INTERNATIONAL ARCTIC SEAS ASSESSMENT PROJECT: SUMMING UP

BELOW THE ARCTIC SEAS

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Rumours surfaced in 1992 that the former Soviet Union had, for over three decades, dumped radioactive wastes in the shallow waters of the Arctic Seas. The news caused great concern in many countries, especially those having an Arctic coastline.

In early 1993 the Office of President of Russia published a document with detailed information on the past dumping operations of the former Soviet Union. According to that document, called the "White Book", the items dumped in the Arctic Seas included six nuclear submarine reactors containing spent fuel; a shielding assembly from an icebreaker reactor containing spent fuel; ten nuclear reactors without fuel; and solid and liquid low-level waste.

The solid wastes were dumped in the Kara Sea, mainly in the shallow fjords of Novaya Zemlya, where the depths of the dumping sites range from 12 to 135 meters and in the Novaya Zemlya Trough at depths of up to 380 meters. Liquid low-level wastes were released in the open Barents and Kara Seas.

In 1993, the IAEA responded to the concern of its Member States and the request of the Contracting Parties to the Convention on Prevention of Marine Pollution by Dumping of Wastes and Other Matter by launching the International Arctic Seas Assessment Project (IASAP). It had two objectives:

- to assess the risks to human health and to the environment associated with the radioactive wastes dumped in the Kara and Barents Seas, and
- to examine possible remedial actions related to the dumped wastes and to advise on their necessity and justification.

The Project involved more than fifty experts from fourteen countries and was steered by an International Advisory Group. Its working areas consisted of:

- examination of the radiological situation in Arctic waters;
- prediction of potential future releases from the dumped wastes;
- modelling of environmental transport of released nuclides and assessing the associated radiological impact on humans and biota; and
- examination of the feasibility, costs and benefits of possible remedial measures.

RADIOLOGICAL SITUATION

In the Project, information based on reactor operating histories and calculated neutron spectra were used to provide estimates of fission products, activation products and actinide inventories of the dumped reactors and fuel assemblies. It was concluded that the total radionuclide inventory of the high-level radioactive waste objects at the time of dumping was 37 PBq. The corresponding inventory of high-level dumped wastes in 1994 was estimated to be 4.7 PBq. In 1994, the main radionuclides were caesium-137, strontium-90, nickel-63 and cobalt-60. In the far future, the year 3000, plutonium isotopes and nickel-59 will dominate the inventory.

Radionuclides in the Environment. The open Kara Sea is relatively uncontaminated compared with some other marine areas. The main contributors to its artificial radionuclide content are direct atmospheric deposition and runoff of global fallout from nuclear weapon tests, discharges from reprocessing plants in western Europe and fallout from the Chernobyl accident.

Measurements of environmental materials suggest that current annual individual doses from artificial radionuclides in the Kara and Barents Seas are very small, between 2 to 10 microSv. Elevated concentrations of

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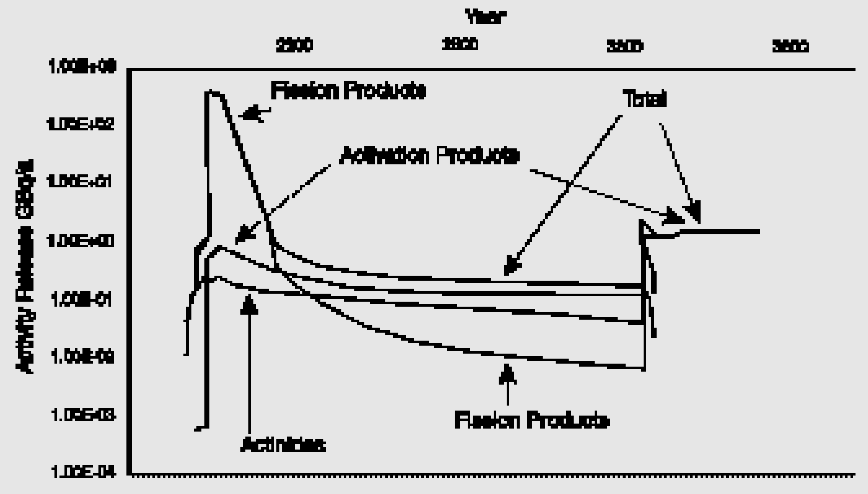
certain radionuclides were detected in sediments within a few meters of the low-level waste containers, suggesting that the containers have leaked. However, these leakages have not led to a measurable increase of radionuclides in the outer parts of the fjords or in the open Kara Sea.

PREDICTED RELEASE RATES FROM ONE DISPOSED REACTOR IN THE KARA SEA



POTENTIAL FUTURE IMPACTS

The rates of release of radionuclides to the environment will depend upon the integrity of materials forming the reactor structure, the barriers added prior to dumping and the nuclear fuel itself.

For each of the dumped high-level waste objects, the construction and composition of barriers were investigated in detail, and the best estimates of the corrosion rates and barrier lifetimes were used in the calculation of release rates. External events, such as collision with ships or, more generally, global cooling followed by glacial scouring of the fjords, could also damage the containment.

Scenarios of radionuclide releases considered were:

- a best estimate scenario where release occurs via the gradual corrosion of the barriers, waste containers and the fuel itself;
- two catastrophic scenarios, causing at certain time points instant or accelerated release of the remaining radionuclide inventory.

Release rates were predicted according to the best estimate scenario from one of the dumped reactors. *(See graph.)* The rates were used with mathematical models of the environmental behaviour of radionuclides to estimate radiation doses to people and biota.

Dose estimates. Doses were estimated for selected population groups, for the world population, and for flora and fauna.

Individual doses. For estimation of doses to individuals, three population groups were considered. Calculations of individual doses were undertaken for time periods covering the peak individual dose rates for each of the three release scenarios.

- Group 1 — a group whose subsistence is heavily dependent on the consumption of Kara Sea fish, marine mammals, seabirds and their eggs, and who spend 250 hours a year on the seashore;
- Group 2 — a hypothetical group of military personnel patrolling the foreshore of the fjords for assumed periods of 100 hours a year. The exposure pathways considered include external radiation and the inhalation of seaspray and re-suspended sediment;
- Group 3 — a group of seafood consumers considered representative of the Northern Russian population eating fish, molluscs and crustaceans harvested from the Barents Sea.

The maximum annual individual doses in each group of seafood consumers (Groups 1 and 3) for all three scenarios are small (less than 1 microSv) and very much less than variations in natural background doses. (The annual doses to the Groups 1 and 3 from naturally occurring polonium-210 in seafood are 500 microSv and 100 microSv, respectively.) Doses to the hypothetical critical group of military personnel patrolling the fjords (Group 2) are higher but, nevertheless, comparable to natural background radiation doses (on average 2400 microSv). *(See table, next page.)*

Collective doses. Collective doses were estimated only for the best estimate release rate scenario. The collective dose to the world population arising from the dispersion of

RADIATION DOSE ESTIMATES OF THE PROJECT

Maximum Total Annual Individual Doses for Selected Population Groups (microSv/year)

Scenario	Annual doses to seafood consumers	Annual doses to military personnel
Best estimate scenario	< 0.1	700
Catastrophic scenarios	0.3- 1	3000-4000

Collective Doses to the World Population (man . Sv)

	Truncation time (up to year) 2050	3000
Nuclides except Carbon-14 and Iodine-129	0.01	1
Carbon-14	NA	8
Iodine-129	NA	0.0001
Total		~10

radionuclides in the world's oceans (nuclides other than carbon-14 and iodine-129) were calculated up to the year 2050 to provide information on the collective dose to the current generation; and over the next 1000 years, a time period which covers the estimated peak releases. The estimated collective doses are 0.01 man.Sv and 1 man.Sv, respectively.

Assuming that the entire carbon-14 inventory of the wastes is released around the year 2000 and integrating the dose to the world's population over 1000 years into the future (i.e., to the year 3000) yields a collective dose of about 8 man.Sv. The corresponding value for iodine-129 is much lower at 0.0001 man.Sv. Thus the total collective dose to the world's population over the next 1000 years would be of the order of 10 man.Sv. *(See table.)*

Dose to flora and fauna. The radiation dose rates to a range of populations of wild organisms, from zooplankton to whales, were calculated and found to be very low. The peak dose rates predicted in this assessment are about 0.1 microGy/h — a dose rate that is considered unlikely to entail any detrimental effects on morbidity, mortality, fertility, fecundity and mutation rate that may influence the maintenance of healthy populations.

It is also relevant to note that only a small proportion of the biota population in local ecosystems could be affected by the releases.

CONSIDERATION OF REMEDIAL ACTIONS

With regard to possible remedial actions, a preliminary engineering feasibility and cost study was conducted for the container of spent fuel from the nuclear icebreaker. The icebreaker holds the largest radionuclide inventory among the dumped waste objects and is the best documented regarding construction and barriers.

Salvage experts chose two potentially realistic remediation options for closer study. The first option was capping *in situ* with concrete or other suitable material to encapsulate the object; the second was its recovery to a land environment. Both options were deemed technically feasible. The costs of marine operations were estimated to be in the range US $5-to-$13 million.

A number of factors require consideration in reaching a decision about the need for remedial actions. From a radiological protection perspective, they include consideration of the doses and risks to the most exposed individuals (the critical group) if action is not taken and the extent to which their situation can be improved by taking action. Another factor concerns the total health impact on exposed populations (proportional to collective dose) and how much of it can be averted by taking remedial action.

PROJECT CONCLUSIONS

The Project reached a number of conclusions:

- Monitoring has shown that releases from identified dumped objects are small and localized to the immediate vicinity of the dumping sites.
- Projected future doses to members of the public in typical local population groups arising from radioactive wastes dumped in the Kara Sea are very small, less than one microSv per year. Projected future doses to a hypothetical group of military personnel patrolling the foreshore of the fjords in which wastes have been dumped are higher, up to 4000 microSv per year but still of the same order as the average annual natural background dose.
- Doses to marine fauna are insignificant, orders of magnitude below those at which detrimental effects on fauna populations might be expected to occur.
- Concerning remedial actions, remediation is not warranted on radiological grounds. ❐