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Long-term consequences of potential radioactive contamination in Northern Norway and Murmansk oblast

The assessment of long-term effects of a hypothetical accident at the Kola NPP leads to a prediction of profound consequences in the Kola Peninsula and northernmost Norway. Previous work has shown that there will be no acute health effects for people living in Northern Norway, even in a worst case scenario accident. Even so, all population groups living in the area will receive ingestion doses exceeding 1 mSv the first year after the accident. Indigenous people, living off reindeer herding will receive ingestion doses up to 180 mSv the first year, and their ingestion dose will exceed 1 mSv the first 40 years if no countermeasures are implemented. The work reveals large regional differences in both transfer of radiocaesium from deposition to reindeer meat, as well as large differences in dietary habits among people living in the area.

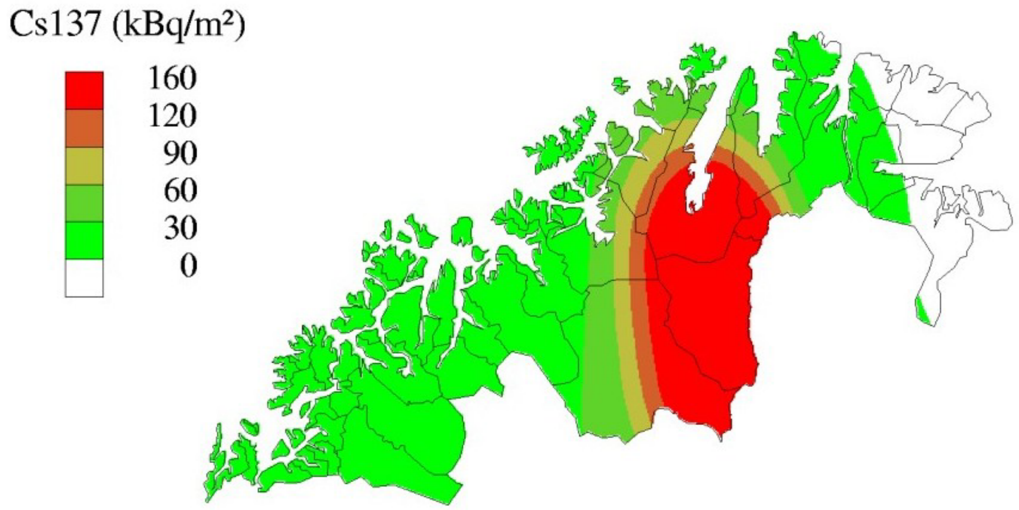

Figure 1.
A worst case scenario for deposition of radiocaesium in Northern Norway, based on wet deposition where all the released material is deposited within 72 hours after release. Each colour indicates a range in calculated radiocaesium deposition, from 0.1-30 kBq/m^2, 30.1-60 kBq/m^2 and so on.

If a severe accident was to occur in one of the Kola NPP reactors, the fallout pattern and level of contamination from the released radioactive material would depend on the specific characteristics of the release scenario and the prevailing weather conditions. In this assessment, two areas have been selected: The northernmost counties in Norway (Troms and Finnmark) and the Murmansk oblast in Russia. A worst case accident scenario described by Stokke (1997), with a maximum release of radioactivity to the atmosphere, was applied. This is listed as "worst" case release in Table 1.

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Table 1. Calculated releases of radionuclides under worst case and a more plausible scenario (Larsen et al. 1999).

	Inventory (PBq)	Fraction released (%)		Activity released (PBq)	
		Worst	Plausible	Worst	plausible
^{137}Cs	117	12	2.5	14.0	2.9
^{134}Cs	156	12	2.5	18.7	3.9
^{90}Sr	85	2	1	1.7	0.9

Rapid deposition close to the source

For Northern Norway, radionuclide deposition was calculated by the Norwegian meteorological institute (DNMI). The DNMI modelled the dispersion of radionuclides from the Kola NPP with weather conditions particularly unfavourable for Norway (Bartnicki and Saltbones 1997; Saltbones *et al.* 1997). A scenario with low precipitation along the transport route in combination with a wet deposition of the total release within 72 hours at the Finnmarksvidda plain (an area with extensive reindeer herding), produced the worst case scenario for Northern Norway (Figure 1).

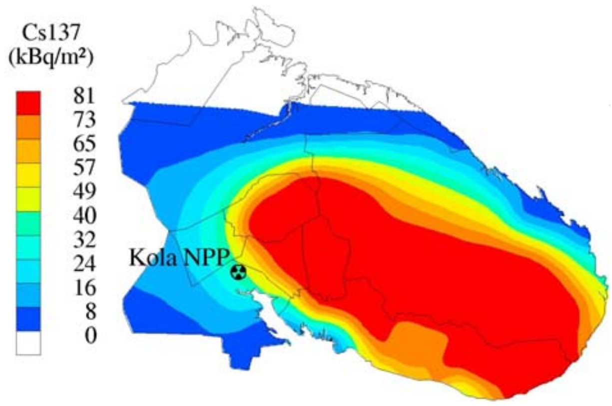

Figure 2. Worst case scenario for deposition of radiocaesium in the Murmansk region, calculated by DMI.

For the Murmansk oblast, the Danish meteoro-logical institute (DMI) provided a deposition scenario, predicting total deposition of radiocaesium 114 hours after a release from the Kola NPP. Thus, the conditions in this scenario are different from the Northern Norway scenario, and the resulting radiocaesium deposition is shown in Figure 2.

Radiocaesium and radiostrontium dominate the long-term consequences

In a short term, days and weeks after the hypothetical accident, the dominant radionuclides will be $^{132}Te/^{132}I$, ^{131}I, ^{103}Ru and $^{140}Ba/^{140}La$. After some time these short-lived radionuclides will decay and the contamination will be dominated by ^{137}Cs and ^{134}Cs (radiocaesium) and to a lesser extent ^{90}Sr (radiostrontium). Radiocaesium and radiostrontium have consequently been included in the long-term assessment, estimating the external and ingestion radiation doses to the population in the affected areas. Even in the short term, the doses will be well below levels where acute radiation damage is observed. Previous estimates show that a worst case scenario will produce an external dose of about 1 mSv the first week in the Kirkenes area, and radioiodine will be the most dominant contributor.

High transfer of long-lived radionuclides in some foodstuffs

Radionuclide transfer to food products is modelled, and the results show that activity levels in e.g. reindeer meat and mushrooms will be well above the intervention level for several decades if no appropriate countermeasures are implemented. Other food stuffs with high uptake of radiocaesium are sheep meat and berries, and for radiostrontium berries and potatoes.

There are substantial differences between the two Norwegian counties in food production characteristics. For most agricultural products, production in Troms is 2-5 fold higher than that for Finnmark. In addition, the soil types in Troms appears to give higher transfer of radiocaesium from soil to plants, due to the soil characteristics at the investigated sites. The reindeer production is 20 fold higher in Finnmark compared to Troms.

The ingestion dose is controlled by dietary habits

Major differences in dietary habits are found between reindeer herders, Norwegian average population and Murmansk average population. Whereas Norwegians consume on average 200 kg of dairy products per year, the Russians consume about ¼ of this. A Russian male reindeer herder consumes on average 110 kg of reindeer meat every year, a Norwegian reindeer herder consumes less, on average 70 kg per year (average for both male and female).

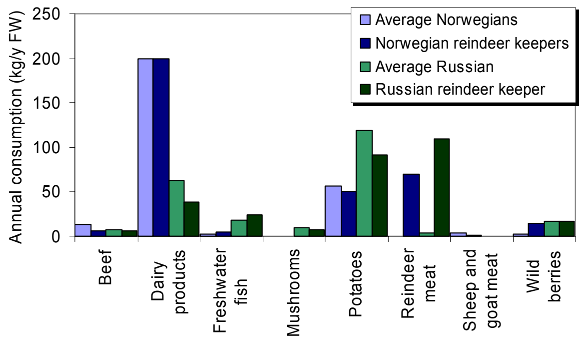

Figure 3. Comparison of dietary data for the different population groups.

The ingestion doses are dominating

The radiation doses to two population groups were considered in this assessment: the reindeer-herding populations and the average population groups in each country.

All foodstuffs consumed by these groups were assumed to be produced locally, and radiation doses and contamination of food products were predicted assuming that no mitigating actions were taken.

The highest individual external gamma doses occur in those areas receiving the highest deposition, but already during the first year, external doses are low compared to ingestion doses.

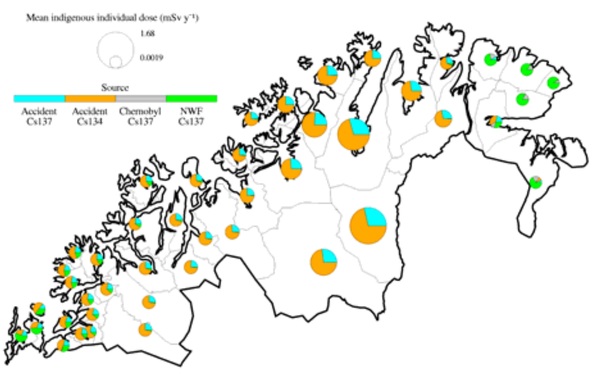

Figure 4. Annual individual external dose to reindeer herders in Troms and Finnmark one year after the accident.

Individual external gamma doses for reindeer herders are twice those of the other inhabitants, due to more time spent out-doors.

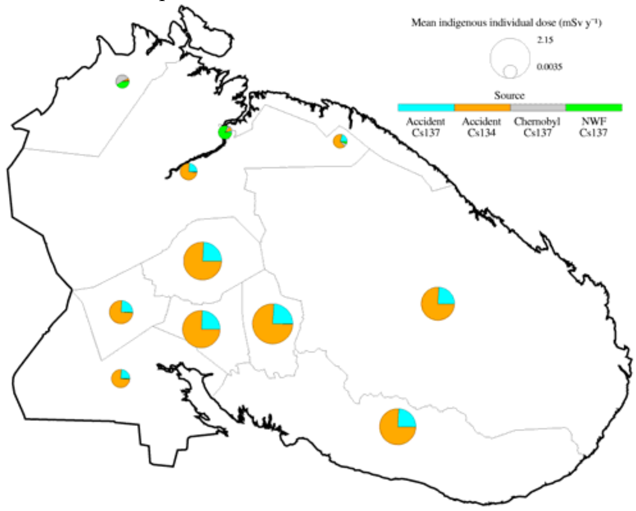

Figure 5. Annual individual external dose to reindeer herders in Murmansk county one year after the accident.

The annual ingestion doses for all population groups in the first year after deposition are predicted to exceed 1 mSv, and the maximum individual ingestion dose will be 300 mSv (reindeer herders in Murmansk oblast).

Annual individual radiocaesium ingestion doses for reindeer herders are significantly greater than those for the other inhabitants. In the first year after deposition, the most significant contributor to annual individual radiocaesium ingestion doses is reindeer meat for all population groups considered, except for the average Norwegian (Figure 6). For this group, reindeer meat, dairy products and sheep meat are the main contributors.

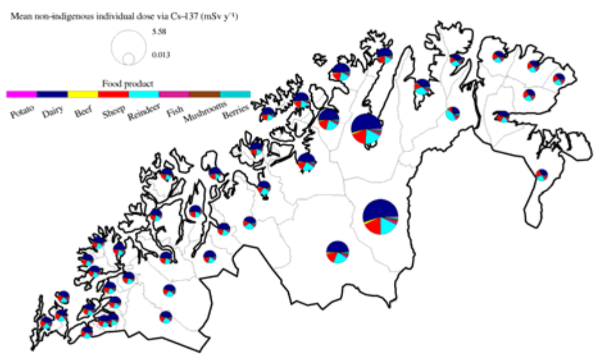

Figure 6. Annual individual ingestion dose to average population in Troms and Finnmark one year after the accident.

Potatoes and dairy products are the largest contributors to the annual individual radiostrontium ingestion doses. Berries are another important radiostrontium contributor to both Russian population groups, whilst reindeer meat is also a strontium source for Russian reindeer herders.

Under all accident scenarios, reindeer herder annual ingestion doses are predicted to exceed 1 mSv for at least 40 years after accident deposition (and are much higher in the first few years); for the other population group, ingestion doses exceed 1 mSv for about 4 years after accident deposition in Troms and Finnmark and about 10 years in the Murmansk oblast.

The location of communities and the type of production are important variables determining the radiological impact; if high deposition occurred in the major reindeer production areas (Finnmark in Norway and Lovozero in the Murmansk oblast) then the impact would be much higher than if deposition occurred in the areas where agricultural production dominated. Also, the timing of the deposition event is important, since dairy animals are housed for much of the year, radiological impact will increase if an accident occurred when animals were outside.

Under all scenarios considered, the results from this assessment clearly show the need for an effective emergency response and the application of countermeasures should an accident of this scale ever occur at the Kola NPP.

Figure 7. The Kola Nuclear Power Plant situated some hundred kilometres south of Murmansk.

Acknowledgement

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