Norway`s ongoing, long-term management of Chernobyl affected rural areas

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Abstract: Norway was the country outside the former Soviet Union that received most radioactive fallout from the Chernobyl accident. The deposition was over 100 kBq/m^2 for Cs-137 is the most affected area. In addition, the extended use of unimproved pastures in the food production system resulted in high activity concentrations in foodstuffs. The effective ecological half-times in the Norwegian terrestrial systems have proven longer than earlier anticipated, and the Norwegian authorities still impose countermeasures for livestock at a large scale, even 18 years after the accident. We envisage the need for countermeasures for at least another decade to produce milk and meat that comply with food intervention limits. Specific measures, e.g. dietary advice and whole body counting, are used for the most vulnerable population groups.
This talk presents the on-going management of contaminated areas in Norway and topics such as activity concentration levels, countermeasures used, compliance with regulations and financial issues are discussed.

1 BACKGROUND

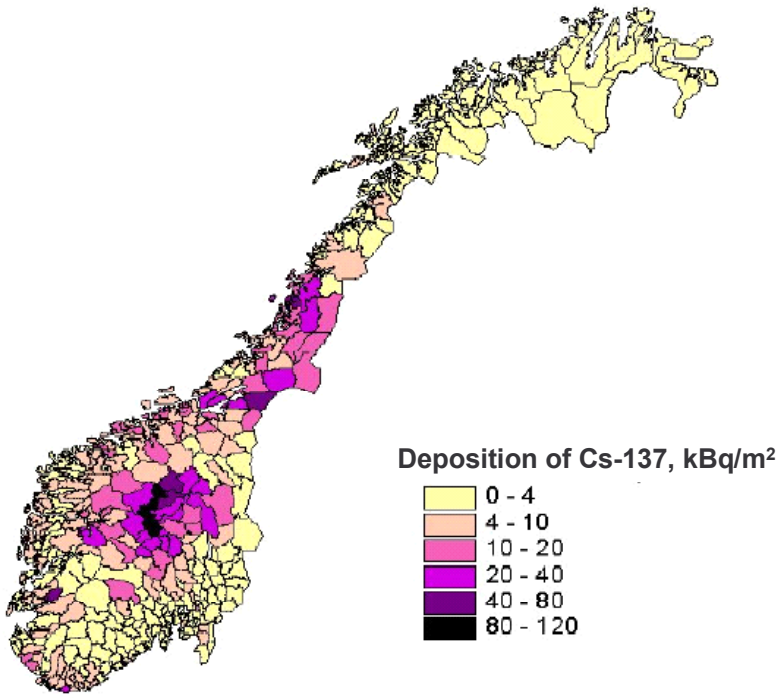
The deposition of Cs-137 in 1986 ranged from about 2 to over 100 kBq/m2 in various parts of Norway. The deposition pattern is shown in Figure 1. The areas with highest contamination coincide with production areas for milk and meat where unimproved pasture is an important food source for grazing animals during summertime. The production of cow's milk, goat's milk and lamb meat was thus heavily affected. The production of reindeer meat was particularly affected since these semi-domesticated animals graze on unimproved pastures all year round with a substantial portion of their diet being lichen.
After a period of denial of the problem, followed by a period of confusion concerning actual contamination levels and contradicting experts` opinions, a management system was implemented from August 1986. The importance of a decentralised approached soon became evident, both concerning regional authorities and the involvement of local producers, manufacturers and the public. This approach was essential for the practical management as well as for the public trust and complience.
To comply with food intervention levels, an extensive countermeasure regime was thus established in autumn 1986. This regime was refined the following years and is still in place in 2004. The effective ecological half-times in the Norwegian terrestrial foodchains are substantially longer than earlier anticipated and we foresee the need for implementing countermeasures for yet another decade.

2 FOOD INTERVENTION LEVELS

The food intervention levels for Cs-137 were set to 370 Bq/kg for milk and infant food and 600 Bq/kg for all other foodstuffs in 1986. It soon became evident that the contamination in reindeer meat was way above this and that it would be impossible to comply with 600 Bq/kg

even if countermeasures were implemented. The level was thus raised to 6000 Bq/kg for reindeer meat in November 1986. The decision was based on the fact that Norwegians in general consume very little reindeer meat per year and that there was a political will to maintain the original way of life of the Sami indigineous people.
The level was lowered to 3000 Bq/kg in 1994 following the natural decrease in contamination levels. The food intervention levels today are thus 370 Bq/kg for milk and infant food, 600 Bq/kg for other basic foodstuffs and 3000 Bq/kg for reindeer meat, game and wild freshwater fish.

Figure 1: Deposition of Cs-137 in Norway in 1986



3 MONITORING PROGRAMME

An extensive monitoring programme is in place to ensure that food sold in the stores are below the food intervention levels and that producers comply with the countermeasure regime imposed. The programme comprises the following:

- Milk and dairy produce is sampled in dairies all year round
- Milk is sampled for selected herds during summer grazing
- Live animals are measured during summer time and prior to slaughter
- Meat is sampled randomly in slaughterhouses
- Food basket survey - 7 foodstuffs sampled in autumn every year in about 100 stores
- Whole body counting (WBC) is performed every three years for the Sami population

4 ACTIVITY CONCENTRATION LEVELS TODAY

4.1 Milk

Dairy cow's milk is sampled every month during grazing season and every two months in winter time. In 2003, the country average activity concentration was 2 Bq/L and the highest value 14 Bq/L. For goat's milk the values were 16 Bq/L and 54 Bq/L, respectively. The low averge values reflect that only part of the dairy herds in Norway were affected by the Chernobyl fallout and that many affected herds still use countermeasures to reduce the activity concentration in milk.
To follow the long term trend if no countermeasures are implemented, some herds in moderately to highly contaminated areas are omitted from the countermeasure regime. Results from these herds show substantially higher activity concentrations for Cs-137. The highest results are around or above the intervention level of 370 Bq/L for milk. Table 1 summarizes some of the highest results from the monitoring programme for these herds in summer 2004. The results for goat's milk are higher than for cow's milk, since the transfer of radiocaesium to meat and milk is higher for small ruminants than for larger ones.

Table 1: Results for Cs-137 in milk from dairy herds where no countermeasures are implemented. The samples are taken in Valdres, the most contaminated area in Norway, during summer grazing 2004.

Sample	Highest result (Bq/L)*
Milk from goat herd	475
Milk from dairy cow herd	276
Milk from single cow	394

* The measurement uncertainty is 10 %

4.2 Meat

Areas with meat production are every autumn divided into intervention zones and non-intervention zones according to results from measurements on live animals. Animals in the intervention zones are imposed a period of countermeasures before slaughter to comply with the food intervention levels.
Meat is therefore randomly sampled in all slaughterhouses - 1% of carcasses from intervention zones and 0.1% from other areas. Results are presented in Table 2. Both average values and geometric means are below the intervention limits, but some maximum values are registered above the limit. The fraction of samples above the limit are usually within a few percent of the total, which is not alarming.

Table 2: Results* from random sampling in slaughterhouses in 2003

	Number of samples	Average	Geometric mean	Max	Min	Std.dev.
		Bq/kg	Bq/kg	Bq/kg	Bq/kg	Bq/kg
Sheep	**1428**					
intervention zones	169	246	139	1600	<10	269
other zones	1259	144	64	2450	<10	232
Beef	**314**					
intervention zones	171	27	15	288	<10	39
other zones	314	21	10	613	<10	46
Reindeer	**92**					
intervention zones	26	2120	2104	3686	613	n/a
other zones	92	630	515	1992	21	497

* The measurement uncertainty is 10 %

4.3 Food basket survey

Results from the food basket survey is presented in Table 3. Both average values and the highest values are generally below the food intervention levels. This proves that the countermeasure regime is working satisactorily. The activity concentrations in the food basket survey corresponds to an estimated individual internal dose of 0.02 mSv/y from ingested radiocaesium for an average Norwegian.

Table 3: Results* from the food basket survey in 2003

Food stuff	Number of samples	Average	Geometric mean	Max	Min	Std.dev.
		Bq/kg	Bq/kg	Bq/kg	Bq/kg	Bq/kg
Beef	87	15	10	100	<10	13
Lamb	95	77	47	350	<10	82
Brown whey cheese	97	74	50	380	<10	65
Wild mushrooms	n/a	n/a	10	470	<10	n/a
Honey	97	185	176	513	<10	133
Game	79	113	51	2208	<10	271
Reindeer	87	578	232	3192	<10	783

* The measurement uncertainty is 10 %

4.4 Whole body counting

The dietary preferences of the Sami population make them more vulnerable to radiocaesium contamination than other Norwegian population groups. WBC is thus performed for two Sami groups every three years. The monitoring for the group in northern Norway was started in 1965 due to the global fallout, while the group in Mid-Norway was included in 1986. The results from this monitoring are presented in Figure 2. In northern Norway the average values for Cs-137 are approximately 20 Bq/kg for both men and women. In Mid-Norway, the results for men are 175 Bq/kg on average, with 430 Bq/kg as the highest single value. For women the results are 100 Bq/kg and 210 Bq/kg, respectively.

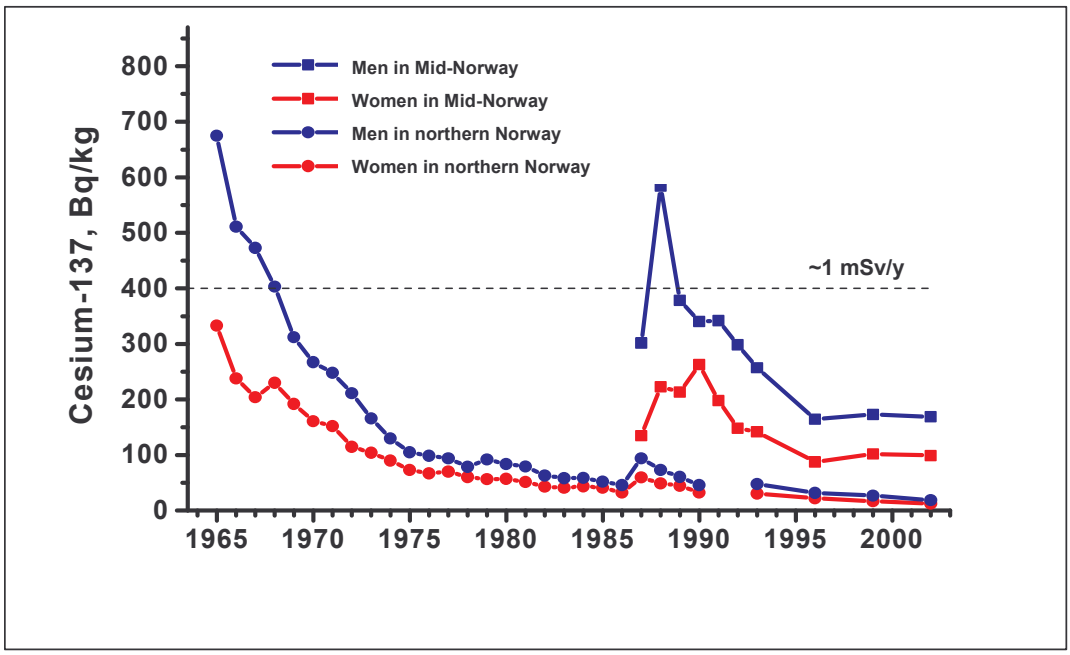


Figure 2: Whole body content of Cs-137 in reindeer herders up to 2002

5 COUNTERMEASURES USED TODAY

In the agricultural sector, three main countermeasures are still in use today. These are:

1. Prussian Blue as an additive in concentrates, saltlicks and boli
2. Clean feeding combined with live monitoring of animals prior to slaughter
3. Autumn slaughter of reindeer instead of winter slaughter

Tens of thousands of animals are still subject to these countermeasures every year.

For the public, dietary advice and WBC is used.

5.1 Prussian Blue

Prussian Blue has an effectiveness of 50-85% in reducing the contamination levels in meat and milk according to distribution method. This is still widely in use for sheep, beef cattle, dairy cows and dairy goats.

5.2 Clean feeding / live monitoring

After live monitoring of animals, the ones with activity concentrations above the food intervention levels are imposed a period of clean feeding according to the biological half-time for radiocaesium. This half-time is 21 days for sheep and 16 days for reindeer. Every year, around 40-50 000 sheep undergo clean feeding prior to slaughter to comply with food intervention levels. Clean feeding is also used for reindeer but at a lesser extent.

5.3 Autumn slaughter of reindeer instead of winter slaughter

Reindeer have a pronounced seasonal variation in radiocaesium levels, being highest in winter time due to lichen as the almost exclusive dietary component in winter. The contamination levels in meat can be up to 85% lower in autumn than in winter since green plants are much less contaminated than lichen (the winter diet). This effectiveness seems to be reducing with time due to the influence of mushrooms on the autumn values. The effective ecological half-times are longer for mushrooms than for lichen, which reduces the difference in autumn and winter values over time.

5.4 Dietary advice / WBC

For the public, dietary advice is used. General dietary advice is given by the Norwegian Food Safety Authority relating consumption frequency and activity concentration, focusing particularly on self gathered food like mushrooms, freshwater fish, reindeer meat and game. The public can get their food samples measured for free at local food control stations. Advice is also given on food preparation methods that reduce the radiocaesium content in prepared food.

For the Sami population both dietary advice, compensation and WBC are used as countermeasures. WBC is offered to the Sami every three years, as already mentionned. They are also adviced to do measures to reduce the contamination levels in reindeer meat for their household consumption to below 600 Bq/kg. Reindeer herders are compensated by the Ministry of Agriculture if their reindeer have activity concentrations above 600 Bq/kg before measures are implemented (250 € per person in the household per year and an extra

125 € per person if above 3000 Bq/kg). This money can be used to clean feed animals, buy reindeer meat from less contaminated areas or buy other kinds of meat.

6 MANAGEMENT AND FINANCIAL ISSUES

The agricultural countermeasures and food stuff monitoring are managed and payed for by the Ministry of Agriculture and Food. The regional management is performed by the Ministry's regional or local offices for Reindeer Administration and for Food Safety Authority. The producers and herders are payed compensation by the Ministry of Agriculture and Food for extra work related to the implementation of countermeasures and losses incurred due to the contamination situation. The total costs today are around 1.8 million € annualy for monitoring, countermeasures and compensations.
The NRPA has responsibility for technical assistance and training of the people who measure radioactivity in foodstuffs and live animals. NRPA also has a role as a general advisor for issues related to radioactivity and radiation protection, like dose limits, dietary advice and measurement techniques. The WBC programme is performed by NRPA. The employees at NRPA are payed by the Ministry of Health and Care Services.

7 PUBLIC COMPLIANCE AND VIEWS

For agricultural producers, the countermeasure regime has become part of daily practice. The monitoring programme shows that they generally comply with the imposed actions. The size of the compensations are discussed from time to time. The farmers are concerned about the long duration of this problem and would like to see the countermeasures soon being redundant.
The reindeer herders are less content with the situation due to their close spiritual and physical contact with the nature and the animals. Their most important food source is the most contaminated foodstuff in Norway and they are in general concerned about health and the long term duration of the problem. When the frequency of WBC was reduced from every year to every three years, some felt abandoned by the authorities. They would like to see the frequency augmented. Even so, others choose not to comply with the dietary advice given and/or not to participate in WBC.
There are articles on monitoring results and countermeasure regimes in local newspapers every year, occasionally in national newspapers. The articles are generally describing the situation and expressing the concern of the long term duration of this, but with no exaggerated fear. It also seems like the public in general is not very concerned about the radioactivity in foodstuffs sold in the store. People in affected areas with a portion of self-gathered foodstuffs (mushroom, game, reindeer) in their diet are more concerned. Some of them use the opportunity to measure their food at local food control stations before consumption.

8 CONCLUSION

The contamination levels in some parts of Norway still justify the use of countermeasures. The system for monitoring and countermeasure implementation is working satisfactorily and the management of radioactivity in the food chain has become part of daily practice. A decentralised management practice has proven vital to the success and the importance of local involvement must be underlined. The long term consequences are much longer than earlier anticipated, and we still cannot say when the countermeasures will be redundant – this concern is shared by producers, the public and the authorities.