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Division of NBC Defence
SE- 901 82 Umeå

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Report title

A survey of Cesium-137 and Strontium-90 in the lower part of the stream Verkmyrån

Abstract (not more than 200 words)

A higher deposition of ^{137}Cs than in the surroundings has earlier been recognised in the lower part of the stream Verkmyrån which is the outlet from the lake Hille. In this study, this area with a higher deposition is examined with a portable gamma spectrometer connected to a GPS, back pack. Five different areas were recognised and measured, an alder forest, a spruce grove within the alder forest, which had showed higher ^{137}Cs levels than the surrounding alder forest, two reed areas and a coniferous forest. The results show that elevated levels of ^{137}Cs are found in the alder forest and the reed areas which were all adjacent to stream. In these areas, the deposition varied between 500 – 1500 kBq/m^2. In the coniferous forest nearer the alder forest but further away from the stream, the deposition was 200 kBq/m^2. Soil samples from the different areas were also taken and sectioned before analysis of ^{137}Cs and ^{90}Sr. The same big difference in the deposition as for ^{137}Cs was not seen for ^{90}Sr in the different areas, the ^{90}Sr deposition varied between 1.5 -3.5 kBq/m^2. Vertical distribution profiles were plotted for the two radio nuclides and the results show that ^{137}Cs and ^{90}Sr have almost the same distribution pattern with a peak in activity at ~ 5cm depth.
The conclusion from this survey is that the elevated levels of ^{137}Cs in the vicinity of the outlet of the stream Verkmyrån come from redistribution from the lake Hille, primarily in 1986. ^{90}Sr was not redistributed from the lake to the wet land at the outlet in the same amount as ^{137}Cs.

Keywords

^{137}Cs, ^{90}Sr, deposition, wet land, redistribution

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Rapportens titel (i översättning)

En kartläggning av cesium-137 och strontium-90 i den nedre delen av Verkmyrån

Sammanfattning (högst 200 ord)

En större deposition av ^{137}Cs upptäcktes m.h.a. flygmätningar 1986 i den nedre delen av Verkmyrån, som är utloppet från Hillesjön. I denna studie har detta område blivit undersökt med en bärbar gammaspektrometer kopplat till en GPS, ”ryggsäck”. Fem olika områden har identifierats och mätts, en alskog, en grandunge i alskogen som har uppvisat en högre ^{137}Cs aktivitet än den omgivande alskogen, två vassområden och en barrskog. Resultaten visar att förhöjda ^{137}Cs-aktiviteter fanns i alskogen, grandungen och i vassområdena. I dessa områden varierade depositionen mellan 500 – 1500 kBq/m^2. Alla dessa områden låg i anslutning till Verkmyrån. I barrskogen som låg nära alskogen, men längre ifrån ån, var depositionen 200 kBq/m^2. Jordprover från de olika områdena togs också och skiktades innan mätning av ^{137}Cs och ^{90}Sr. Samma stora skillnad i deposition som för ^{137}Cs kunde inte ses inte för ^{90}Sr i de olika områdena. Djupprofiler uppmättes för de två radionukliderna och ^{137}Cs och ^{90}Sr uppvisar väldigt likartade distributionsmönster i de olika områdena, med en max i aktiviteten vid ~ 5 cm djup.
Slutsatsen från denna kartläggning är att de förhöjda ^{137}Cs-värdena i området närmast ån kommer från omfördelning av aktivitet från Hillesjön, som främst skedde 1986. ^{90}Sr har inte omfördelats från Hillesjön till utloppet i samma utsträckning som ^{137}Cs.

Nyckelord

^{137}Cs, ^{90}Sr, beläggning, våtmark, omfördelning

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CONTENTS

Introduction

Radioactive fallout from nuclear weapon tests and accidental releases of radio nuclides from the Chernobyl accident has led to contamination of Swedish ecosystems. As a result of a an intensive wet deposition of Chernobyl debris in April 1986 the municipality of Gästrikland received radioactive cesium fallout at levels that were one order of magnitude higher than the average for Sweden. A close inspection of the airborne gamma spectrometry data (RESUME 95, 1997) from the region has revealed small areas that are even 100 fold higher in deposition than the average for Sweden (SSI, 1999). One such area that is situated along the stream "Verkmyrån" has been the subject for a closer mapping of ^{137}Cs deposition (Tjärnhage et al, 2000). The local elevated levels observed could have at least three explanations:

1. A larger fallout in this particular area, as a result of local and more effective wash out from the radioactive plume or intensive rain than in the surroundings in 1986.
2. Redistribution of radioactive debris from the lake "Hillesjön" via the stream to this area during the spring flooding primarily in 1986.
3. Redistribution from the surrounding hill slopes via soil water

In 2001 a more detailed survey was done in the alder forest and a reed area at the end of Verkmyrån both with the backpack and by soil sampling. In this report, anomalies in ^{137}Cs deposition within these accumulation areas are presented a well as depth distribution of ^{137}Cs and ^{90}Sr in soil.

Experimental

Backpack measurements and soil sampling were done in five different areas:

- In an alder forest, situated next to the stream and effected by seasonal flooding, where backpack measurements had indicated an accumulation of radiocesium.
- A spruce grove within the alder forest, where even higher dose rates than in the surrounding alder forest indicated an anomaly of limited distribution.
- Two reed areas also recognised in 2000 as areas of higher activity. One sampling site was next to the alder forest and the other sampling site closer to the sea. Both sites are exposed to seasonal flooding.
- A coniferous forest located in the adjacent of the alder forest. This sampling site was further away from the stream and higher up in the terrain and not effected by stream flooding.

The "gamma measurement backpack" is a portable gamma spectrometer with a 3"x3" sodium iodide crystal. The unit contains also a multi channel analyser, high voltage supply, amplifier, GPS and a logger.
The backpack was calibrated for ^{137}Cs in relation to various soil samples taken in the alder forest, coniferous forest, inner and outer reed areas. "Backpack" measurements done in a circle of approximately 10 m around each sampling site were used for the calibration of the "backpack" and between 5 – 20 "backpack" spectrums were used at each area. The soil samples were measured by HPGe gamma-ray spectrometers at the FOI laboratory in Umeå. The calculated calibration factors were then used for all backpack measurements done in the separate areas.

Three replicate soil samples were taken in each area described above and the soil sampler had an area of 14.5 cm^2. Samples were taken down to 50 cm where possible and the samples were cut into the following sequence: 0-2.5, 2.5-7.5, 7.5-17.5, 17.5-37.5, 37.5-42.5, 42.5-47.5 and 47.5-50 cm. Vegetation samples were taken in an area of 250 cm^2 right above the soil samples.
All samples were dried, homogenised and measured in the FOI laboratory on a HPGe gamma spectrometer to 1000 counts or more in the ^{137}Cs peak, which gave a measurement uncertainty of 1 % or less.

^{90}Sr analysis was done in one soil profile at each sampling place. After the sample was measured on the HPGe gamma spectrometer, 3g (for soil) or 10g (for vegetation) of the sample was taken for the ^{90}Sr analysis.

Soil samples were dissolved by litiumborate fusion followed by dissolution in acid, and vegetation samples were dissolved by wet ashing. Strontium separations were done with extraction chromatography, with Eichrom´s Sr resin. After separation of Sr, the samples were set aside for ^{90}Y ingrowths (2 weeks). The Cerenkov radiation from ^{90}Y was then measured with a Quantulus 1220 scintillation counter (Nygren et al 2002).

The statistical error (S.D.) for the radio analytical measurements are in all cases less than 1% for ^{137}Cs and less than 5 % for ^{90}Sr except in one measurement in the spruce grove, where it was 12 %.

Results and discussion

The spatial variability of ^{137}Cs

The distribution of ^{137}Cs from the “backpack” measurements in the outlet area is shown in figure 1. A larger plot of the “backpack” results is presented in appendix 1. It is evident from the figures that the activity is higher in the alder forest and reed areas along the stream than in the surrounding coniferous forest.

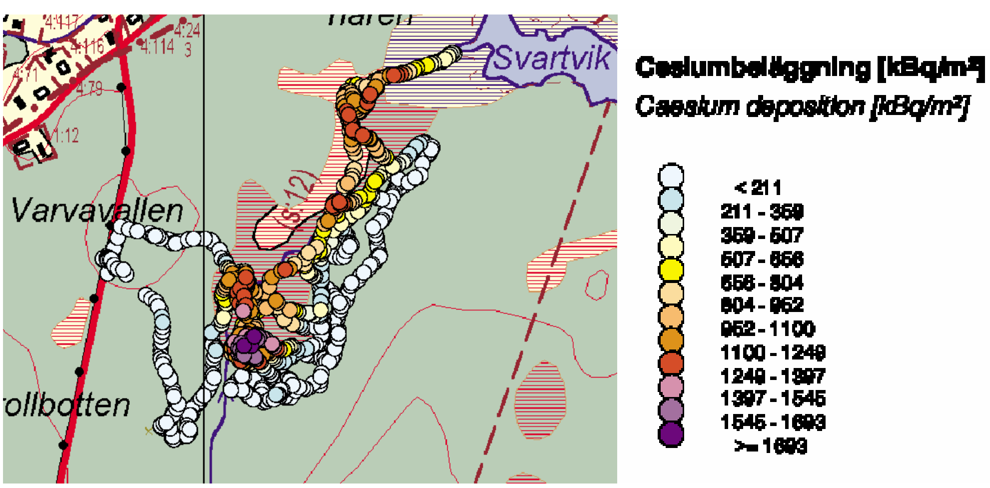


Figure 1. Map over the “backpack” measurements taken at the stream Verkmyrån. Green indicates the coniferous forest on mineral soil, alder forest (red lines) and reed areas (blue lines).

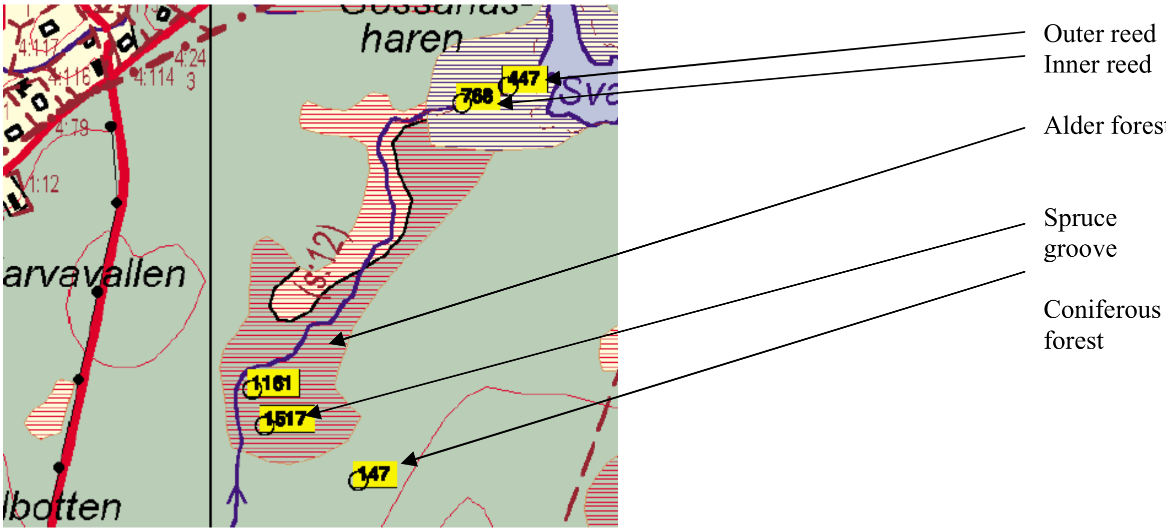


Figure 2. Map over the soil sampling sites. The numbers in the figure represents the measured activity in kBq/m^2.

This observation is also in agreement with the results from the soil samples (figure 2). The mean ^{137}Cs deposition calculated from backpack measurements and soil samples is higher in the alder forest, spruce grove and the reed (figure 3) than in the surrounding coniferous forest. Furthermore, among the areas with elevated activity the deposition seems to decrease towards the outer reed and sea (cf figure 1).

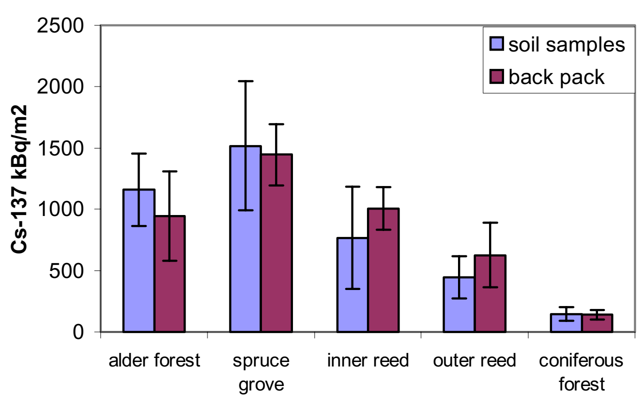


Figure 3. The average deposition of ^{137}Cs calculated from soil samples and “backpack” measurements. Error bars indicate S.D. (Cf. Appendix 2).

Vertical ^{137}Cs distribution in soil

Alder forest

The alder forest consists of mature alder trees and the ground vegetation of grass and herbaceous plants with a height of 50 to 150 cm. The vertical distribution of ^{137}Cs in the alder forest soil is shown in figure 4. There is a peak in the ^{137}Cs activity in the 2,5-7,5 cm slice in two of the profiles, but in the third profile this peak appears at 10 cm. ^{137}Cs could be seen down to the 37.5 – 42.5 cm layer(cf appendix 2).

Spruce grove

The spruce grove consists of about 5 – 10 spruces in the alder forest. Reconnaissance with a GM tube indicated a local elevation in dose rate in the grove compared to the surrounding alder forest. This was later verified with the backpack measurements, figure 1 and 2. The vertical distribution of ^{137}Cs shows the same pattern as in the alder forest, with a peak in the 2,5-7,5 cm slice but it seems as the ^{137}Cs has not migrated as deep here as in the alder forest. In the spruce grove the ^{137}Cs was detected down to 20 – 30 cm (figure 5).

Inner reed

In the inner reed area the ground consists of reed litter gradually moulded in deeper layers. The depth distribution of ^{137}Cs shows the same pattern as two of the profiles in the alder forest and all three profiles show a peak in the 2,5-7,5 cm slice (figure 6). Most of the activity is located in the first 10 - 15 cm and has the most superficial distribution of ^{137}Cs among the profiles.

Outer reed

The samples from the outer reed were taken as close to the sea as it was possible to walk. The ground was wetter and more porous than in the inner reed area. The litter carpet ended at about 10 to 20 cm depth followed by more or less dissolved organic matter in water and hence not possible to sample with the technique used. The depth distribution of ^{137}Cs shows a peak in the 2,5-7,5 cm slice in the profile which texture resembled those in the inner reed while ^{137}Cs in the other two profiles increased with depth (figure 7).

Mixed coniferous forest

The coniferous forest mainly consisted of Norway spruce that gradually exchanged to Scots pine in drier areas. Bilberry, half grasses and mosses dominated in the ground vegetation. A significant fraction of the mineral soil consisted of large stones which made soil sampling down to 40 cm impossible. Samples could only be taken down to 10 cm in the organic soil and the mineral soil fraction was not reached. The first slice, 0 – 2,5 cm consisted of litter, the second slice, 2.5 – 7.5 cm consisted of a mix of litter and humus and the third slice, 7.5 – 10 cm was more humified. The distribution of ^{137}Cs in the soil samples is shown in figure 8. As can be seen the three samples show three different distributions, and the ^{137}Cs peak that is shown in the other areas is absent in the 2,5-7,5 cm slice.

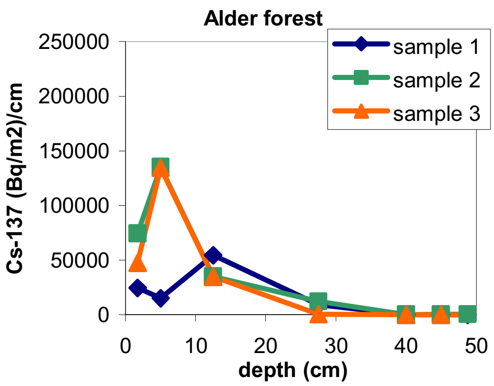


Figure 4. The vertical distribution of ^{137}Cs in the alder forest.

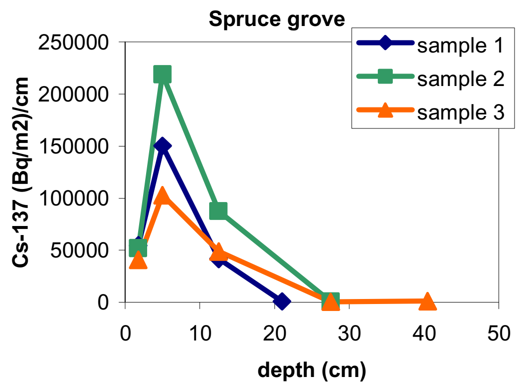


Figure 5. The vertical distribution of ^{137}Cs in the spruce grove.

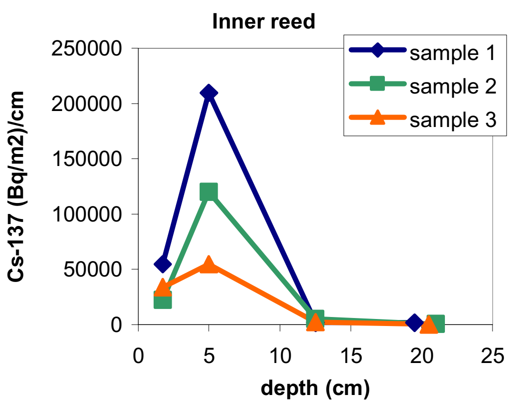


Figure 6. The vertical ^{137}Cs distribution in soil samples from the inner reed.

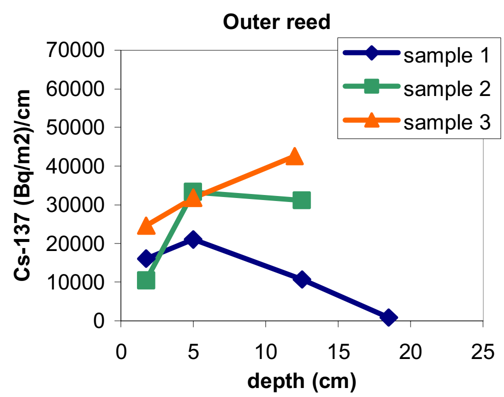


Figure 7. The vertical ^{137}Cs distribution in soil samples from the outer reed.

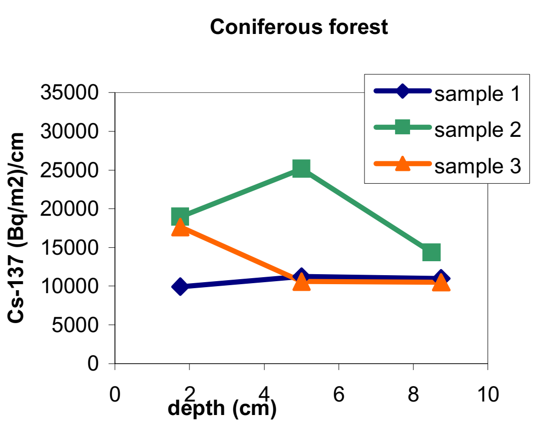


Figure 8. The ^{137}Cs vertical distribution in soil samples from the coniferous forest.

Vertical strontium-90 distribution in soil

One profile in each area was analyzed for ^{90}Sr. All areas show a peak in activity in the 2,5-7,5 cm slice (figure 9).

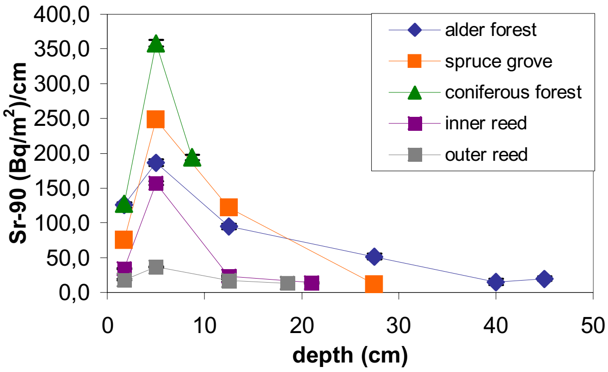
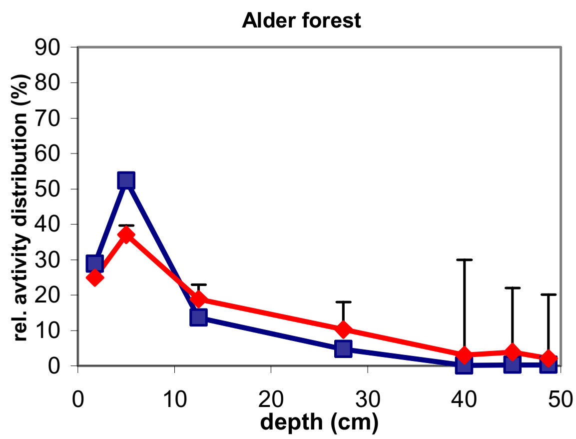


Figure 9. The ^{90}Sr distribution in the soil in individual cores from the five different areas. Note that the standard deviation is so small that it is hardly seen in the figure.

Figures 10 to 14, compare the relative depth distribution of ^{90}Sr and ^{137}Cs in the same soil profiles, in percentage of their total activity. The distribution of ^{90}Sr resembles the distribution of ^{137}Cs in the alder forest but ^{90}Sr is found further down in the soil than ^{137}Cs, even at a depth of 40 –50 cm there is still some ^{90}Sr activity. In contrast to the alder forest the depth distribution of ^{90}Sr in the spruce stand is more equal to that of ^{137}Cs (figure 11). As in all other cases there is a peak in relative activity in the 2,5-7,5 cm slice. The same pattern as in the alder forest is found in the inner reed (figure 12). Also in the outer reed there is a trend of relatively more ^{90}Sr than ^{137}Cs in deeper layers (figure 13). In the coniferous forest soil the depth distribution of ^{90}Sr and ^{137}Cs differs (figure 14). While the depth distribution of ^{90}Sr resembles that in the other areas ^{137}Cs increases with depth. Due to the soil texture with a high density of large stones the profiles all ended at stone surfaces. Deeper layers of soil that may have included ^{90}Sr and ^{137}Cs was not possible to sample. The results in this study show that ^{90}Sr and ^{137}Cs have distribution patterns in soil that resemble each other in most of the sampling sites. In the coniferous forest the patterns are not as clear as in the other areas.



10. The relative distributions of ^{90}Sr (red) and ^{137}Cs (blue) in the samples from the alder forest.

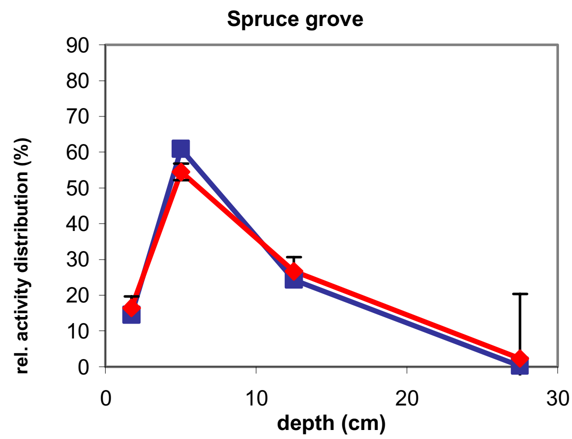


Figure 11. The relative distributions of ^{90}Sr (red) and ^{137}Cs (blue) in the samples from the spruce grove.

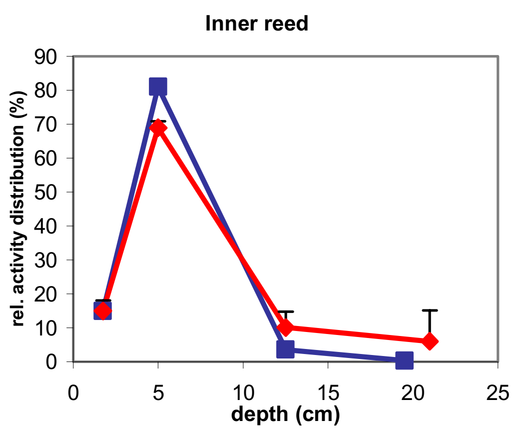


Figure 12. The relative distributions of ^{90}Sr (red) and ^{137}Cs(blue) in the samples from the inner reed.

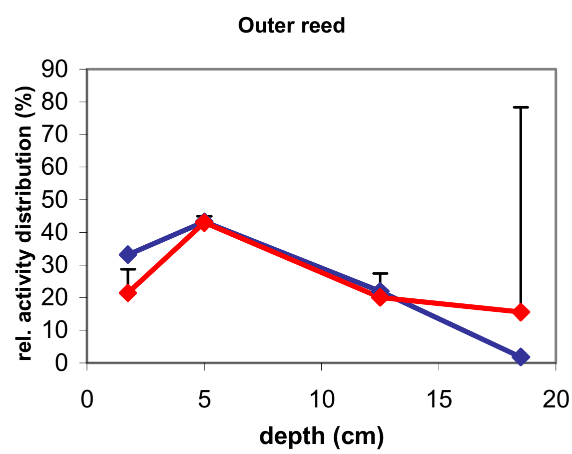


Figure 13. The relative distributions of ^{90}Sr (red) and ^{137}Cs (blue) in the samples from the outer reed.

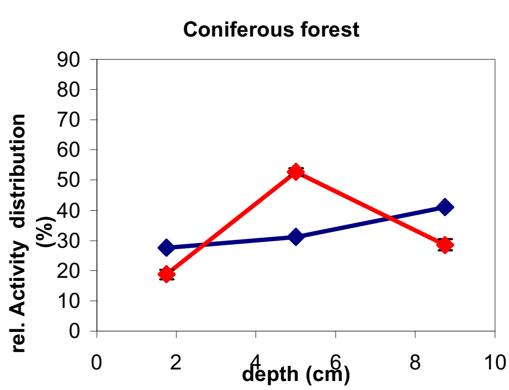


Figure 14. The relative distributions of ^{90}Sr (red) and ^{137}Cs (blue) in the samples from the coniferous forest.

$^{90}Sr/^{137}Cs$ ratios

Based on one soil profile in each area, the load of ^{90}Sr, lies between 0.3 – 3.4 kBq m^{-2} (table 1). As in the case for ^{137}Cs, the load of ^{90}Sr seems to be lower in the outer reed than in the inner reed. Given that only one sample per area has been analysed and hence no information is available on the spatial variability within the areas, no trend is observed in ^{90}Sr load between the coniferous forest and the alder forest and inner reed.

The measurements of ^{137}Cs in the soil samples suggest that the load in the coniferous forest was 150 kBq m^{-2} ± 50 kBq m^{-2} (n=3, Cf. Appendix 2). Since this area is elevated and not subject to flooding it was used as a reference area for ^{137}Cs and ^{90}Sr deposition (2.6 kBq m^{-2} ± 0.03 kBq m^{-2} n=1).

With a $^{90}Sr/^{137}Cs$ ratio of 0.01-0.03 in the Chernobyl fallout (*Moberg et al, 1991)*, the load of ^{90}Sr from Chernobyl should be somewhere between 1 and 3 kBq/m^2 based on a ^{137}Cs load of 150 kBq m^{-2} in year 2000. The $^{90}Sr/^{137}Cs$ ratio in the fallout from the nuclear weapons test was ca 0.6 (*Moberg et al, 1991).* The ^{90}Sr load from nuclear weapons tests should then be about 0,5 kBq m^{-2} (given that the nuclear weapons ^{137}Cs load was 1,2 kBq m^{-2} in year 2000) and hence the total deposition of ^{90}Sr should be about 1.5 – 3.5 kBq/m^2 in the area. The load of ^{90}Sr in all areas except the reed fall within this range. The outer reed shows a lower value for ^{90}Sr. The reed areas are more or less constantly saturated by water and have low soil densities and as a consequence it could be possible that ^{90}Sr may be more effectively "washed out". The ^{137}Cs activity was also lower in the reed than in the alder forest.

The calculated ratios between ^{90}Sr and ^{137}Cs in one soil profile per area are presented in table 1. Only the coniferous forest, that has the ratio 0.02, falls within the range 0.01-0.03 expected from the Chernobyl fallout (*Moberg et al, 1991)*, while the other areas as a result of the high load of ^{137}Cs show lower ratios.

Table 1. The ratio between ^{90}Sr and ^{137}Cs in the studied areas.

Area	**Ratio**[1] $^{90}Sr/^{137}Cs$	**S.D.** %	***^{90}Sr*** *kBq m^{-2}*	***S.D.***	***^{137}Cs*** *kBq m^{-2}*	***S.D.***
Alder forest	0.003	3	*3.4*	*0.1*	*1460*	*17*
Spruce grove	0.002	3	*2.9*	*0.07*	*2120*	*24*
Inner reed	0.002	3	*1.2*	*0.02*	*713*	*13*
Outer reed	0.001	7	*0.33*	*0.02*	*253*	*2.7*
Coniferous forest	0.02	2	*2.6*	*0.03*	*108*	*2.2*

[1] The ratios represent one soil profile in each area. *The individual loads in the profiles are indicated in Italian letters.*

The $^{90}Sr/^{137}Cs$ ratio in stream water draining the lake Hille catchment was between 0.3-0.4 in 1996 and at least one order of magnitude higher than the present results in soil (table 2).

The activity in water related to the measured load in soil ranges for ^{90}Sr between 0.002 – 0.004 and for cesium between 0.0001-0.0015 (Bq m^{-3}/Bq m^{-2}). The higher ratios for ^{90}Sr in stream water compared to the load in soil imply that ^{90}Sr is more effectively discharged than ^{137}Cs from the actual catchment (Saxén et al, 1998).

As a result of a higher content of ^{137}Cs in the lake than in the adjacent streams a lower ratio is observed but this ratio is still one order of magnitude higher than in the reed areas and alder forest exposed to flooding. Unfortunately no figures for the stream that drain the lake exist.

Table 2. Ratios for ^{90}Sr and ^{137}Cs measured in water from the lake "Hillesjön" and surrounding streams sampled in 1996. Figures within brackets represent the fraction (%) of activity that has a diameter less than 45 µm.

Area	**^{90}Sr Bq m^{-3}**	**^{137}Cs Bq m^{-3}**	**Ratio $^{90}Sr/^{137}Cs$**	**System**
Lake Hillesjön	8.3 (100)	230 (97)	0.04	Lake
Ängland	9.4 (100)	23 (87)	0.4	Stream into lake
Hille south	4.6 (100)	15 (100)	0.3	Stream into lake
Bladmyran	8.4 (100)	30 (100)	0.3	Stream into lake

If ^{137}Cs and ^{90}Sr are intercepted equally in the study area during flooding, then based on the ratio in the lake the present results imply that discharge from the lake during later years is not likely the cause for the high load of ^{137}Cs in the flooded areas. Given the same assumptions and that ^{90}Sr seems to be more mobile than ^{137}Cs, discharge from the surrounding hill slopes is also unlikely to be the origin for the high load of cesium in the alder forest and reed areas.

The high load of ^{137}Cs in the alder forest and the reed areas was most likely caused by flooding and an effective retention of ^{137}Cs. The retention of ^{90}Sr seems to be far less effective which could be result of a different chemical form of Sr than Cs i.e. ionic while Cs has a high affinity to particles. The high load of Ca expected in the flooded out stream areas would also lead to a lower retention of ^{90}Sr than ^{137}Cs. A sharp border in load of ^{137}Cs between the alder forest and the adjacent and topographically elevated coniferous forest determined by the backpack technique also supports the hypothesis above. The deposition in the coniferous forest is consistent with what is measured in other places around the coastal area. Hence it is likely that the accumulation in the alder forest and reed area must be due to redistribution from the lake "Hillesjön" via the stream Verkmyrån. The main contribution to the elevated values in the alder forest and reed areas should have occurred during the spring flood in 1986 when the intercepted fallout still was in the water phase of the lake. It is likely that the contribution during later years have been less significant. Larger fallout from air in this narrow area in the outlet from Verkmyrån is less likely to be the explanation.

The soil profiles show resemblance between the vertical distribution of ^{90}Sr and ^{137}Cs. Further more ^{90}Sr seems to have a tail of activity in the deeper slices that is not seen for ^{137}Cs. The observation can be interpreted as a higher vertical mobility for ^{90}Sr, which is in line with the higher relative discharge via stream water (table 1). This has also been seen in other studies. Studies of migration of ^{90}Sr and ^{137}Cs in undisturbed soils in Russia after the Chernobyl accident showed a similar vertical distribution of ^{90}Sr and ^{137}Cs as in the present study (*Knatko, 1996*). Soil samples from three different places were analysed six years after the

Chernobyl fallout and at all places the distribution pattern of ^{90}Sr and ^{137}Cs resembled each other with a somewhat higher degree of ^{137}Cs in the upper part of the soils.

The behaviour of ^{90}Sr and ^{137}Cs reported in this study imply that these two nuclides contribute in different ways, to the impact of fallout on this kind of ecosystem and should be subject for further studies. To get a better understanding of the long-term behaviour in the Hille catchment it would be useful to analyse ^{90}Sr in lake and estuary sediment, the stream that drains the lake and at greater soil depths in the alder forest.

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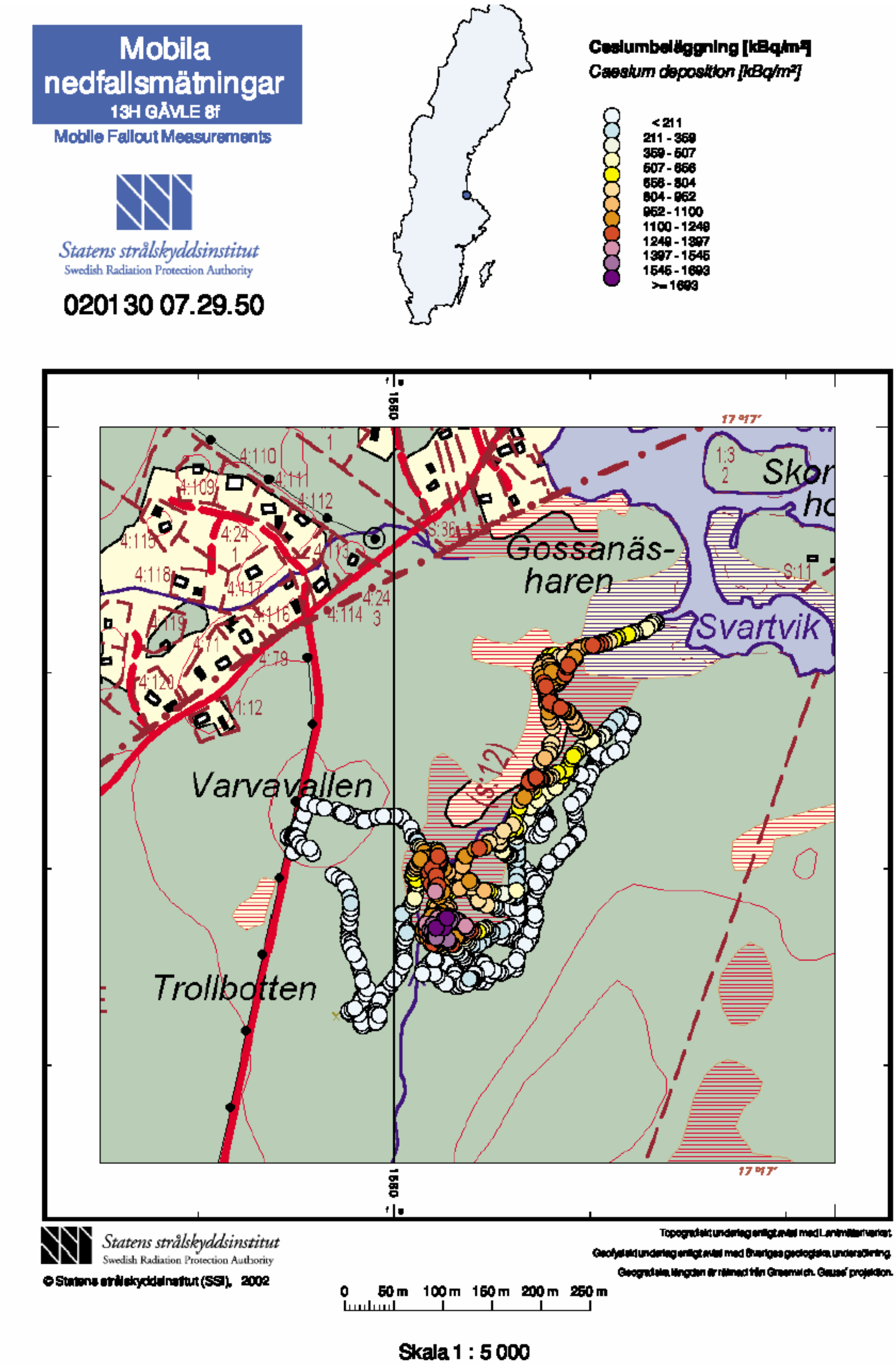
Appendix 1



Mobila nedfallsmätningar
13H GÄVLE 8f
Mobile Fallout Measurements
Statens strålskyddsinstitut
Swedish Radiation Protection Authority
020130 07.29.50
Cesiumbeläggning [kBq/m²]
Caesium deposition [kBq/m²]
< 211
211 - 359
359 - 507
507 - 656
656 - 804
804 - 952
952 - 1100
1100 - 1249
1249 - 1397
1397 - 1545
1545 - 1693
>= 1693
Gossanäs-
haren
Svartvik
Varvavallen
Trollbotten
17°17′
Statens strålskyddsinstitut
Swedish Radiation Protection Authority
© Statens strålskyddsinstitut (SSI), 2002
Topografiskt underlag enligt avtal med Lantmäteriverket.
Geofysiskt underlag enligt avtal med Sveriges geologiska undersökning.
Geografiska längden är räknad från Greenwich. Gauss' projektion.
0 50 m 100 m 150 m 200 m 250 m
Skala 1 : 5 000

Appendix 2

Table 1. Values for ^{137}Cs and ^{90}Sr in vegetation

	sample no	Cs-137 Bq/kg	Sr-90 Bq/kg
alder forest	1	824	
	2	810	9
	3	762	
spruce grove	1	1240	
	2	1345	7
	3	1106	
inner reed	1	885	
	2	802	9
	3	689	
outer reed	1	519	12
	2	459	
	3	556	
coniferous forest	1	7811	46
	2	6419	
	3	7221	

Table 2. Values for ^{137}Cs and ^{90}Sr in soil samples.

	sample 1 depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm	**sample 2** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm	Sr-90 Bq/m2	Sr-90 Bq/m2/cm	**sample 3** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm
alder forest	0-2.5	61493	24597	0-2.5	186152	74461	314	152	0-2.5	118920	47568
	2.5-7.5	75426	15085	2.5-7.5	675954	135191	933	144	2.5-7.5	671664	134333
	7.5-17.5	543303	54330	7.5-17.5	349989	34999	948	37	7.5-17.5	348498	34850
	17.5-37.5	188218	9411	17.5-37.5	244376	12219	1032	0	17.5-37.5	9136	457
	37.5-42.5	191	38	37.5-42.5	1704	341	75	0	37.5-42.5	105	21
	42.5-47.5	137	27	42.5-47.5	3404	681	98	0	42.5-47.5	-12	-2
	47.5-50	61	24	47.5-50	1510	604	27	-16	47.5-50	-1086	-435
total Bq/m2		868828			1463088		3427			1147224	

	sample 1 depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm	**sample 2** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm	Sr-90 Bq/m2	Sr-90 Bq/m2/cm	**sample 3** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm
spruce grove	0-2.5	136768	54707	0-2.5	129994	51998	188	75	0-2.5	102373	40949
	2.5-7.5	751724	150345	2.5-7.5	1094060	218812	1245	249	2.5-7.5	515148	103030
	7.5-17.5	416817	41682	7.5-17.5	876279	87628	1220	122	7.5-17.5	488850	48885
	17.5-24.5	6901	986	17.5-37.5	16404	820	214	11	17.5-37.5	10019	501
									37.5-43.5	7066	1178
total Bq/m2		1312210			2116738		2867			1123457	

Tablel 2 contd.

inner reed	**sample 1** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm	**sample 2** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm	Sr-90 Bq/m2	Sr-90 Bq/m2/cm	**sample 3** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm
	0-2.5	136617	54647	0-2.5	55494	22198	85	34	0-2.5	84532	33813
	2.5-7.5	1048710	209742	2.5-7.5	600953	120191	786	157	2.5-7.5	273409	54682
	7.5-17.5	17318	1732	7.5-17.5	53177	5318	230	23	7.5-17.5	22687	2269
	17.5-21.5	6448	1612	17.5-24.5	3724	532	96	14	17.5-23.5	1675	279
total Bq/m2		1209094			713349		1197			382304	

outer reed	**sample 1** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm	Sr-90 Bq/m2	Sr-90 Bq/m2/cm	**sample 2** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm	**sample 3** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm
	0-2.5	40253	16101	46	18	0-2.5	26063	10425	0-2.5	61572	24629
	2.5-7.5	105004	21001	85	17	2.5-7.5	166366	33273	2.5-7.5	159059	31812
	7.5-17.5	106457	10646	171	17	7.5-17.5	311521	31152	7.5-(16)	362111	42601
	17.5-19.5	1702	851	26	13						
total Bq/m2		253416		328			503951			582742	

coniferous forest	**sample 1** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm	Sr-90 Bq/m2	Sr-90 Bq/m2/cm	**sample 2** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm	**sample 3** depth (cm)	Cs-137 Bq/m2	Cs-137 Bq/m2/cm
	0-2.5	24840	9936	319	127	0-2.5	47378	18951	0-2.5	44122	17649
	2.5-7.5	56201	11240	1792	358	2.5-7.5	125681	25136	2.5-7.5	53049	10610
	7.5-10	27564	11026	485	194	7.5-9.5	35817	14327	7.5-10	26287	10515
total Bq/m2		108605		2595			208876			123457	