140 40 n.d. 200 25 Vitasaari 7300 600 229 8 3500 200 26 Pihtipudas 46000 3000 333 20 9400 500 37 Juva n.d. 120 n.d. n.d. 141 40 Joutseno n.d. n.d. n.d. n.d. 42 Punkaharju 1200 500 n.d. n.d. n.d. 42 Punkaharju n.d. n.d. n.d.	15	Punkalaidun	14900	400	625	14	5700	200
17 Hartula n.d. n.d. n.d. 18 Loimaan mlk 15000 3000 1180 40 n.d. 20 Rihhimäki 15000 2000 850 30 n.d. 21 Hankasalmi n.d. n.d. n.d. n.d. 21 Hankasalmi n.d. 140 40 n.d. 22 Leivonmäki n.d. 140 40 n.d. 25 Viitasaari 7300 600 229 8 3500 200 26 Pihtipudas 46000 3000 330 20 n.d. n.d. 30 Juva n.d. 130 20 n.d. n.d. 40 Joutseno n.d. n.d. n.d. n.d. n.d. 41 Riautjärvi 1200 500 n.d. n.d. n.d. 42 Punkaharju 4700 1300 n.d. n.d. n.d. 43 Tajatsarai n.d. n.d. n.d. n.d. .d.	16	Köyliö	28000	1400	900	50	7400	600
18 Loimaan mik 15000 3000 1180 40 n.d. 19 Janakkala n.d. 630 60 n.d. 21 Riihimäki 15000 2000 850 30 n.d. 21 Harkasalmi n.d. 140 40 n.d. 22 Leivomäki n.d. 140 40 n.d. 25 Viitasaari 7300 600 229 8 3500 200 26 Pihtipudas 46000 3000 330 20 5400 500 37 Juva n.d. 130 20 n.d. n.d. 40 Joutseno n.d. n.d. n.d. n.d. 42 Purkaharju 4700 1300 n.d. n.d. n.d. 44 Taipasaari n.d. n.d. n.d. n.d. n.d. 44 Hakikariyai n.d. n.d. n.d. n.d. n.d. <td>17</td> <td>Hattula</td> <td>n.d.</td> <td></td> <td>n.d.</td> <td></td> <td>n.d.</td> <td></td>	17	Hattula	n.d.		n.d.		n.d.	
19 Janakkala n.d. 630 60 n.d. 20 Rihimäki 15000 2000 850 30 n.d. 21 Hankasalmi n.d. n.d. n.d. 142 22 Leivonmäki n.d. 140 40 n.d. 200 25 Viitasaari 7300 600 229 8 3500 200 26 Pihtipudas 46000 3000 330 20 5400 500 27 Heinolan mik n.d. 126 11 n.d. 100 36 Kyrjärvi n.d. n.d. n.d. n.d. 100 40 Joutseno n.d. n.d. n.d. n.d. n.d. 41 Rajalsari n.d. n.d. n.d. n.d. n.d. 42 Punkaharju n.d. n.d. n.d. n.d. n.d. 43 Kalkelin mik n.d. n.d. n.d.	18	Loimaan mlk	15000	3000	1180	40	n.d.	
20 Riihimäki 15000 2000 850 30 n.d. 21 Hankasalmi n.d. n.d. n.d. n.d. 22 Leivonmäki n.d. 140 40 n.d. 25 Viltasaari 7300 600 229 8 3500 200 26 Pihtipudas 46000 3000 330 20 5400 500 37 Juva n.d. 126 11 n.d. 140 40 Joutseno n.d. n.d. n.d. n.d. n.d. 41 Raukaharju 2100 500 n.d. n.d. n.d. 42 Punkaharju 7000 1300 n.d. n.d. n.d. 43 Valkeala 15000 360 20 n.d. 144 44 Taupovaara n.d. n.d. n.d. 140 44 Haukivori n.d. n.d. n.d. 140	19	Janakkala	n.d.		630	60	n.d.	
21 Hankasalmi n.d. n.d. Hankasalmi 22 Leivonmäki n.d. 140 40 n.d. 22 Viitsaaari 7300 600 229 8 3500 200 26 Pihtipudas 46000 3000 330 20 5400 500 27 Heinolan mik n.d. 136 50 3000 600 37 Juva n.d. 130 20 n.d. 40 40 Joutseno n.d. n.d. n.d. n.d. 140 41 Rajalsari n.d. n.d. n.d. n.d. 140 42 Punkaharju 4700 1300 n.d. n.d. 140 43 Kontiolahti 2100 300 360 20 n.d. 44 Tajajasari n.d. n.d. n.d. 140 44 Tajaskari n.d. n.d. n.d. 140	20	Riihimäki	15000	2000	850	30	n.d.	
22 Leivonmäki n.d. 140 40 n.d. 25 Viitasaari 7300 600 229 8 3500 200 26 Pithipudas 46000 3000 330 20 5400 500 27 Heinolan mik n.d. 126 11 n.d. 3000 600 37 Juva n.d. 130 20 n.d. n.d. 40 Joutseno n.d. n.d. n.d. n.d. n.d. 41 Rautjärvi 2100 500 n.d. n.d. n.d. 42 Punkaharju 4700 1300 n.d. n.d. n.d. 43 Valkeala 1500 3000 860 40 n.d. 44 Taipalsaari n.d. n.d. n.d. n.d. 44 Haukivuori 8200 1500 360 20 n.d. 45 Valkkeala n.d. n.d. <	21	Hankasalmi	n.d.		n.d.		n.d.	
25 Viitasaari 7300 600 229 8 3500 200 26 Pihtipudas 46000 3000 330 20 5400 500 27 Heinolan mik n.d. 126 11 n.d. 360 50 3000 600 37 Juva n.d. 130 20 n.d. n.d. 40 Joutseno n.d. n.d. n.d. n.d. n.d. 41 Raujazain n.d. n.d. n.d. n.d. n.d. 42 Punkaharju 4700 1300 n.d. n.d. n.d. 44 Taipalsaari n.d. n.d. n.d. n.d. n.d. 44 Taipalsaari n.d.	22	Leivonmäki	n.d.		140	40	n.d.	
26 Pihtipudas 46000 3000 330 20 5400 500 27 Heinolan mik n.d. 126 11 n.d. 600	25	Viitasaari	7300	600	229	8	3500	200
27 Heinolan milk n.d. 126 11 n.d. 36 Kyyjärvi n.d. 360 50 3000 600 40 Joutseno n.d. n.d. n.d. n.d. n.d. 41 Rautjärvi 2100 500 n.d. n.d. n.d. 42 Punkaharju 4700 1300 n.d. n.d. n.d. 44 Taipalsaari n.d. n.d. n.d. n.d. n.d. 44 Kontiolahti 8200 1500 366 20 n.d. 1.d. 44 Haukivuori 8200 1500 366 20 n.d. 1.d. 47 Mikkelin mlk n.d. n.d. n.d. n.d. 1.d. 48 Kontiolahti 1.d. n.d. n.d. n.d. 1.d. 52 Pyhäselkä n.d. n.d. n.d. n.d. 5.d. 53 Suonenjoki n.d.	26	Pihtipudas	46000	3000	330	20	5400	500
Instrume	27	Heinolan mlk	nd		126	11	nd	
box ryrration rule box box <thb< td=""><td>36</td><td>Kvviärvi</td><td>n d</td><td></td><td>360</td><td>50</td><td>3000</td><td>600</td></thb<>	36	Kvviärvi	n d		360	50	3000	600
Original Ind. Ind. Ind. Ind. 40 Joutseno n.d. n.d. n.d. n.d. 41 Rauţiārvi 2100 500 n.d. n.d. n.d. 42 Punkaharju 4700 1300 n.d. n.d. n.d. 45 Valkeala 15000 3000 860 40 n.d. 45 Valkeala 15000 3000 860 40 n.d. 46 Haukivuori 8200 1500 360 20 n.d. 47 Mikkelin mik n.d. n.d. n.d. n.d. n.d. 48 Kontiolahti 2100 300 30 2 340 90 49 Tohmajārvi n.d. n.d. n.d. n.d. n.d. 50 Ilomantsi n.d. n.d. n.d. n.d. n.d. 51 Tuupovaara n.d. n.d. n.d. n.d. sooo </td <td>37</td> <td>Juva</td> <td>n.d.</td> <td></td> <td>130</td> <td>20</td> <td>nd</td> <td>000</td>	37	Juva	n.d.		130	20	nd	000
No. Ind. Ind. Ind. Ind. Ind. 41 Rautjärvi 2100 500 n.d. n.d. Ind. 42 Punkaharju 4700 1300 n.d. n.d. Ind. 44 Taipalsaari n.d. n.d. n.d. Ind. Ind. 44 Taipalsaari n.d. n.d. n.d. Ind. Ind. 45 Valkeala 1500 3000 860 40 n.d. 46 Haukivuori 8200 1500 300 30 2 340 90 47 Mikkelin mik n.d. n.d. n.d. n.d. Ind. 100	40	loutseno	n.d.		nd	20	n.d.	
Hadigari Lico Soo Ind. Ind. 44 Taipalsaari n.d. n.d. n.d. 44 Taipalsaari n.d. n.d. n.d. 44 Taipalsaari n.d. n.d. n.d. 45 Valkeala 15000 3000 860 40 n.d. 45 Valkeala 15000 3000 300 20 n.d. 47 Mikkelin mlk n.d. n.d. n.d. n.d. 48 Kontiolahti 2100 300 30 2 340 90 49 Tohmajärvi n.d. n.d. n.d. n.d. n.d. 51 Tuupovaara n.d. n.d. n.d. n.d. 53 51 Tuupovaara n.d. n.d. n.d. n.d. 54 52 Suonenjoki n.d. n.d. n.d. n.d. 530 600 55 Suonenjoki n.d. n	40 41	Bautiärvi	2100	500	n d		n.d.	
** **<	12	Punkahariu	4700	1300	n.d.		n.d.	
Harpatsaan Ind. Ind. Ind. 44 Valkeala 1500 3000 860 40 n.d. 46 Haukivuori 8200 1500 360 20 n.d. 47 Mikkelin mlk n.d. n.d. n.d. n.d. 48 Kontiolahti 2100 300 30 2 340 90 49 Tohmajärvi n.d. n.d. n.d. n.d. n.d. 160 50 llomantsi n.d. n.d. n.d. n.d. 160 200 200 200 255 Suonenjoki n.d. n.d. 160 200 200 255 Suonenjoki n.d. n.d. n.d. 5300 200 200 200 255 Suonenjoki 12600 1100 390 15 1800 300 200 200 600 600 600 600 600 600 600 600 600 600 600	42	Taipalaari	4700 nd	1300	n.u.		n.d.	
No. Valueara 13000 3000 3000 3000 40 Ind. 46 Haukivuori 8200 1500 360 20 n.d. 47 Mikkelin mlk n.d. n.d. n.d. n.d. 48 Kontiolahti 2100 300 30 2 340 90 49 Tohmajärvi n.d. n.d. n.d. n.d. n.d. 50 Ilomantsi n.d. n.d. n.d. n.d. n.d. 51 Tuupovaara n.d. n.d. n.d. n.d. n.d. 53 Rääkkylä n.d. n.d. n.d. n.d. 55 Suonenjoki n.d. n.d. n.d. n.d. 5300 600 55 Suonenjoki 1.2600 1100 390 15 1800 300 57 Pielavesi n.d. n.d. 5300 600 58 Kartula n.d. n.d. </td <td>44</td> <td>Valkoala</td> <td>15000</td> <td>2000</td> <td>11.U. 860</td> <td>40</td> <td>n.u.</td> <td></td>	44	Valkoala	15000	2000	11.U. 860	40	n.u.	
House House <th< td=""><td>40</td><td>Vaineala</td><td>8200</td><td>1500</td><td>260</td><td>40</td><td>n.u.</td><td></td></th<>	40	Vaineala	8200	1500	260	40	n.u.	
44 Mikkelin mik n.d. n.d. n.d. 48 Kotiolahti 2100 300 30 2 340 90 49 Tohmajärvi n.d. n.d. n.d. n.d. n.d. 1 50 Ilomantsi n.d. n.d. n.d. n.d. n.d. 1 51 Tuupovaara n.d. n.d. n.d. n.d. 1 1 52 Pyhäselkä n.d. n.d. n.d. n.d. 1 </td <td>40</td> <td></td> <td>8200 m.d</td> <td>1500</td> <td>360</td> <td>20</td> <td>n.a.</td> <td></td>	40		8200 m.d	1500	360	20	n.a.	
Ho Kontolatilit 2100 300 30 2 340 90 49 Tohmajärvi n.d. n.d. n.d. n.d. n.d. n.d. 100	47	Mikkelin mik	n.a.	200	n.a.	0	n.a.	00
449 10nmajarvi n.d. n.d. n.d. 50 Ilomantsi n.d. n.d. n.d. 51 Tuupovaara n.d. n.d. n.d. 52 Pyhäselkä n.d. n.d. n.d. 53 Rääkkylä n.d. n.d. n.d. 54 Rautavaara 3700 700 n.d. n.d. 55 Suonenjoki n.d. n.d. n.d. 1600 55 Suonenjoki n.d. n.d. n.d. 1600 56 Suonenjoki 12600 1100 390 15 1800 300 57 Pielavesi n.d. n.d. 5300 600 58 Kartula n.d. 270 50 2900 600 60 Kiuruvesi 7300 3000 230 20 7100 400 61 Kiuruvesi 16000 500 85 8 2500 200 62 Kiuruvesi 12000 2000 n.d. n.d. n.d.	48	Kontiolanti	2100	300	30	2	340	90
b0 Ilomantsi n.d. n.d. n.d. 51 Tuupovaara n.d. n.d. n.d. 52 Pyhäselkä n.d. n.d. n.d. 53 Rääkkylä n.d. n.d. n.d. 54 Rautavaara 3700 700 n.d. n.d. 55 Suonenjoki n.d. n.d. n.d. 56 Suonenjoki n.d. n.d. n.d. 56 Suonenjoki n.d. n.d. 5300 600 57 Pielavesi n.d. 1600 390 15 1800 300 58 Karttula n.d. 270 50 2900 600 60 Kiuruvesi 18000 3000 230 20 7100 400 61 Kiuruvesi 17000 2000 85 8 2500 200 63 Kiuruvesi 17000 2000 n.d. n.d.	49	Tonmajarvi	n.a.		n.a.		n.a.	
51 1 Uupovaara n.d. n.d. n.d. 52 Pyhäselkä n.d. n.d. n.d. 53 Rääkkylä n.d. n.d. n.d. 54 Rautavaara 3700 700 n.d. 2400 200 55 Suonenjoki n.d. n.d. n.d. 160 55 Suonenjoki n.d. n.d. n.d. 160 300 56 Suonenjoki n.d. n.d. n.d. 5300 600 57 Pielavesi n.d. n.d. 5300 600 58 Kartula n.d. 270 50 2900 600 60 Kiuruvesi 16000 500 85 8 2500 200 61 Kiuruvesi 17000 2000 240 20 11400 600 64 Sonkajärvi 12000 2000 n.d. n.d. n.d. 9 64 Isua n.d. n.d. n.d. n.d. 9 9	50	liomantsi	n.d.		n.d.		n.d.	
52 Pyhaselka n.d. n.d. n.d. 53 Rääkkylä n.d. n.d. n.d. 54 Rautavaara 3700 700 n.d. 2400 200 55 Suonenjoki n.d. n.d. n.d. 1.6. 55 Suonenjoki n.d. n.d. n.d. 1.6. 56 Suonenjoki 12600 1100 390 15 1800 300 57 Pielavesi n.d. n.d. 5300 600 58 Karttula n.d. 270 50 2900 600 60 Kiuruvesi 73000 3000 230 20 7100 400 61 Kiuruvesi 16000 500 85 8 2500 200 62 Kiuruvesi 17000 2000 240 20 11400 600 64 Sonkajärvi 12000 2000 n.d. n.d. n.d. . 95 Vimpeli 13900 900 680 30 n.d.	51	Tuupovaara	n.d.		n.d.		n.d.	
53 Hääkkylä n.d. n.d. n.d. 54 Rautavaara 3700 700 n.d. 2400 200 55 Suonenjoki n.d. n.d. n.d. 55 Suonenjoki n.d. n.d. 55 55 Suonenjoki 12600 1100 390 15 1800 300 56 Suonenjoki 12600 1100 390 15 1800 300 57 Pielavesi n.d. n.d. 5300 600 68 Karttula n.d. 270 50 2900 600 60 Kiuruvesi 73000 3000 230 20 7100 400 61 Kiuruvesi 16000 500 85 8 2500 200 62 Kiuruvesi 17000 2000 240 20 11400 600 64 Sonkajärvi 12000 2000 n.d. n.d. 9 9 Jalasjärvi n.d. 9 9 Jalasjärvi n.d. n.d. 9	52	Pyhaselka	n.d.		n.d.		n.d.	
54 Hautavaara 3700 700 n.d. 2400 200 55 Suonenjoki n.d. n.d. n.d. n.d. 55 Suonenjoki n.d. n.d. n.d. status 56 Suonenjoki 12600 1100 390 15 1800 300 57 Pielavesi n.d. n.d. 5300 600 58 Karttula n.d. 270 50 2900 600 60 Kiuruvesi 73000 3000 230 20 7100 400 61 Kiuruvesi 16000 500 85 8 2500 200 62 Kiuruvesi 17000 2000 240 20 11400 600 64 Sonkajärvi 12000 2000 n.d. 85500 600 65 Ilomantsi n.d. n.d. n.d. 90 900 680 30 n.d. 96 Halsua n.d. n.d. n.d. 1.d. 90 100 200 <	53	Rääkkylä	n.d.		n.d.		n.d.	
55 Suonenjoki n.d. n.d. n.d. 55 Suonenjoki n.d. n.d. n.d. 56 Suonenjoki 12600 1100 390 15 1800 300 57 Pielavesi n.d. n.d. 5300 600 58 Karttula n.d. 270 50 2900 600 60 Kiuruvesi 73000 3000 230 20 7100 400 61 Kiuruvesi 16000 500 85 8 2500 200 62 Kiuruvesi 5200 900 107 5 3500 200 63 Kiuruvesi 17000 2000 240 20 11400 600 64 Sonkajärvi 12000 2000 n.d. n.d. 90 680 30 n.d. 95 Vimpeli 13900 900 680 30 n.d. 90 99 Jalasjärvi n.d. n.d. n.d. 90 110 800 200 <tr< td=""><td>54</td><td>Rautavaara</td><td>3700</td><td>700</td><td>n.d.</td><td></td><td>2400</td><td>200</td></tr<>	54	Rautavaara	3700	700	n.d.		2400	200
55 Suonenjoki n.d. n.d. n.d. 56 Suonenjoki 12600 1100 390 15 1800 300 57 Pielavesi n.d. n.d. 5300 600 58 Karttula n.d. 270 50 2900 600 60 Kiuruvesi 73000 3000 230 20 7100 400 61 Kiuruvesi 16000 500 85 8 2500 200 62 Kiuruvesi 5200 900 107 5 3500 200 63 Kiuruvesi 17000 2000 n.d. 8500 600 64 Sonkajärvi 12000 2000 n.d. n.d. 90 65 Ilomantsi n.d. n.d. n.d. 90 660 600 600 65 Vimpeli 13900 900 680 30 n.d. 90 900 680 900 600 600 600 600 600 600 200 100 <	55	Suonenjoki	n.d.		n.d.		n.d.	
56 Suonenjoki 12600 1100 390 15 1800 300 57 Pielavesi n.d. n.d. 5300 600 58 Karttula n.d. 270 50 2900 600 60 Kiuruvesi 73000 3000 230 20 7100 400 61 Kiuruvesi 16000 500 85 8 2500 200 62 Kiuruvesi 5200 900 107 5 3500 200 63 Kiuruvesi 17000 2000 240 20 11400 600 64 Sonkajärvi 12000 2000 n.d. 8500 600 65 Ilomantsi n.d. n.d. n.d. 9 96 Halsua n.d. n.d. n.d. 9 99 Jalasjärvi n.d. 590 30 6300 600 100 Peräseinäjoki 3400 800 </td <td>55</td> <td>Suonenjoki</td> <td>n.d.</td> <td></td> <td>n.d.</td> <td></td> <td>n.d.</td> <td></td>	55	Suonenjoki	n.d.		n.d.		n.d.	
57 Pielavesi n.d. n.d. 5300 600 58 Karttula n.d. 270 50 2900 600 60 Kiuruvesi 73000 3000 230 20 7100 400 61 Kiuruvesi 16000 500 85 8 2500 200 62 Kiuruvesi 5200 900 107 5 3500 200 63 Kiuruvesi 17000 2000 240 20 11400 600 64 Sonkajärvi 12000 2000 n.d. 8500 600 65 Ilomantsi n.d. n.d. n.d. 9 96 Halsua n.d. n.d. n.d. 9 97 Jalasjärvi n.d. 590 30 6300 600 100 Peräseinäjoki 3400 800 144 13 800 200 111 Loimaa 15100 900 390 20 n.d. 111 135 Kerimäki 3100	56	Suonenjoki	12600	1100	390	15	1800	300
58 Karttula n.d. 270 50 2900 600 60 Kiuruvesi 73000 3000 230 20 7100 400 61 Kiuruvesi 16000 500 85 8 2500 200 62 Kiuruvesi 5200 900 107 5 3500 200 63 Kiuruvesi 17000 2000 240 20 11400 600 64 Sonkajärvi 12000 2000 n.d. 8500 600 65 Ilomantsi n.d. n.d. n.d. 9 9 94 Halsua n.d. n.d. n.d. 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 0 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	57	Pielavesi	n.d.		n.d.		5300	600
60 Kiuruvesi 73000 3000 230 20 7100 400 61 Kiuruvesi 16000 500 85 8 2500 200 62 Kiuruvesi 5200 900 107 5 3500 200 63 Kiuruvesi 17000 2000 240 20 11400 600 64 Sonkajärvi 12000 2000 n.d. 8500 600 65 Ilomantsi n.d. n.d. n.d. 9 9 900 900 680 30 n.d. 900 680 30 10 900 680 30 1.0 900 900 680 30 1.0 900 900 680 30 1.0 900 900 680 30 600 600 100 900 900 300 600 200 100 10 Köyliö 11600 800 460 20 3500 400 <t< td=""><td>58</td><td>Karttula</td><td>n.d.</td><td></td><td>270</td><td>50</td><td>2900</td><td>600</td></t<>	58	Karttula	n.d.		270	50	2900	600
61 Kiuruvesi 16000 500 85 8 2500 200 62 Kiuruvesi 5200 900 107 5 3500 200 63 Kiuruvesi 17000 2000 240 20 11400 600 64 Sonkajärvi 12000 2000 n.d. 8500 600 65 Ilomantsi n.d. n.d. n.d. 9 900 680 30 n.d. 96 Halsua n.d. n.d. n.d. n.d. 9 9 Jalasjärvi n.d. 590 30 6300 600 100 Peräseinäjoki 3400 800 144 13 800 200 110 Köyliö 11600 800 460 20 3500 400 111 Loimaa 15100 900 390 20 n.d. 117 135 Kerimäki 3100 600 270 9 n.d. 136 136 Mikkelin mlk 7400 1800 230	60	Kiuruvesi	73000	3000	230	20	7100	400
62 Kiuruvesi 5200 900 107 5 3500 200 63 Kiuruvesi 17000 2000 240 20 11400 600 64 Sonkajärvi 12000 2000 n.d. 8500 600 65 Ilomantsi n.d. n.d. n.d. n.d. 9 95 Vimpeli 13900 900 680 30 n.d. 9 96 Halsua n.d. n.d. n.d. 9 9 Jalasjärvi n.d. 10 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 200 3500 400 100 800 460 20 3500 400 111 Loimaa 15100 900 390 20 n.d. 117 Hartola n.d. 460 40 n.d. 135 Kerimäki	61	Kiuruvesi	16000	500	85	8	2500	200
63 Kiuruvesi 17000 2000 240 20 11400 600 64 Sonkajärvi 12000 2000 n.d. 8500 600 65 Ilomantsi n.d. n.d. n.d. n.d. 95 Vimpeli 13900 900 680 30 n.d. 96 Halsua n.d. n.d. n.d. 99 Jalasjärvi n.d. 590 30 6300 600 100 Peräseinäjoki 3400 800 144 13 800 200 110 Köyliö 11600 800 460 20 3500 400 111 Loimaa 15100 900 390 20 n.d. 117 117 Hartola n.d. 460 40 n.d. 135 Kerimäki 3100 600 270 9 n.d. 136 Mikkelin mlk 7400 1800 230 20 n.d. 140	62	Kiuruvesi	5200	900	107	5	3500	200
64 Sonkajärvi 1200 2000 n.d. 8500 600 65 Ilomantsi n.d. n.d. n.d. n.d. n.d. n.d. 90 65 1000 n.d. n.d. n.d. n.d. 90 900 680 30 n.d. 90 900 680 90 600 600 600 200 100 900 900 390 200 110 Köyliö 11600 800 460 20 3500 400 111 Loimaa 15100 900 390 20 n.d. 117 Hartola n.d. 460 40 n.d. 1135 Kerimäki 3100 600 270 9 n.d. 136	63	Kiuruvesi	17000	2000	240	20	11400	600
65 Ilomantsi n.d. n.d. n.d. 95 Vimpeli 13900 900 680 30 n.d. 96 Halsua n.d. n.d. n.d. n.d. 99 Jalasjärvi n.d. 590 30 6300 600 100 Peräseinäjoki 3400 800 144 13 800 200 110 Köyliö 11600 800 460 20 3500 400 111 Loimaa 15100 900 390 20 n.d. 117 117 Hartola n.d. 460 40 n.d. 135 Kerimäki 3100 600 270 9 n.d. 135 Kerimäki 3100 600 230 20 n.d. 140 140 Lieksa n.d. n.d. n.d. n.d. 1.d.	64	Sonkajärvi	12000	2000	n.d.		8500	600
95 Vimpeli 13900 900 680 30 n.d. 96 Halsua n.d. n.d. n.d. n.d. n.d. 99 Jalasjärvi n.d. 590 30 6300 600 100 Peräseinäjoki 3400 800 144 13 800 200 110 Köyliö 11600 800 460 20 3500 400 111 Loimaa 15100 900 390 20 n.d. 117 Hartola n.d. 460 40 n.d. 135 Kerimäki 3100 600 270 9 n.d. 136 Mikkelin mlk 7400 1800 230 20 n.d. 140 Lieksa n.d. n.d. n.d. n.d.	65	llomantsi	n.d.		n.d.		n.d.	
96 Halsua n.d. n.d. 99 Jalasjärvi n.d. 590 30 6300 600 100 Peräseinäjoki 3400 800 144 13 800 200 110 Köyliö 11600 800 460 20 3500 400 111 Loimaa 15100 900 390 20 n.d. 117 Hartola n.d. 460 40 n.d. 135 Kerimäki 3100 600 270 9 n.d. 136 Mikkelin mlk 7400 1800 230 20 n.d. 140 Lieksa n.d. n.d. n.d. N.d.	95	Vimpeli	13900	900	680	30	n.d.	
99 Jalasjärvi n.d. 590 30 6300 600 100 Peräseinäjoki 3400 800 144 13 800 200 110 Köyliö 11600 800 460 20 3500 400 111 Loimaa 15100 900 390 20 n.d. 117 Hartola n.d. 460 40 n.d. 135 Kerimäki 3100 600 270 9 n.d. 136 Mikkelin mlk 7400 1800 230 20 n.d. 140 Lieksa n.d. n.d. n.d. 1.d.	96	Halsua	n.d.		n.d.		n.d.	
100 Peräseinäjoki 3400 800 144 13 800 200 110 Köyliö 11600 800 460 20 3500 400 111 Loimaa 15100 900 390 20 n.d. 117 Hartola n.d. 460 40 n.d. 135 Kerimäki 3100 600 270 9 n.d. 136 Mikkelin mlk 7400 1800 230 20 n.d. 140 Lieksa n.d. n.d. n.d. 1.d.	99	Jalasjärvi	n.d.		590	30	6300	600
110 Köyliö 11600 800 460 20 3500 400 111 Loimaa 15100 900 390 20 n.d. 117 Hartola n.d. 460 40 n.d. 135 Kerimäki 3100 600 270 9 n.d. 136 Mikkelin mlk 7400 1800 230 20 n.d. 140 Lieksa n.d. n.d. n.d. 1.d.	100	Peräseinäjoki	3400	800	144	13	800	200
111 Loimaa 15100 900 390 20 n.d. 117 Hartola n.d. 460 40 n.d. 135 Kerimäki 3100 600 270 9 n.d. 136 Mikkelin mlk 7400 1800 230 20 n.d. 140 Lieksa n.d. n.d. n.d. n.d.	110	Köyliö	11600	800	460	20	3500	400
117 Hartola n.d. 460 40 n.d. 135 Kerimäki 3100 600 270 9 n.d. 136 Mikkelin mlk 7400 1800 230 20 n.d. 140 Lieksa n.d. n.d. n.d.	111	Loimaa	15100	900	390	20	n.d.	
135 Kerimäki 3100 600 270 9 n.d. 136 Mikkelin mlk 7400 1800 230 20 n.d. 140 Lieksa n.d. n.d. n.d.	117	Hartola	n.d.		460	40	n.d.	
136 Mikkelin mlk 7400 1800 230 20 n.d. 140 Lieksa n.d. n.d. n.d. n.d.	135	Kerimäki	3100	600	270	9	n.d.	
140 Lieksa n.d. n.d. n.d.	136	Mikkelin mlk	7400	1800	230	20	n.d.	
	140	Lieksa	n.d.	-	n.d.	-	n.d.	

Table 2. The observed deposition values (Bq m⁻² \pm 1 σ propagated counting error decay-corrected to 1 May 1986) of ¹²⁵Sb, ¹⁰⁶Ru, and ¹⁴⁴Ce based on peat samples (n.d. = not detected).

continued

No.	Community	Ru-106		Sb-125		Ce-144	
		(Bq m ⁻²)	±1 σ	(Bq m ⁻²)	±1 <i>0</i>	(Bq m ⁻²)	±1 <i>0</i>
143	Valtimo	n.d.		n.d.		11200	1100
144	Rautavaara	27000	3000	n.d.		8400	600
146	Suonenjoki	n.d.		480	90	n.d.	
148	Pielavesi	n.d.		390	40	4400	800
149	Keitele	11900	1000	315	11	8500	300
152	Keitele	4700	1000	130	12	4400	300
168	Kauhava	n.d.		490	30	1600	400
201	Kitee	n.d.		28	6	n.d.	
202	Lieksa	1900	300	19	4	n.d.	

Table 2. Continued.

Table 3. The observed deposition values (Bq m⁻² \pm 1 σ propagated counting error decay-corrected to 1 May 1986) of ¹³⁴Cs and ¹³⁷Cs based on lichen samples.

Sample	Community	Lat.	at. Long.	Cs-1	Cs-134		Cs-137	
no.		(°N)	(°E)	(Bq m ⁻²)	±1 σ	(Bq m ⁻²)	±1 σ	
300-86	Vaskijärvi	60.6	24.3	3550	50	6800	200	
302-86	Jokioinen	60.8	23.5	4030	50	7200	200	
303-86	Kalanti, Jaakkola	60.8	21.5	46500	300	75500	1500	
304-86	Uusikaupunki	60.8	21.4	37100	200	61300	1300	
304-86b	Uusikaupunki	60.8	21.4	33500	400	58000	2000	
306-86	Kalanti, kirkko	60.8	21.6	46600	400	86000	2000	
308-86	Kalanti, kirkko	60.8	21.6	38900	200	62900	1300	
310-86	Hiidenvesi	60.4	24.3	1380	20	2720	60	
311-86	Yläne	60.9	22.3	29400	300	50900	1000	
314-86	Wessö	60.3	25.8	7730	70	15400	200	
316-86	Pietarsaari	63.7	22.7	21300	200	36300	800	
317-86	Wessö	60.3	25.8	9990	130	20900	500	
318-86	Wessö	60.3	25.8	4420	50	10000	200	
321-86	Wessö	60.3	25.8	4910	50	10700	200	
322-86	Wessö	60.3	25.8	6090	90	12500	200	
323-86	Pärnäsaari	61.2	25.6	41600	200	64700	1200	
325-86	Tenhola	60.0	23.2	825	10	2160	30	
326-86	Båtviken	59.9	23.3	440	6	1900	30	
327-86	Ristiina	61.5	27.3	4300	50	8390	140	
328-86	Huittinen	61.2	22.8	27000	200	45800	900	
330-86	Wessö	60.3	25.8	4440	50	8300	200	
337-86	Kausala	60.9	26.3	43600	400	70000	1400	
338-86	Pertunmaa	61.4	26.5	8840	90	16400	500	
421-87	Sotkamo	64.0	28.8	2030	30	6840	140	
10-87	Kaamanen	69.1	27.1	377	9	1320	50	

in areas with simultaneous occurrence of precipitation (Paatero *et al.* 2002). On the other hand, a high deposition occurred at the southwestern coast of Finland despite the lack of precipitation in this area. This can be attributed to the dry deposition of hot particles (Saari *et al.* 1989). The aerodynamic diameters of these particles were of such magnitude that their gravitational settling had to be taken into account when assessing their behaviour in the atmosphere (Pöllänen *et al.* 1997). The deposition might have been overestimated in the region of Oulu because there were no samples from this area. A relatively low deposition occurred in the Hanko region. This

Sample	Community	ity Ru-106		Sb-1	25	Ce-144	
no.		(Bq m ⁻²)	±1 <i>0</i>	(Bq m ⁻²)	±1 σ	(Bq m ⁻²)	±1 <i>0</i>
300-86	Vaskijärvi	1650	60	133	9	240	20
302-86	Jokioinen	1820	50	159	8	760	20
303-86	Kalanti, Jaakkola	16900	300	1930	40	9000	200
304-86	Uusikaupunki	14400	200	1650	30	2920	90
304-86b	Uusikaupunki	11400	400	1300	70	3050	130
306-86	Kalanti, kirkko	29100	500	2590	60	3480	100
308-86	Kalanti, kirkko	14700	300	1650	40	2950	80
310-86	Hiidenvesi	540	20	60	5	238	11
311-86	Yläne	13500	200	1320	30	5060	110
314-86	Wessö	5270	110	298	11	660	30
316-86	Pietarsaari	1580	60	510	20	450	30
317-86	Wessö	6900	200	440	20	720	50
318-86	Wessö	2980	80	118	9	520	30
321-86	Wessö	4070	100	590	50	204	9
322-86	Wessö	3270	140	230	30	150	20
323-86	Pärnäsaari	2970	80	840	20	870	30
325-86	Tenhola	470	20	n.d.		91	5
326-86	Båtviken	770	60	17	2	235	9
327-86	Ristiina	950	30	105	6	160	9
328-86	Huittinen	9300	200	970	30	3430	90
330-86	Wessö	2790	70	117	7	n.d.	
337-86	Kausala	3660	100	830	30	370	20
338-86	Pertunmaa	1490	40	94	3	188	8
421-87	Sotkamo	1320	40	n.d.		1090	30
10-87	Kaamanen	n.d.		n.d.		n.d.	

Table 4. The observed deposition values (Bq m⁻² \pm 1 σ propagated counting error decay-corrected to 1 May 1986) of ¹²⁵Sb, ¹⁰⁶Ru, and ¹⁴⁴Ce based on lichen samples.

Table 5. Statistical parameters of the interpolated deposition values (Bq m⁻² decay-corrected to 1 May 1986).

Parameter	Cs-134	Cs-137	Ru-106	Sb-125	Ce-144
Minimum	38	97	35	1	19
10% value	522	1104	323	13	148
25% value	1103	2148	882	36	270
Median	2450	4806	2022	96	647
75% value	8312	15032	5346	330	2159
90% value	20155	35940	13213	927	4209
Maximum	108980	183140	28148	5216	30952
Arithm. mean	7319	12864	4202	319	1615
Geom. mean	2966	5677	2002	105	706

can be explained by the surrounding cold sea surface which stratifies the lower troposphere, thereby reducing the vertical transport of radionuclides. On the other hand, this implies that the obtained deposition value for the south-western archipelago was probably overestimated.

The regional deposition of cesium isotopes 137 and 134 (Figs. 3 and 4) differed from that of ¹⁴⁴Ce because cesium is a volatile element

with a boiling point of 678 °C. Compared with the refractory nuclides, a higher proportion of cesium was emitted from the burning reactor during several days after the initial explosion. The deposition was highest in southwestern Finland. Again, the deposition was relatively low in the Hanko–Helsinki region. Our results confirm the earlier *in situ* observations of high deposition values in the Varkaus–Kuopio region, Kuhmo



Fig. 3. Regional distribution of the ¹³⁷Cs deposition (Bq m⁻²) in Finland decay-corrected to 1 May 1986. The three classes of deposition represent the 0–50 (light grey, < 4806 Bq m⁻²), 50–75 (dark grey, 4806–15032 Bq m⁻²) and 75–100 (black, > 15032 Bq m⁻²) percentiles of the interpolated deposition values.

region and Kotka-Kouvola region (Arvela et al. 1990, Kettunen 2006). A comparison of previous results with our results suggests that an overestimated deposition in the Oulu region was obtained in this study. The deposition values obtained in this study are of the same order of magnitude as those found in Sweden, ranging from a few kBq m⁻² to > 85 kBq m⁻² (Persson *et* al. 1987). In Estonia, the ¹³⁷Cs deposition varied between 0.11 and 50 kBq m⁻² (Lust et al. 2006). The highest deposition values were found in northeastern Estonia. This is in agreement with our results, showing that the deposition was high in the Kotka-Kouvola region. This area is directly north of the northeastern Estonia on the northern shore of the Gulf of Finland. The observed average ¹³⁴Cs to ¹³⁷Cs activity ratio, 0.527 ± 0.010 decay-corrected to 1 May 1986,



Fig. 4. Regional distribution of the ¹³⁴Cs deposition (Bq m⁻²) in Finland decay-corrected to 1 May 1986. The three classes of deposition represent the 0–50, 50–75, and 75–100 percentiles of the interpolated deposition values. The three classes of deposition represent the 0–50 (light grey, < 2450 Bq m⁻²), 50–75 (dark grey, 2450–8312 Bq m⁻²) and 75–100 (black, > 8312 Bq m⁻²) percentiles of the interpolated deposition values.

is in agreement with the earlier studies. Arvela *et al.* (1989) reported a value of 0.59 for this ratio, while Antonov *et al.* (1988) gave a value of 0.486 and Toivonen *et al.* (1988) gave a value of 0.55 \pm 0.09. Early Soviet emission estimates gave a slightly higher value of 0.655 (International Atomic Energy Agency 1986). Based on the core inventory calculations of Kirchner and Noack (1988), the ratio observed in this study corresponds to a burnup of 13 GWd tU⁻¹, also in agreement with the earlier studies (USSR State Committee on the Utilization of Atomic Energy 1986, Persson *et al.* 1987, Paatero *et al.* 1998).

Even though ruthenium is a refractory element, the behaviour of ¹⁰³Ru and ¹⁰⁶Ru has been shown to resemble the behaviour of volatile ele-



Fig. 5. Regional distribution of the ¹⁰⁶Ru deposition (Bq m⁻²) in Finland decay-corrected to 1 May 1986. The three classes of deposition represent the 0–50, 50–75, and 75–100 percentiles of the interpolated deposition values. The three classes of deposition represent the 0–50 (light grey, < 2022 Bq m⁻²), 50–75 (dark grey, 2022–5346 Bq m⁻²) and 75–100 (black, > 5346 Bq m⁻²) percentiles of the interpolated deposition values.

ments. This has been explained by the formation of volatile ruthenium oxides. Ruthenium tetroxide has a melting point of 25.5 °C (Devell *et al.* 1986, Jantunen *et al.* 1991). The high deposition of ¹⁰⁶Ru at the Iisalmi–Kuopio region, Kuhmo region and Kotka–Kouvola region (Fig. 5) is similar to the observed ¹⁰³Ru deposition (Arvela *et al.* 1990). On the other hand, a zone of a relatively low deposition from Uusikaarlepyy to Lappeenranta was also observed for ¹⁰³Ru.

The deposition pattern of ¹²⁵Sb resembled those of cesium isotopes (Fig. 6). Again the areas of the highest deposition were south-western Finland, Kotka–Kouvola region and Varkaus– Kuopio region. The results suggest that antimony, having a melting point of 631 °C and boiling



Fig. 6. Regional distribution of the ¹²⁵Sb deposition (Bq m⁻²) in Finland decay-corrected to 1 May 1986. The three classes of deposition represent the 0–50, 50–75, and 75–100 percentiles of the interpolated deposition values. The three classes of deposition represent the 0–50 (light grey, < 96 Bq m⁻²), 50–75 (dark grey, 96–330 Bq m⁻²) and 75–100 (black, > 330 Bq m⁻²) percentiles of the interpolated deposition values.

point of 1750 °C, behaved like volatile nuclides in the destroyed reactor. For comparison, in Greece the ¹²⁵Sb deposition varied between 0 and 4.6 kBq m⁻² (National Technical University of Athens: http://arcas.nuclear.ntua.gr).

An estimation of the total activity of the five studied nuclides deposited in Finland was obtained by multiplying the arithmetic means of the interpolated deposition values (Table 5) with the geographical area of Finland, 338 000 km². The results are presented in Table 6, which includes also a comparison to the reactor core inventory and total emissions (International Atomic Energy Agency 1986, USSR State Committee on the Utilization of Atomic Energy 1986). Of the five studied gamma emitters, ¹³⁷Cs

Table 6. Total activity deposited in Finland (decay-corrected to 1 May 1986) and fractions from core inventory and atmospheric releases (International Atomic Energy Agency 1986, USSR State Committee on the Utilization of Atomic Energy 1986).

Nuclide	Total deposition (Bq) (1 May 1986)	Total deposition (g) (1 May 1986)	Fraction of inventory (%)	Fraction of emissions (%)
Cs-134	2.5 × 10 ¹⁵	52	1.3	13
Cs-137	$4.3 imes 10^{15}$	1400	1.5	12
Ru-106	$1.4 imes 10^{15}$	12	0.071	2.4
Sb-125	1.1×10^{14}	2.8		
Ce-144	5.5×10^{14}	4.6	0.017	0.61

was found to be the most abundant nuclide both by activity and mass in the Chernobyl-derived fallout in Finland. Its total deposition value obtained in this study, 4.3 PBq, is somewhat higher than the value reported by De Cort et al. (1998) which was 3.1 PBq. This discrepancy is partly explained by the reason that, contrary to the other nuclides in this study, the ¹³⁷Cs estimate contains an unknown fraction originating from the atmospheric nuclear tests. According to De Cort et al. (1998) Finland received the highest amount of ¹³⁷Cs from the accident outside the former Soviet Union. Depending on the nuclide, 0.017%-1.5% of the reactor core inventory and 0.6%-13% of the atmospheric emissions were deposited in Finland. The spatial unevenness of the Chernobyl deposition can be observed also from the large differences between the arithmetic and the geometric means of the interpolated deposition values in Table 5.

Conclusions

This study verifies the regional deposition pattern of ¹³⁷Cs obtained with aircraft and carborne *in-situ* measurements. The results include the first nation-wide deposition estimates of ¹³⁴Cs, ¹⁴⁴Ce, ¹⁰⁶Ru and ¹²⁵Sb. The behaviour of ¹²⁵Sb was found to be similar to that of cesium during the release and transport of contamination from the destroyed reactor. It was also noted that depending on the nuclide 0.017%–1.5% of the reactor core inventory and 0.6%–13% of the atmospheric emissions were deposited in Finland. These percentages were proportional to the volatility of the nuclides. In the future the data reported here can be used in the verification of long-range atmospheric transport and dispersion models such as SILAM (Sofiev *et al.* 2006).

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