Session A, Track 2: Lessons Learned from Chernobyl I

Wednesday, September 9, 1998
10:45 a.m. - 12:35 p.m.

Chair. Thomas McKenna, United States Nuclear Regulatory Commission

Consequences of the Chernobyl Accident and Emergency Preparedness in Norway

Ole Harbitz, Lavrans Skuterud and Per Strand

Norwegian Radiation Protection Authority, Norway

INTRODUCTION

Heavy precipitation from the air masses during the critical days after the Chernobyl accident led to wet deposition of considerable amounts of radioactive fallout in Norway. It was estimated that 6% of the total released radioactive material was deposited in Norway (Backe et al. 1987). Due to highly unusual meteorological conditions, these deposits concentrated in some sparsely populated regions in southern and mid-Norway, while densely populated areas received less fallout. The mountainous and forest areas with large amounts of fallout (in spots, up to 600 kBq m-2 of radiocesium) are important production areas for certain animal products.

The most severely contaminated foodstuffs were produced in semi-natural ecosystems. These included meat from sheep, reindeer, game and cattle (to some extent), and milk from goats and cattle. Radiocesium levels up to 150 kBq kg-1 in reindeer meat and 40 kBq kg-1 in sheep were observed. Freshwater fish also showed high radioactivity levels (up to 35 kBq kg-1).

DISCUSSION

In June 1986, the Norwegian Directorate of Health imposed intervention radioactivity levels for the nuclides ^{137}Cs and ^{134}Cs. The intervention levels were 370 Bq kg-1 for milk and baby food, and 600 Bq kg-1 for all other foodstuffs. To maintain reindeer breeding in Norway and to reduce the social effects for the Sami reindeer breeders, it was necessary to consider a higher intervention level for reindeer meat. In November 1986, the intervention level for reindeer was increased to 6000 Bq kg-1 and in July 1987, the level for wild freshwater fish and game was also increased to 6000 Bq kg-1.

Dietary advice was given to the parts of the population consuming high amounts of reindeer meat or freshwater fish. This advice was published by the health authorities as a brochure in 1986, and gave guidance as to how often people could eat the most affected foodstuffs, depending on their activity levels (kg of meat or fish per year and as meals per week). The brochure also included some examples regarding how to prepare food to reduce the radiocesium content. The main goal of the dietary advice was that nobody should have an intake of radiocaesium exceeding 400 kBq the first year after the Chernobyl accident and exceeding 80 kBq y-1 during the subsequent years.

In 1986 about 35% of all lambs were contaminated at levels above the intervention level at the normal time of slaughter. Between 1986 and 1997 the proportion has varied between 30% and 5% of the total livestock. In 1997 about 10% of all lamb and mutton, and 27% of reindeer had activity levels above the intervention levels. Thus a persistent need for pre-slaughter countermeasures is existing. After 1986, countermeasures have been very successful in reducing the amount of meat declared as unfit for human consumption to a negligible fraction. Cesium binders (Prussian Blue - AFCF) in salt lick, boli and mixed in concentrate, and special feeding of lamb and sheep are the extensively used countermeasures. During the period 1986-1994 a total of 1,566,000 lamb and sheep have been involved in special feeding programs; 320,000 of these in 1986. Compensation paid to the farmers for their additional workload amounts to a total of 23 mill USD for the whole period.

The human population was subject to irradiation from three sources after the fallout; external radiation from deposited radionuclides, inhalation of radionuclides from the air and ingestion of radionuclides through foodstuffs. Figure 1 shows the monthly doses from intake of food together with the monthly doses from external doses due to the fallout on the ground. The first few months after the accident, the external exposure was the major contributor to dose. After this period the exposure from contaminated foodstuffs was the major contributor. However, the prognoses for the coming 50 years is that the external exposure again will be the major contributor. The total individual dose over 50 years will in average be in the order of 2 mSv, giving a collective dose over 50 years to the Norwegian population (4 million people) in the order of 8000 manSv. There are however groups of the population with special dietary preferences receiving significantly higher doses than the average: The reindeer herding Samis, but also persons with higher consumption of game than the average. Among these groups, dietary advices have been very efficient in reducing doses. While the average total dose received during 50 years have been estimated to 20 mSv to these groups, it could have been 5-10 times higher if no advices were given.

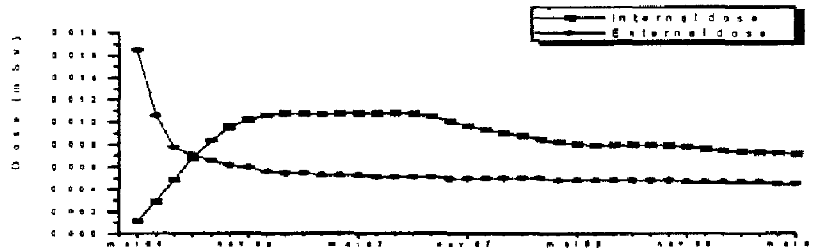

Figure 1 Average monthly doses from the Chernobyl fallout to the Norwegian population (Strand 1994).

Countermeasures and Cost-benefit Analysis

Six types of countermeasures have been introduced in Norway to reduce radiation doses following the Chernobyl accident: Interdiction of food, special feeding, fertilization of natural pasture, use of cesium binders in animals, changing diet and changing the slaughtering time for reindeer and sheep. Countermeasures considered, but not implemented, were relocation of animals to uncontaminated areas and restrictions on some agricultural production in contaminated areas. The monetary cost of averted radiation dose (in units of manSv) has been considered. It is assumed that the relationship between dose and effect is linear. The cost of detriment is therefore equated with the collective dose multiplied by α. The α value is dependent on society's willingness to save a statistical life. The willingness is compared with other risks faced by society. Currently, in the Nordic countries, an 'α' value of 100,000 USD per manSv is recommended. Countermeasures with a cost of averted dose below this value are justified, and this was the fact for almost all countermeasures introduced in Norway after the Chernobyl accident (Table l). Thus, from a radiation protection point of view the implementation of countermeasures in Norway after the Chernobyl accident was justified. The countermeasures implemented reduced the doses and the potential health risk. This, together with social and economical considerations established the basis for the mitigation strategy in the aftermath of the Chernobyl accident.

Table 1. Cost of countermeasures in terms of man.Sv saved (Strand 1994).

Countermeasure	USD man.Sv-1
Interdiction of sheep	170,000
Interdiction of reindeer	57,000
Special feeding	42,000
Change of slaughter time	16,000
Giese salt (AFCF) concentrate	170
Dietary advice, 1987	6

The cost effectiveness of different countermeasures varied considerably in Norway (Table 1). However, this simple cost-benefit analysis does not show the total cost for society. The economic losses for agriculture could have become considerable due to the population's decisions to avoid contaminated food. Immediately after the accident the situation was not clear due to insufficient knowledge of the fallout and its consequences. In Norway, as in several other European countries, the health authorities introduced intervention levels at an early stage after the accident. There was little room for optimization in the situation. Later, after some rationalization, a clearer radiological protection philosophy was introduced.

Ideally, a countermeasures contingency program should have been drawn up in preparation for an accident so that correct decisions could have been made promptly and correctly. In the event, the countermeasures applied were carefully monitored and a more or less optimum situation was achieved. In retrospect, it was shown that most of the countermeasures employed were justified. The maintenance of confidence in the foodstuffs on the market is extremely important when considering the social costs to society. Thus, it is necessary to compare more than just the costs of the countermeasures as such and the averted dose, when estimating the total societal costs.

A decrease in the sale of some agricultural produce represented a potential economic loss considerably higher than the cost of the implemented countermeasures. Not all the countermeasures would have had the desired effect in satisfying the consumers. The implementation of intervention levels was of great importance in this respect. It resulted in an active implementation of countermeasures in agriculture and only in some limited use of dietary advice to critical groups.

The use of dietary advice alone instead of special feeding would perhaps have given the same adverted dose at a lower direct monetary cost. However, the special feeding program led to activity levels in food below the intervention levels and no active involvement by the consumers was called for. The combination of the different countermeasures took this into consideration and hopefully gave the maximum reduction of the total negative consequences. A decrease in consumption of some of the most affected foodstuffs (e.g. lamb) occurred. The decrease in consumption of lamb was about 5 to 10% in the first years. This represented a loss of about $8 to $15 million USD for the producers. On the other hand, if no countermeasures except interdiction had been used, and intervention levels were maintained, the costs would have been about $15 to 60 million USD each year. Without countermeasures, lost sales of lamb could have been considerable.

CONCLUSION

From the discussion above one may conclude that the measures introduced to protect the population from negative health consequences of the Chernobyl accident were relatively extensive and resource demanding. Their main purpose was to reduce the physical health effects by reducing radiation dose. The dose was reduced and the relationship between cost and reduced dose was acceptable. Without the implementation of countermeasures the agricultural community could probably have suffered much greater losses through an extensive decline in the sales of the sensitive foodstuffs (e.g. lamb and reindeer meat).

REFERENCES

Per Strand (1994): Radioactive fallout in Norway from the Chernobyl accident. Studies on the behaviour of radiocaesium in the environment and possible health impacts. NRPA Report 1994:2, Norwegian Radiation Protection Authority, Østerås, Norway.