# RADIOACTIVE CONTAMINATION IN THE ARCTIC — PRESENT SITUATION AND FUTURE CHALLENGES

P. STRAND
Norwegian Radiation Protection Authority, Osteras, Norway

***Abstract***

*There is currently a focus on radioactivity and the Arctic region. The reason for this is the high number of nuclear sources in parts of the Arctic and the vulnerability of Arctic systems to radioactive contamination. The Arctic environment is also perceived as a wilderness and the need for the protection of this wilderness against contamination is great. In 1991, the International Arctic Environmental Protection Strategy (IAEPS) was launched and the Arctic Monitoring and Assessment Programme (AMAP) established. AMAP is undertaking an assessment of the radioactive contamination of the Arctic and its radiological consequences. This paper summarises some of current knowledge about sources of radioactive contamination, vulnerability, exposure of man, and potential sources for radioactive contamination within Arctic and some views on the future needs for work concerning radioactivity in Arctic.*

## 1. INTRODUCTION

There is currently a focus on radioactivity and the Arctic region. The reason for this is probably the high number of nuclear sources in parts of the Arctic and the vulnerability of Arctic systems to radioactive contamination. The Arctic environment is also perceived as a wilderness and the need for the protection of this wilderness against contamination is great. In the last decade information has also been released concerning the nuclear situation which has caused concern in many countries. Due to such concerns, the International Arctic Environmental Protection Strategy (IAEPS) was launched in 1991 and the Arctic Monitoring and Assessment Programme (AMAP) was established. AMAP is undertaking an assessment of the radioactive contamination of the Arctic and its radiological consequences. In 1996 IAEPS became part of the Arctic Council. AMAP presented one main report in 1997 [AMAP 1997] and another in 1998 [AMAP 1998]. There are also several other national, bilateral and international programmes in existence which deal with this issue. This paper summarises some of current knowledge about sources of radioactive contamination, vulnerability, exposure of man, and potential sources for radioactive contamination within Arctic and some views on the future needs for work concerning radioactivity in Arctic.

## 2. PAST AND PRESENT RADIOACTIVE CONTAMINATION

There are three main sources of radioactive contamination in the Arctic today: global fallout from nuclear tests, releases from nuclear reprocessing plants in Western Europe and Chernobyl fallout. A total of 518 atmospheric nuclear explosions took place up to 1980. The spatial distribution of $^{137}Cs$ of this fallout onto land is shown in Figure 1. [Strand et al. 1998].

The major source of radiocaesium to the Arctic from West European nuclear reprocessing plants is Sellafield in the UK. Releases started in 1952 and continue up to the present day with major releases having occurred between 1974 and 1982. The releases of $^{99}Tc$ and $^{137}Cs$ from Sellafield and the subsequent contamination levels in the Barents Sea are shown in Figure 2. Releases of $^{99}Tc$ increased in 1994 from the reprocessing plant at Sellafield and have recently led to increased concentrations of $^{99}$Tc in northern marine environments and further into the Arctic Seas.

Following the Chernobyl accident in 1986, a major release of radioactive material spread over large areas in Europe, with the radioactive cloud and fallout also reaching Arctic areas, mainly the North West Russia and Northern Fenno-Scandia, with deposition levels in the order of 1-5 kBq/m$^2$ $^{137}$Cs. Deposition levels in the order of 10-200 kBq/m$^2$ were, however, observed just south of the Polar Circle. Radioactive contamination of the North and Baltic Seas provides continuously indirect contamination to the Arctic marine environment via transport pathways along the Norwegian coast.

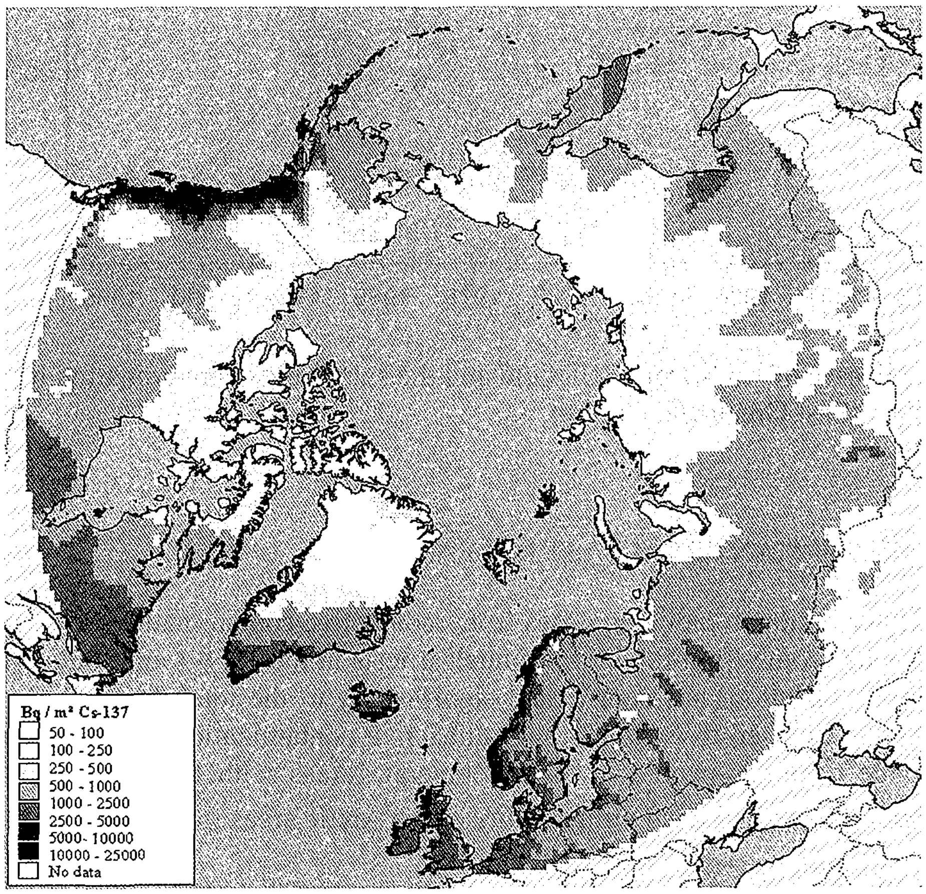


FIG. 1. Estimated spatial distribution of $^{137}$Cs fallout from nuclear weapons testing.

There do also exist several other sources which have given small or only localized contamination such as the Thule accident in Greenland, where an American plane carrying nuclear bombs was involved, from the accident with the Komsomolets submarine in the Norwegian Sea, waste storage sites and from dumping of radioactive waste in the sea. Former releases from the nuclear reprocessing plant at Mayak in the Urals, even if it has not contaminated Arctic areas to a substantial degree with earlier discharges, is today a considerable source contained in the environment and, through the potential for transport of radionuclides via the Ob River, is a source to be considered as a threat to the Arctic environment. The releases of radioactive caesium and strontium from Mayak were nearly 100 times higher than the releases of these radionuclides from Chernobyl. Today the radionuclide inventory is stored mainly in lakes and reservoirs, with potential risk for leakage to the rivers and into the Northern Seas.

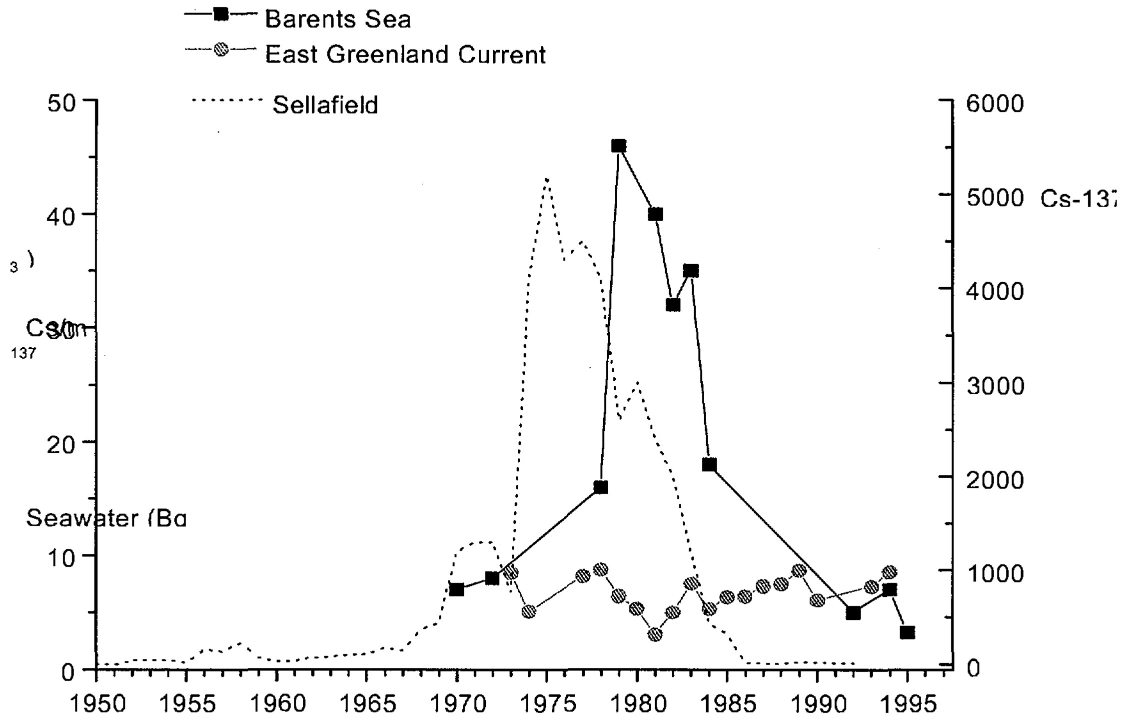


FIG. 2. The releases of $^{137}Cs$ from Sellafield and the subsequent contamination levels in the Barents Sea and East Greenland Current.

## 3. EXPOSURE OF MAN FROM PAST RELEASE

The largest contribution to radiation doses from radioactive contamination to the population in northern areas has come from fallout from nuclear tests in the 1950's and '60's. In some areas also the Chernobyl fallout has contributed significantly to the total dose. The population in northern areas is exposed to a dose, from radioactive contamination, which is about 5 times higher than the dose for people in more temperate areas with the same deposition. This illustrates the higher transfer and vulnerability of the Arctic areas from $^{137}Cs$ contamination.

Indigenous people in the Arctic, mainly living off traditional food products from mountain, forest and lakes, e.g. reindeer-herding Saamis, receive the highest doses from radioactive contamination.

Radiation doses to both the average population and the special groups depend mainly on intake of locally-produced terrestrial products. In comparison, Arctic population groups with mainly marine products in their diet, receive relatively low doses. The most exposed population groups in the Arctic can on average receive up to 50 times higher individual doses than members of the average population.

The intake by the general Arctic population of radiocaesium from different foodstuffs during the period 1990-1994 in the 8 Arctic countries are shown in Figure 3 [Strand et al. 1998]. For the average Arctic populations, a range of different food products contribute to the total $^{137}Cs$ intake. Canada is an exception, with the domination of reindeer meat consumption in the intake of radiocaesium.

The regional effect on dietary preferences is also clearly shown in Figure 3. For example, goat cheese is only an important source for radioceasium intake in Norway. Mushrooms are important in Sweden, Finland and Russia. However, there is a considerable lack in knowledge concerning the importance of natural food products in the transfer of radionuclides to man. In contrast, people who consume only marine products, such as marine fish and mammals, receive doses that are at least an order of magnitude lower than people consuming terrestrial products such as reindeer/caribou meat, freshwater fish and mushrooms. The intake for the selected groups were considerably higher as shown in Figure 4. The major contributor to the intake for these groups was reindeer meat.

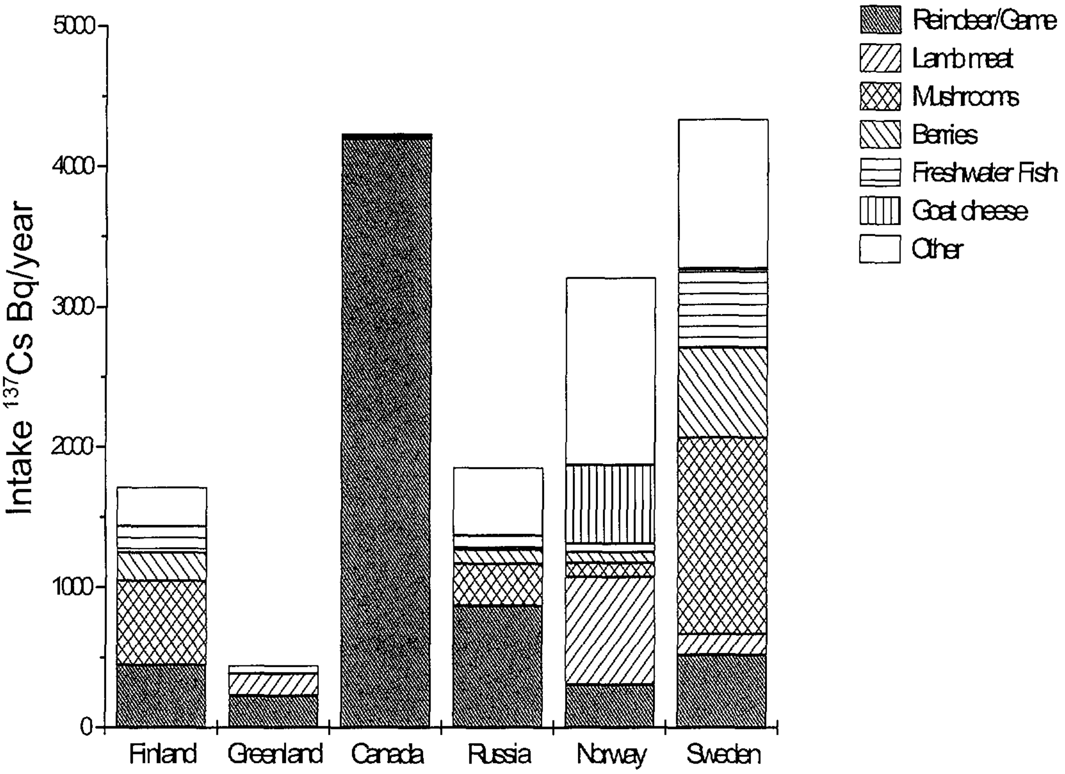


FIG. 3. Yearly intakes by the average populations during 1990-1994.

The major contribution (» 15 000 manSv) to the collective dose to Arctic populations results from fallout from nuclear weapons testing, with a range of individual dose commitments between 1 and 150 mSv [Strand et al. 1998]. The second most important contribution (» 500 manSv) to collective dose within the Arctic derives from the Chernobyl accident, with individual dose commitments normally in the range 1 to 50 mSv. Individual annual doses to the most exposed residents of the Arctic from Chernobyl releases, however, could be approximately 10 to 20 mSv/y in the most affected areas. Countermeasures introduced by some countries following the Chernobyl accident and, in some cases, maintained to the present day, have resulted in reduced individual doses and dose commitments. Releases from the Sellafield fuel reprocessing plant provide the third most important collective dose contribution (» 50 manSv) with a relatively small contribution to individual dose (*i.e.* in the range 0 to 0.05 mSv) [CEC 1990].

The total exposure of man from the dumping of nuclear waste is very small even taking into consideration the potential future dose. Smaller-scale releases from accidents in military operations, such as those in northern Russia, the plutonium spill at Thule and the loss of the

*Komsomolets* submarine in the Norwegian Sea, have resulted in no significant increases in radiation exposures to the Arctic populations. For other releases to the environment, such as from the Mayak reprocessing plant, it has been difficult to assess the collective or individual doses to Arctic populations from the releases especially, before 1960.

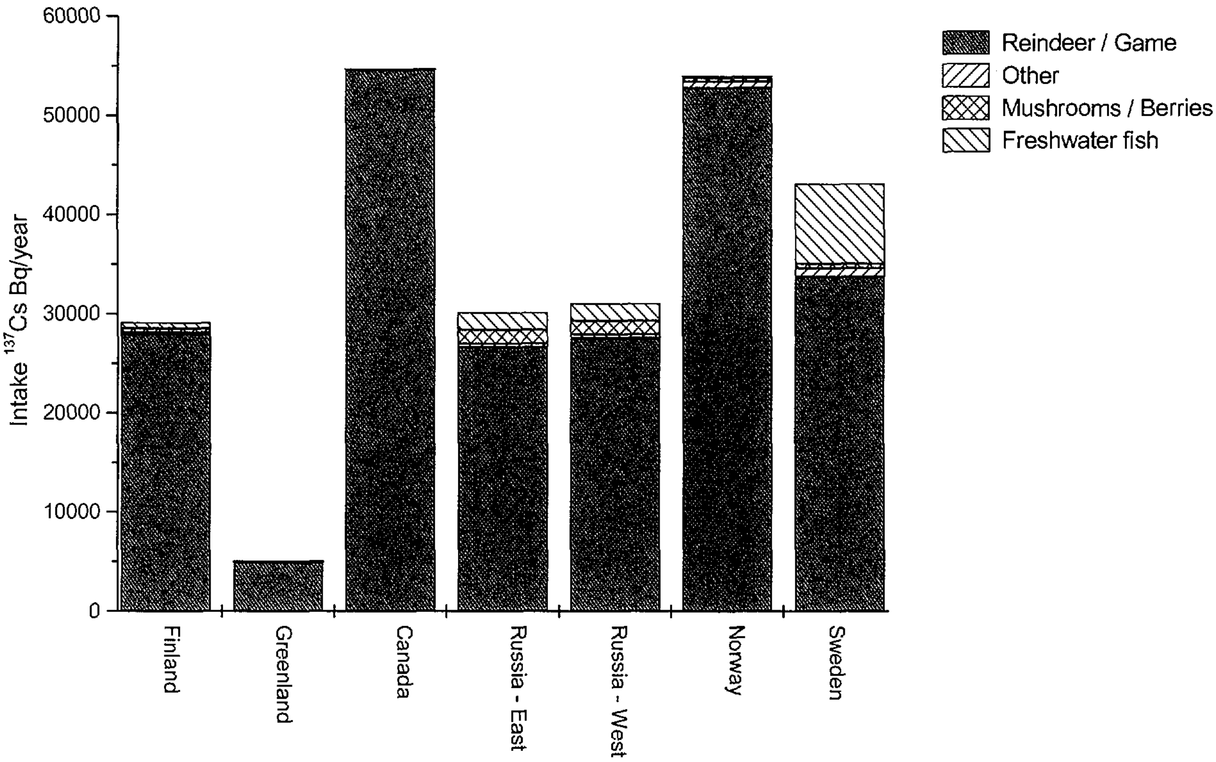


FIG. 4. Yearly intakes by the selected indigenous groups, during 1990-1994.

## 4. POTENTIAL THREATS TO ARCTIC AND FUTURE NEED FOR RISK AND IMPACT ASSESSMENT

The concentration and number of nuclear installations and the potential for releases cause concern, especially since the vulnerability of Arctic populations is much greater than for populations in temperate areas due to the importance of terrestrial semi-natural exposure pathways. The largest threat to the environment and the population in the Arctic today is connected to potential accidents in nuclear power plants, during handling and storage of nuclear weapons, decommissioning and refuelling of nuclear powered vessels and during storage of radioactive waste.

The future work should concentrate on an assessment of the possible consequences of potential major radiation accidents or releases in the Arctic terrestrial or aquatic environments and their vicinity. Knowledge gaps relating to important pathways of human exposure and environmental contamination in the Arctic, such as long-term migration of radionuclides, changes with time in characteristics of the diet of different Arctic population groups, reasons for the high variability in levels determined in different foodstuffs need to be addressed. To fulfil some of these gaps, additional experimental, surveys and modelling work will be needed. High priority should be given to studying the site-specific vulnerability of particular Arctic regions and communities as an essential basis for the prediction of consequences of potential radioactive contamination. Radiation monitoring in the Arctic environment should be continued, in order to acquire both spatial and temporal information as input data for assessment. Finally, the need for developing a system for assessing the consequence of radiation exposure for Arctic flora and fauna has a high priority. There has historically been a focus on the consequences on peoples' health, not the effect on the environment itself, in assessing the impact of radioactive contamination. This work needs collaboration at an international level and, with this in mind, AMAP and IUR will work together on this topic.

***Risk Management-need for closer links between Risk Assessment and Action Programs.*** It is imperative that action is based on risk and impact assessments and furthermore that the results of such actions are reassessed. Currently, communication and interaction is poor between the existing Risk and Impact assessment Programs devised to assess and monitor contamination in the Arctic and the Action Programs tasked to devise strategies and respond to existing radioactive contamination sources by implementing short-or long-term solutions. It is vital to bridge this gap and foster an interdependence between the Risk Assessment and Practical Programs to improve monitoring, response strategies and the implementation of action plans.

## REFERENCES


[1] CEC, 1990. The radiological exposure of the population of the European Community from radioactivity in North European marine waters: Project «Marina», Commission of the European Communities (1990). Radiation Protection Report 47, Directorate of Nuclear Safety, Impact of Industry on the environment and Waste Management, Directorate General Environment, Consumer Protection and Nuclear Safety, EUR 12483 EN. 571 pp.

[2] Strand et al., 1998. P. Strand, M.Balonov, A.Aarkrog, M.Bewers, B.Howard, A.Salo, Y.S.Tsaturov.Arctic Pollution Issues. AMAP Assessment Report. Chapter 8 pp 525, AMAP 1998.

[3] Herrmann et al., 1995. Herrmann, J., Kershaw, P.J., Dubois, P.B., Gueguenaiat, P.(1995). The distribution of artificial radionuclides in the English Channel, southern North Sea, Skagerrak and Kattegat. 1990-1993. Jour. Mar. syst., 6, p.427-456

[4] Arctic Pollution Issues: A State of the Arctic Environment Report, AMAP Arctic Monitoring Assessment Programme, 1997

[5] AMAP Assessment Report: Arctic Pollution Issues. Arctic Monitoring and Assessment Programme, Oslo 1998

## DISCUSSION AFTER THE PRESENTATION OF P. STRAND

**E.D. STUKIN (Russian Federation):** You said that two of your colleagues are working on the platform above the "Kursk" submarine. What can you say about the radioactivity levels due to the submarine's reactor?

**P. STRAND (Norway):** They have not detected any radioactivity that could be ascribed to the reactor. The data obtained so far do not suggest that the reactor is leaking. It looks as if the reactor safety system worked well and that the reactor was shut down properly.

**YU. A. IZRAEL (Russian Federation-Session Chair):** That conclusion is supported by measurements which were carried out by specialists from Russia's Institute of Global Climate and Ecology after the "Kursk" accident and the results of which were included in the proceedings of the International Conference on Radioactivity after Nuclear Explosion and Accidents held in Moscow last April.

**V. NOVIKOV (International Institute of Applied Systems Analysis):** Could you give any examples of cases where the countermeasures which were taken resulted in an increase-rather than a decrease-of risk?

**P. STRAND (Norway):** No, I cannot. It is simply a principle that countermeasures should not be taken if they will result in a risk increase. For that reason, there are cases where radioactive waste dumped at sea has been left where it is.