# The Russian-Swedish Tundra Radioecology Expedition 1994

Bertil R.R. Persson, Elis Holm, Kjell-Åke Carlsson, Dan Josefsson and Per Roos

*Radiation Physics Department, Lund University, S-221 85 Lund, Sweden*

## INTRODUCTION

The territory of the Russian Arctic and Sub Arctic includes three natural zones: polar deserts, tundra and forest-tundra. The north-eastern territories of Russia occupy 10 million $km^2$ with a population of about 11 million people. The current state of the environment in the Far North of Russia is being determined by economical use of its resources.

With physical-geographical and economical factors the Russian North can be divided into 6 meridian sectors. In the first sector, on the Kola peninsula, ecosystem cover is highly degraded, especially in western part. This area is very rich in metallic ores (nickel, copper, iron) and that caused the development of smelting industry. One more considerable source of pollution is apatite processing industry producing fertilisers. The demand for electricity led to construction of nuclear-, coal- and hydroelectric power-stations. This activity has resulted in an ecological disaster of the western part of the Kola Peninsula.

Concerning the East on northern plains of the European Russia good reindeer pastures and tribal lands of the Nenets people existed not long ago. Intensive geological search and well drilling of rich oil-deposits in the tundra east of the Kanin peninsula has brought the ecosystems to the brink of degradation. Further north to the south-east the Pechoorrsky coal basin is situated: Vorkuta coal mines supply the entire Siberian and European North with coal. In these region reindeer pastures are over grazed, trees on the northern border of forest and forest-tundra zones have been cut and therefore tundra spread southward 100-150 km.

The tundra of western Siberia relates to the third sector, Yamal-Nenets region. Here on the Yamal and Gydan peninsulas vast deposit of natural gas was found in the 1970s. The current state of environment in the North of W. Siberia can be described as close to crisis. Further exploitation of the area inevitably will make the situation worse as more northern, vulnerable ecosystems are met with.

Region 4 of the Russian North in central Siberia are located within the area of Tymyr peninsula. The latter is the northernmost continental bulk of land and has the biggest reindeer population in Russia. In the southern part of the region the black spot of Norilsk smelters is situated. Here is one of the world's richest deposits of nickel and copper. The extensive pollution emitted by the Norilsk enterprises is spreading to NE to the centre of the Taymyr peninsula.

Further to the East are the tundras of Yakutia and Chukota. These two regions have vast deposits of gold tin and other metal ores as well as brown coal fields. The regions have reindeer pasturing and are comparatively little damaged.

The main big rivers with outflow to the North are from west to east: Petjora, Ob, Jenisej, Lena, Indigirka, Kolmyra. The radio ecology program focus on the outflow of radio nuclides from these rivers and the effect of mixing with sea water. We will look for differences in the outflow of radio nuclides from these rivers and use this information to model the water flow and mixing processes.

**Table 1.**
**Expedition route and research sites of the "Tundra Ecology-94" expedition 1994.**

| Visiting date 1 | On return date 2 | Site No. | Name | Position |
|---|---|---|---|---|
| 06-04 | 09-08 | | Gothenburg | |
| 06-08>>09 | 09-02 | | Murmansk | |
| 06-10 | 08-31 | 1(27) | Kachkovsky Bay, Kola Peninsula | 67.30°N 41.00°E |
| 06 12>>13 | 08-29>>30 | 2(26) | North-eastern Kanin Peninsula | 68.15°N 6.00°E |
| 06-14>>15 | 08-26>>28 | 3(25) | Kolguyev Island | 69.15°N 50.00°E |
| 06-15>>16 | 08-25>>26 | 4(24) | Pechora Bay | 68.5°N 54.00°E |
| 06-17>>20 | 08-22>>08-23 | 5(23) | Western Yamal Peninsula | 70,45°N 67.00°E |
| 06-21>>22 | 08-20>>21 | 6 (22) | Belyi Island, Northern Yamal Peninsula | 73.00°N 70.00°E |
| 06-22>>23 | 08-18>>19 | | Dickson | |
| 06-23 | | 7 | Arctic Institute Islands | 75.00°N, 82.00°E |
| 06-24>>26 | 08-15>>17 | 8(21) | North West of Taymyr Peninsula | 76.00°N 94.00°E |
| 06-27>>28 | 08-13>>14 | 9(20) | Chelyuskin Peninsula | 77.20°N 102.00°E |
| 08-29>>30 | 08-10>>11 | 10(19) | North-east of Taymyr Peninsula | 76.00°N 112.00°E |
| 07-03>>05 | | | Khatanga rotation point 1 | 74.00°N 110.00°E |
| 07-05>>06 | | 11 | Olenekskiy Bay | 73.15°N 120.00°E |
| | 08-08>>08-08 | | Tiksi rotation point 2 | 74.00°N 110.00°E |
| | 08-03>>08-04 | 12 | Yana Delta | 71.30°N 136.00°E |
| 07-10>>11 | 07-31>>08-02 | 13 | New Siberian Islands | 75.00°N 140.00°E |
| 07-14>>15 | | 14 | Lopatka Peninsular, North-Western Indigirka | 71.45°N 149.00°E |
| 07-17>>18 | | 15 | North-east of Kolyma Delta | 71.45°N 158.00°E |
| 07-20>>21 | | 16 | Ayon Island | 69.50°N 168.00°E |
| 07-22>>26 | | 17 | | |
| | | | South-western Wrangels Island | 70.50°N 179.00°E |
| 07-25 | point of return | 18 | Kolyuchinskaya Bay | 67.00°N 173.45°E |

The development of nuclear technology power production results in creation of large quantities of radioactive waste (RAW) which is partly disposed in the Northern seas. The location of officially chosen areas for disposal of RAW are in the area of Barents sea and Kara sea (Novozemelskaya Depression, Sedova Bay, Novaya Zemlia). The largest number of disposals of low and medium active RAW was conducted in 1967 and 1988.

Among all the dumps of RAW in Northern seas the largest ecological dangers are presented by the items with spent nuclear fuel. Submarine sections with nuclear reactors have been dumped in the area about (72-74)°N (55-5)8°E that is close to the route of our expedition. (Adm. of Pres. of Russian Fed. 1993)

It is important to investigate the ecology of the antropogenic radio nuclides $^{137}Cs$, $^{90}Sr$, and $^{239,240}Pu$ in the Northern Sea to explain the origin from different sources. It has been shown from our earlier expedition on ODEN 1991 that the levels of $^{137}Cs$ are higher in the central Arctic Ocean than further south in Barents Sea. The question is if this is due to inflow from the Atlantic or is due to other origin.

It is also interesting to study the outflow of $^{90}Sr$ from the rivers along the Siberian coast to investigate if the permafrost enhances the run-off of radionuclides from tundra.

Study of anthropogenic radionuclides in the mixing zone between fresh and salt water at the different river systems along the Siberian coast is of particular interest. Previous investigations we have performed in collaboration with Russian and Norwegian scientists, in the Kara Sea show no accumulation of radionuclides in this area from the river Ob.

During the expedition we have also studied the variations in the cosmic $\mu^-$-meson radiation, gamma radiation level and UV-radiation at two wavelengths (365 and 296 nm). We have also a meteorological station with GPS that make recordings every 15 min.

## RESULTS

### Marine radioecology

After drying the cartridge filter for 1-2 days at 60 ° C the activity was measured on board with a NaI(Tl) scintillation spectrometer. In the laboratory in Lund the filters were ashed at low temperature amd measured with Ge-detector. The activity concentration in surface water varied from around 6 Bq/m$^3$ in the western regions (70°N, 0-80°E) and around 10 Bq/m$^3$ in the central parts (70°N,80-140°E) to around 2 Bq/m$^3$ in the most eastern parts (70°N,140-170°E). The activity concentration in the North Atlantic was around 7 - 9 Bq/m$^3$. More details on the results of measurements of Cs-137 on the Cu-ferrocyanate filters are presented in Figure 1 and Figure 2 for surface water and bottomwater measured on-board and in the laboratory at Lund respectively.

Sediments were taken at most stations and stored in plastic tubes for analysis at the laboratory in Lund. Preliminary measurements on a few samples does not indicate any extreme levels of $^{137}Cs$(below 20 mBq/kg).

### Terrestrial radioecology

Some of the tundra ground profiles have been measured and displayed in Figure 3. The surface activity concentration is around 20 Bq/kg and the maximum concentration of around 30 Bq/kg is found at some cm depth. Thus there is no fresh fallout present in these soils. The Cs-137 presents originate most probably from atmospheric nuclear tests during the 60th.

Several species of lemmings and vole have been whole body counted and the results are given in Table 1. To get as good statistics as possible several animals were put together in a Marinelli vial. The average activity concentration was around 7 Bq/kg for lemmings and Dicrostonyx was around 10 Bq/kg for Microtus oeconomus and gregalis.

Faeces from fox collected by Anders Angebjörn during leg 1. It was dried and then measured for Cs-137 and the rasults are given in Table 2. The level is much higher than in lemmings that is assumed to be an important food for the fox. The activity concentration was around 40 Bq/kg.

Caribou samples were received from the Russian and Swedish reindeer research groups. The results are given in Table 3. The activity level in the muscle tissues was in average 27.4 ### 2.5 Bq per kg fresh weight that is well below the limit of restrictions (300 Bq/kg in Sweden).There was no activity of Cs-134 recorded in the samples we measured on board. Preliminary results from measurements onboard. More caribou samples will be analysed in the future collaboration between the research teams.

**Acknowledgements**
We will thank the Swedish Polar secretariat for the experienced leadership and excellent logistic support. We will give a special honour to the oceanographic Russian crew on board without whom we would not have been able to take all the sediment samples. We are very grateful to all the Russian and Swedish expedition members who have supported us with biological samples for radio ecological investigations. Last but not least we thank all the generous sponsors who have supported the institute of radiation physics in Lund and the whole expedition.

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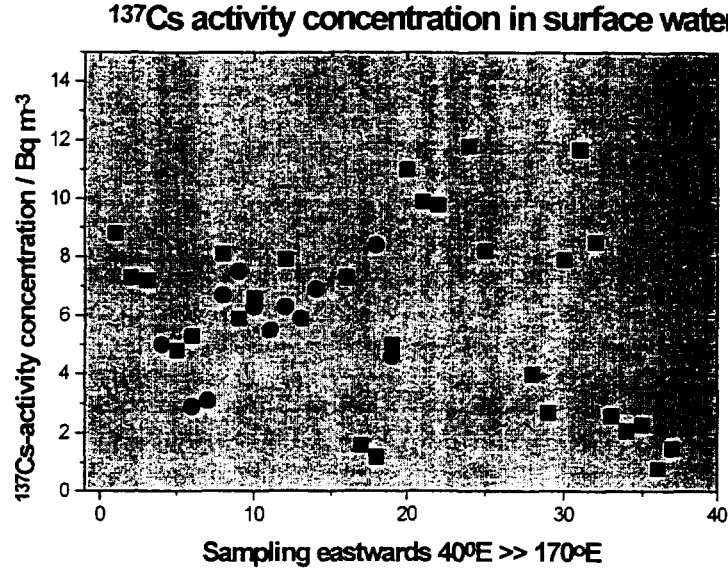


**Figure 1**

$^{137}$Cs- activity concentration in surface water sampled during Tundra-Radioecology expedition 1994-06-04 -- 09-08 along the siberian coast eastwards 40°E - 170°E. The circles indicate samples measured on-board with NaI-detector and the squares samples measured with Ge-detector in the laboratory at Lund after ashing the filters.

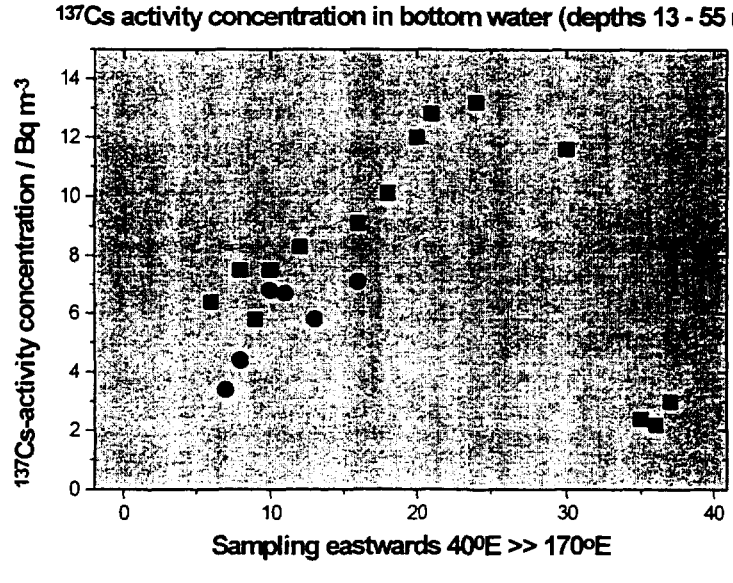


**Figure 2**

$^{137}$Cs- activity concentration in bottom water sampled during Tundra-Radioecology expedition 1994-06-04 -- 09-08 along the Siberian coast eastwards 40°E - 170°E The circles indicate samples measured on-board with NaI-detector and the squares samples measured with Ge-detector in the laboratory at Lund after ashing the filters.

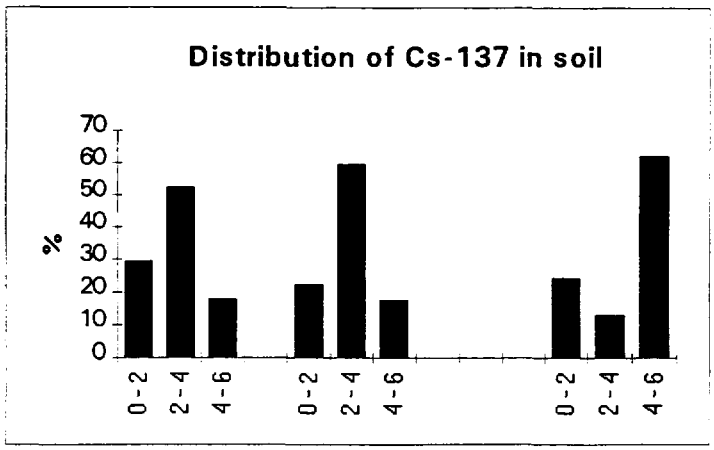


**Figure 3**
Percentage distribution of $^{137}Cs$ in different layer of ground samples at sites 2,3 and 4

**Table 1.**
Cs-137 activity concentration in various species of lemmings and vole.

| Species (no. of animals, weight g) | Site- date | Bq/kg | Average Bq/kg |
|---|---|---|---|
| Dicrostonyx torquatus (3, 183 g) | 5 - 19/6 | 6.3 | 6 |
| Microtus oeconomus (3, 177 g) | 2 - 12/6 | 9.8 | |
| Microtus gregalis (2, 104 g) | 5 - 19/6 | 9.3 | 10 |
| Lemmus sibiricus (3, 183 g) | 5 - 19/6 | 7.8 | |
| Lemmus sibiricus (5, 344 g) | 5 - 19/6 | 5,7 | 7 |
| Lemmus sibiricus (7, 350 g) | 8 - 25/6 | 8.5 | |
| Lemmus sibiricus (5, 292 g) | 8 - 26/6 | 8.3 | 8 |
| Lemmus sibiricus (15, 292 g) | 15 - 20/7 | 7.6 ±0.5 | |
| Lemmus sibiricus (5, 292 g) | 17 - 26/7 | 3.6±0.2 | 6 |
| Lemmus sibiricus (3) + Dicrostonyx torquatus (2) | 9 - 28/6 | 4.6 | 5 |

**Table 2**
Cs-137 activity concentration in fox faeces

| Date | Site | Weight | Bq/kg d.wt. |
|---|---|---|---|
| 13-June | 13 | 56 g d. wt. | 36 |
| 15-June | 15 | 75 g d. wt. | 41 |
| 29-June | 29 | 129 g d. wt. | 40 |

**Table 3**
$^{137}Cs$ activity concentration in caribou samples.

| Sample | | Site- date | Bq/kg | Remark |
|---|---|---|---|---|
| Muscle | 1225 g ww | 8 - 25/6 | 28 | |
| Liver | 39 g ww | 8 - 25/6 | 31 | |
| Kidney | 25 g ww | 8 - 25/6 | 77 | |
| | | | | |
| Muscle | 60 g ww | 26 - 30/8 | 46 | Average |
| Muscle | 40 g ww | 26 - 30/8 | 17 | site 26 |
| Muscle | 40 g ww | 26 - 30/8 | 11 | 24,7±0.6 Bq/k |
| | | | | |
| Muscle | 90 g ww | 22 - 23/8 | 35 | Average |
| Muscle | 110 g ww | 22 - 23/8 | 32 | site 22 |
| Muscle | 60 g ww | 22 - 23/8 | 22 | 29,7±0.7 Bq/k |