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EKO-2

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EKO-2

LONG ECOLOGICAL HALF-LIVES IN SEMI-NATURAL SYSTEMS

LANGE ØKOLOGISKE HALVERINGSTIDER I SEMINATURLIGE SYSTEMER

Annual report 1996 / Årsrapport 1996
Project plan 1997 / Planer 1997

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SUMMARY

The EKO-2 project, "Long ecological half-lives in semi-natural systems", consists of three subprojects; sheep grazing on uncultivated pasture, mushrooms and freshwater fish. The main aim is to identify the contribution from semi-natural systems, by determining ecological half-lives for specific foodstuffs from these areas, and thus determine dose to man.

Foodstuffs from semi-natural areas (such as uncultivated pastures) account for a considerable portion of the dose to man, especially with time after a fall-out situation. The EKO-2 projects are described in "Prosjektplaner for programmet 1994-1997" ("Project plans for the programme 1994-1997") NKS(94)7.

In the three ongoing projects we have produced or used data for 8-10 years after the Chernobyl accident. The time series have been very necessary for predicting ecological half-lives for radiocesium and radiostrontium. Unfortunately, the data for radiostrontium have been very scarce.

The recovery of Nordic ecosystems from contamination by ^{137}Cs originating from the Chernobyl accident is gradually slowing down, at the same time as areas vary widely in susceptibility and recovery rates. Accordingly, ecological half-lives are gradually increasing and cannot be treated as constants, over neither time nor space. Although it has not been easy to determine simple or general ecological half-lives, the projects have given us useful understanding of the mechanisms governing the transfer of radionuclides, and more knowledge about typical Nordic ecosystems.

Transfer of radiocesium and radiostrontium from soil to vegetation and sheep («the sheep project»)
The soil - vegetation - sheep - system is being studied in five countries; Iceland, the Faeroe Islands, Denmark, Sweden and Norway. Co-ordinated collection of soil, vegetation and meet samples have been performed every year since 1990 (in this framework since 1994). These time series give good basis for calculating the ecological half-lives in the different areas studied.

Large differences in transfer are found, especially in the soil to plant transfer between the different locations, most of it can be described by the different soil types. Emphasis the last year will be put on analysis of data, and improvement of the developed model.

Transfer of radiocesium via mushrooms to roe deer and man («the forest project»)
After a slow start in 1994, many results from this project have been published during 1996. Questionnaires have been implemented in Sweden, Denmark and Finland, in Sweden and Denmark with focus on mushrooms, and a more thorough investigation in Finland on natural products for consumption. Unfortunately, 1995 and 1996 have not been particularly good mushroom years, and some of the results may not be representative for a good year. The questionnaire will be used also in Norway.

Mushrooms also plays an important role in the uptake of radiocesium by animals living in the forest. We have chosen to study roe deer, and samples of roe deer meat, rumen and grazing plant have been collected during 1995 and 1996. The samples are still being analysed.

Ecological half-lives in limnic ecosystems («limnic systems»)
The main aim in the project has been to investigate the processes and mechanisms leading to radiocesium being easily available for uptake in e.g. fish. Systematic collection of data has enabled the construction of a GIS system to show fallout levels of ^{137}Cs, influence from catchment areas, and prediction of ^{137}Cs in fish. In general, the ^{137}Cs levels in fish in the studied Swedish and Finnish lakes show no significant decrease since 1991.

Co-ordinated work has also been performed on the investigation of run-off surrounding areas. Samples have been collected from lakes and streams in Norwegian, Swedish and Finnish areas.

Data on horizontal and vertical variations in sediments from 20 lakes have been collected, and there is a strong relationship between Cs inventory and the sedimentation rate within the lake. The chemical mobility of ^{137}Cs in lake and stream sediments has been investigated by sequential extraction. The predictive models indicate half-lives of ^{137}Cs in lakes of about 10 years.

A larger study has been done on laboratory studies of uptake of ^{137}Cs by algae (representing the start of the food chain). The influence of different ionic concentration in water, uptake mechanisms and kinetics have been studied.

Results presented in 1996

Presentations

Presented at: International symposium on ionising radiation: Protection of the Natural Environment in Stockholm, Sweden 20-24 May 1996:

Nylén T "*A Nordic study on the origin and dynamics of Cs-137 discharge from land to streams, rivers and lakes and residence times in different terrestrial biotopes*"

Brittain JE & Bjornstad HE. "*A long-term study of radiocesium transport to a subalpine lake from its catchment.*"

Andersson, T. & Nylén, T. "*Geographical and temporal variation in the transfer of ^{137}Cs to fresh water and fish from different types of soils.*"

Meili, M, Konitzer, K, Braf, L & Baines, SB. "*Sediments as a long-term secondary source of Chernobyl ^{137}Cs in lake ecosystems.*"

Koulikov, AO & Meili, M.: "*Physiological modelling of radiocaesium turnover in fish.*"

Andersson I, Lönsjö H & Rosén K. "*Transfer of Cs-137 from Soil to Vegetation and to Grazing Lambs in a MountainArea in Northern Sweden. Ecological Half-life of the Nuclide.*"

Presented at: The 7th International Symposium: The interactions between Sediments and Water. Baveno (I), 22-25 September 1996:

Meili, M.: "*Resuspension and focusing of lake sediments: Spatial and temporal patterns derived from sediment traps.*"

Meili, M & Konitzer, K. "*Modelling resuspension and focusing of lake sediments as a function of basin morphometry.*"

Konitzer, K & Meili, M. "*Horizontal distribution of 137Cs in lake sediments as a function of epilimnion depth.*"

Weyhenmeyer, GA, Håkanson, L & Meili, M. "*A model for the distribution of resuspended sediment in lakes - calibrated with sediment trap data from 11 lakes.*"

Presented at: International symposium on Radioecology 1986, Austrian Soil Science Society, Vienna 22-24 April 1996:

Johanson KJ & Nikolova I. *"The role of fungi in the transfer of 137Cs in the forest ecosystem."*

Presented at: The 11th meeting of the Nordic Society of Radiation Protection and the 7th Radioecology Seminar, Reykjavík, Island 26-29 August 1996:

Oughton D, Skipperud L & Tronstad E. "*Mobility of Cs and Sr in Soils: Implications for Transfer Factors and Ecological Half-lives in Nordic Ecosystems.*"

Johanson KJ. *"Svampens roll i överföring av Cs-137 från skogen til människa."*

Saxén R, Jaakkola T & Rantavaara A. *"Distribution of ^{137}Cs and ^{90}Sr in a Finnish lake ecosystem."*

Þórsson J, Pálsson SE & Ólafsdóttir ED. *"Sheep grazing and radiocaesium, some external factors."*

Moring M. *"^{137}Cs in a large freshwater basin - A dynamic model."*

Amundsen I, Hove K & Strand P. *"Transfer and long term behaviour of ^{137}Cs in sheep at Tjøtta, Norway, 1988-1995. Report from the NKS EKO2 experiment in Norway."*

Andersson I, Lönsjö H & Rosén K. *"Transfer of Cs-137 from Soil to Vegetation and to Grazing Lambs in a Mountain Area in Northern Sweden. Ecological Half-life of the Nuclide."*

Markkula ML, Rantavaara A. *"Consumption of mushrooms and some other wild food products in Finland."*

Manuscripts

Nylén T. (1996). "*Uptake, turnover and transport of radiocesium in boreal forest ecosystems.*" Thesis. FOA-R--96-00242-4.3—SE.

Andersson, T. & Nylén, T. (1996) "*Läckage av Cs-137 från olika mark- och vegetationstyper - Geografisk koppling till halter i vatten och sötvattenfisk.*" Rapport, SSI

Koulikov, AO & Meili, M (1996). "*Modelling the dynamics of fish contamination by Chernobyl radiocaesium: an analytical solution based on potassium mass balance.*" In: Proceedings of the 9th International Congress on Radiation Protection (IRPA9), Vienna, 14-19 Apr. 96 (extended abstract, 3 pages).

Meili, M & Wörman, A (1996). "*Desorption and diffusion of episodic pollutants in sediments: a 3-phase model applied to Chernobyl ^{137}Cs.*" Applied Geochemistry 11:311-316.

Brittain JE, Bjornstad HE, Sundblad B & Saxén R (1996). "*The characterisation and retention of different transport phases of ^{137}Cs and ^{90}Sr in three contrasting Nordic Lakes.*" In: Proceedings of the International CEC Seminar on Freshwater and Estuarine Radioecology, Lisbon, March 1994. Elsevier Science B.V., Amsterdam (in press).

Meili, M, Braf, L & Konitzer, K (1996). "*Sediment resuspension as a long-term secondary source of Chernobyl ^{137}Cs in lake ecosystems: the example of Blacksåstjärn (Sweden).*" In: Proceedings of the International CEC Seminar on Freshwater and Estuarine Radioecology, Lisbon, March 1994. Elsevier Science B.V., Amsterdam (in press).

Konitzer, K & Meili, M (1996). "*Redistribution of sedimentary 137Cs in small Swedish lakes after the Chernobyl fallout 1986.*" In: Proceedings of the International CEC Seminar on Freshwater and Estuarine Radioecology, Lisbon, March 1994. Elsevier Science B.V., Amsterdam (in press).

Koulikov, AO & Meili, M (1996). *"Physiological modelling of radiocaesium turnover in fish."* In: Proceedings of the International Symposium on Ionising Radiation: Protection of the Natural Environment. Swedish Radiation Protection Institute, Stockholm, 20-24 May 1996 (in press, 6 pages).

Koulikov, AO & Meili, M. *"Modelling the dynamics of fish contamination by Chernobyl radiocaesium: an analytical solution based on potassium mass balance."* (submitted to J. Environ. Radioact.)

Ugedal O, Forseth T & Jonsson, B. *"A functional model of radiocesium turnover in brown trout." Ecological Application* (in press)

Saxén R, Jaakkola T & Rantavaara A. *"Distribution of ^{137}Cs and ^{90}Sr in the southern part of lake Päijänne"*. Radiokhimiya, Vol. 38, No. 4, 1996, pp. 365-370.

Saxén R & Koskelainen U. *"Radioactivity of surface water and freshwater fish in Finland in 1991-1994"*. Report STUK-A129. Helsinki: Finnish Centre for Radiation and Nuclear Safety, 1996.

Strandberg M (1996). *"The use of natural products for consumption in Denmark."* R-EKO-2(1996)1

Nikolova, I Johanson KJ & Dahlberg A. *"Radiocesium in fruit bodies and mycorrhizae in ectomycorrhizal fungi."* J. Environ. Radioactivity. In press

Dahlberg, A Nikolova, I & Johanson KJ. *"Intraspecific variation of ^{137}Cs activity concentrations in sporocarp of Suillus variegatus in seven Swedish population."* Mycological Res. In press.

Johanson KJ & Nikolova I (1996). *"The role of fungi in the transfer of ^{137}Cs in the forest ecosystem."* In proceedings of the international symposium on Radioecology, Austrian Soil Science Society, Vienna 1996.

Strandberg M & Knudsen H. *"Mushroom spores and ^{137}Cs in faeces of the Roe Deer."* J. Envir. Radioactivity 23.

Herlin AH & Andersson I (1996). *"Soil ingestion in farm animals."* Swedish University of Agricultural Sciences, ISSN 1104-7313 Report 105 1996.

The sheep project will be reported in a separate EKO-2 technical report:
The sheep project 1996 TR-EKO-2(1996)1

SAMMENDRAG

EKO-2 prosjektet, "Lange økologiske halveringstider i semi-naturlige systemer" består av tre delprosjekt; sauer som beiter i utmarksområder, sopp i skogssystemer og ferskvannsfisk. Hovedmålet med prosjektene er å bestemme konsum av matvarer produsert i semi-naturlige systemer, økologisk halveringstid for enkelte av disse matvarene, og derved bestemme dosebidraget til mennesker.
Matvarer fra semi-naturlige systemer (som for eksempel utmarksbeite) bidrar med en vesentlig del av interndosen hos mennesker i de nordiske landene, spesielt en tid etter selve nedfallet.
EKO-2 prosjektene er beskrevet i "Prosjektplaner for programmet 1994-1997" NKS(94)7.

I de tre pågående prosjektene har vi produsert eller samlet data for 8-10 år etter Tsjernobyl ulykken. Tidsseriene har vært svært nødvendige for å kunne bestemme økologiske halveringstider for radiocesium og radiostrontium. Dessverre eksisterer det fremdeles lite data på radiostrontium nivåer.
Restitueringen av nordiske økosystemer etter forurensing av ^{137}Cs går langsommere nå sammenliknet med den første perioden etter Tsjernobyl ulykken. Samtidig er det store variasjoner i sårbarhet og restitueringshastigheter mellom de ulike områdene. Tilsvarende øker de økologiske halveringstidene over tid, og kan derfor ikke behandles som en konstant, hverken over tid eller sted. Det har ikke vært enkelt å bestemme enkle eller generelle økologiske halveringstider, men prosjektet har gitt oss nyttig innsikt i mekanismene som styrer opptak av radionuklider og utvidet kunnskap om typisk nordiske økosystemer.

Overføring av radiocesium og radiostrontium fra jord til vegetasjon og lam ("lammeprosjektet")
Systemet jord - vegetasjon - lam har vært studert i fem land; Island, Færøyene, Danmark, Sverige og Norge. Koordinert prøveinnsamling av jord, vegetasjon og kjøtt prøver har vært gjennomført hvert år siden 1990 (i dette programmet siden 1994). Disse tidsseriene vil gi et godt grunnlag for beregning av de økologiske halveringstidene i de ulike områdene.

Store forskjeller i overføring av radiocesium er funnet, spesielt fra jord til beiteplanter. Mesteparten av denne forskjellen kan forklares ved ulike jordtyper. I prosjektets siste år vil det bli lagt vekt på databearbeiding og forbedring av den utviklede modellen.

Overføring av radiocesium via sopp til rådyr og menneske ("skogsprosjektet")
Etter en treg start i 1994 har mange resultater fra dette delprosjektet blitt publisert i løpet av 1996. Spørreundersøkelser har vært gjennomført i Sverige, Danmark og Finland når det gjelder konsum av naturprodukter. I Sverige og Danmark har hovedvekten vært på sopp, mens i Finland har en mer omfattende undersøkelse vært gjennomført. Hverken 1995 eller 1996 har vært gode soppår, det er derfor mulig at resultatene ikke vil være representative for et godt soppår. Spørreundersøkelsen skal også gjennomføres i Norge.

Sopp spiller en viktig rolle også når det gjelder opptak av radiocesium hos dyr som lever i skogen. Vi har valgt å undersøke rådyr, og prøver av rådyrkjøtt, vom og beiteplanter har vært samlet inn i 1995 og 1996. Prøvene er fremdeles til analyse.

Økologiske halveringstider i limniske økosystemer ("limniske systemer")
Hovedmålet med prosjektet har vært å undersøke de prosessene som medfører at radiocesium er lett tilgjengelig for opptak i f.eks. fisk. Systematisk innsamling av data har gjort det mulig å

opprette et GIS-system som viser nedfallsnivåer av ^{137}Cs, tilførsel fra avrenningsområdene og forventete nivåer av ^{137}Cs i fisk. Generelt viser nivåene av ^{137}Cs i fisk i de undersøkte svenske of finske innsjøene ingen nedgang etter 1991.

Koordinert prøveinnsamling har vært gjennomført når det gjelder undersøkelser av avrenning fra omkringliggende områder og til innsjøen. Prøver har vært samlet fra innsjøer og bekker i norske, svenske og finske sjøer.

Også data på horisontal og vertikal fordeling i sedimenter har vært samlet fra et tyvetalls sjøer. Resultatene viser at det er en sterk korrelasjon mellom Cs-innhold (inventory) og sedimentasjonshastighet i innsjøen. Den kjemiske mobiliteten til ^{137}Cs i sjø- og bekkesedimenter har vært undersøkt ved hjelp av sekvensiell ekstraksjon. Modeller indikerer at både den fysiske og kjemiske mobiliteten til ^{137}Cs i innsjøer ligger på rundt 10 år.

Et større arbeid har også vært gjennomført på undersøkelse av opptak av ^{137}Cs i alger i laboratorieforsøk. Hvordan ionekonsentrasjonen i vannet påvirker opptaket, samt kinetikk og opptaksmekanismer har vært studert.

Resultater rapportert i 1996

Presentasjoner

Presentert ved: International symposium on ionising radiation: Protection of the Natural Environment i Stockholm, Sverige 20.-24. mai 1996:

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Johanson KJ. *"Svampens roll i överföring av Cs-137 från skogen til människa."*

Saxén R, Jaakkola T & Rantavaara A. *"Distribution of ^{137}Cs and ^{90}Sr in a Finnish lake ecosystem."*

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Amundsen I, Hove K & Strand P. *"Transfer and long term behaviour of ^{137}Cs in sheep at Tjøtta, Norway, 1988-1995. Report from the NKS EKO2 experiment in Norway."*

Andersson I, Lönsjö H & Rosén K. *"Transfer of Cs-137 from Soil to Vegetation and to Grazing Lambs in a Mountain Area in Northern Sweden. Ecological Half-life of the Nuclide."*

Markkula ML, Rantavaara A. *"Consumption of mushrooms and some other wild food products in Finland."*

Manuskripter

Nylén T. (1996). *"Uptake, turnover and transport of radiocesium in boreal forest ecosystems."* Dr.avhandling FOA-R--96-00242-4.3—SE.

Andersson, T. & Nylén, T (1996). *"Läckage av Cs-137 från olika mark- och vegetationstyper - Geografisk koppling till halter i vatten och sötvattenfisk."* Rapport, SSI

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Konitzer, K & Meili, M (1996). *"Redistribution of sedimentary 137Cs in small Swedish lakes after the Chernobyl fallout 1986."* I: Proceedings of the International CEC Seminar on Freshwater and Estuarine Radioecology, Lisboa, mars 1994. Elsevier Science B.V., Amsterdam (til trykking).

Koulikov, AO & Meili, M (1996). *"Physiological modelling of radiocaesium turnover in fish."* I: Proceedings of the International Symposium on Ionising Radiation: Protection of the Natural Environment. Swedish Radiation Protection Institute, Stockholm, 20-24 mai 1996 (til trykking, 6 sider).

Koulikov, AO & Meili, M. *"Modelling the dynamics of fish contamination by Chernobyl radiocaesium: an analytical solution based on potassium mass balance."* (akseptert av J. Environ. Radioact.)

Ugedal O, Forseth T & Jonsson, B. *"A functional model of radiocesium turnover in brown trout." Ecological Application* (in press)

Saxén R, Jaakkola T & Rantavaara A. *"Distribution of ^{137}Cs and ^{90}Sr in the southern part of lake Päijänne"*. Radiokhimiya, Vol. 38, No. 4, 1996, pp. 365-370.

Saxén R & Koskelainen U. *"Radioactivity of surface water and freshwater fish in Finland in 1991-1994"*. Report STUK-A129. Helsinki: Finnish Centre for Radiation and Nuclear Safety, 1996.

Strandberg M (1996). *"The use of natural products for consumption in Denmark."* R-EKO-2(1996)1

Nikolova, I Johanson KJ & Dahlberg A. *"Radiocesium in fruit bodies and mycorrhizae in ectomycorrhizal fungi."* J. Environ. Radioactivity. (til trykking)

Dahlberg, A Nikolova, I & Johanson KJ. *"Intraspecific variation of ^{137}Cs activity concentrations in sporocarp of Suillus variegatus in seven Swedish population."* Mycological Res. (til trykking)

Johanson KJ & Nikolova I (1996). *"The role of fungi in the transfer of ^{137}Cs in the forest ecosystem."* I proceedings of the international symposium on Radioecology, Austrian Soil Science Society, Wien 1996.

Strandberg M & Knudsen H. *"Mushroom spores and ^{137}Cs in faeces of the Roe Deer."* J. Envir. Radioactivity 23.

Herlin AH & Andersson I (1996). *"Soil ingestion in farm animals."* Swedish University of Agricultural Sciences, ISSN 1104-7313 Rapport 105 1996.

Lammeprosjektet vil bli rapportert i en egen teknisk rapport:
The sheep project 1996 TR-EKO-2(1996)1

ANNUAL REPORT 1996

EKO-2.1 Transfer of radiocesium and radiostrontium from soil to vegetation and sheep («the sheep project»)

Sampling in the selected areas was performed also during the summer of 1996. The year 1996 did not turn out to be the "good mushroom year" we were hoping for. Results from the investigation of mushroom intake by sheep are therefore difficult to interpret. The change of the Icelandic site (after 1994) clearly demonstrates the inhomogeneity of uncultivated areas in Iceland. A more thorough description of the results from each country is presented in the technical report, TR-EKO-2(1996)1. This report contains only a summary of the work performed.

The group has had two meetings this year, one in Uppsala in May and one in Roskilde in December. Also there was an informal group meeting in Reykjavik during the 11th meeting of the Nordic Society of Radiation Protection and the 7th Radioecology Seminar. Several presentations of the work was presented at this seminar.

Part A. The production method's influence on ecological half-lives in sheep meat
As part of the yearly mapping of radioactivity levels, the number of grazing animals, grazing area, the length of the grazing period and the carcass weight have been recorded. Also average precipitation and temperature during the grazing period is recorded. This year chemical analyses of the soil and vegetation (nutrition levels) have been included.

Part B. Study of the effects of intake of fungi
Faeces samples were collected during the grazing period at all sites. Unfortunately, 1996 was not a good mushroom year either, and the amount of fungi spores in faeces samples varies from 1-5 spores per sample. There has been some problems getting the spore analysis done, since Morten Strandberg changed job.

Part C. Study of the effects of ingestion of soil
The test performed in 1995, using scandium as an indicator of soil intake showed to be successful, and analyses are now being done on faeces samples from all sites. The scandium method has proven to be very sensitive and well suited for this investigation. Preliminary results show that the amount of soil ingested is very small at all sites. In some cases the vegetation contains more soil than what is found in sheep faeces, indicating that the sheep are grazing selectively on cleaner plants.

Part D. Study of the effects of mobility of stable Cs and Sr in soil
Soil and vegetation samples from all sites except the new Icelandic site have been analysed for stable Cs and Sr, and other trace elements (Ce, Co, Cr, Eu, Fe, Rb, Sc, Se, and Zn). Stable Cs and Sr transfer factors will give important information to the equilibrium transfer factors at different sites and help identifying sites that are ecological sensitive to Cs. Especially the soil from Iceland shows high transfer of stable Cs and Sr. Tracer studies of ^{134}Cs and ^{85}Sr have been included to study the rate of fixation to irreversibly bound sites in soils.

Planned activities in 1997

The sub-projects (A, C & D) will be running in 1997, as previously planned. It is important to continue sampling, in order to get as long time series as possible. Input to modelling work has been given as questionnaires, and more emphasis will be put on the model work next year.

Two meetings are planned in 1997. The first meeting will be held 29-30 May at Alnarp, Sweden. The second and possibly later meetings will focus on writing of the final report.

Requested NKS funding in 1997

THE SHEEP PROJECT	1997
Sweden	100.000
Norway	75.000
Denmark	100.000
Iceland	100.000
The Faeroe Islands	75.000
Study of intake of fungi	-
Study of soil ingestion	60.000
Model work	60.000
Meetings	30.000
Total	600.000

EKO-2.2 Transfer of radiocesium via mushrooms to roe deer and man («the forest project»)

The forest project has been formed into three subject areas; the use of natural products for consumption (with focus on mushrooms), ecological half-lives, and levels of radiocesium in roe deer and their consumption of fungi. Unfortunately, neither 1995 nor 1996 have been good fungi year, it has therefore been difficult to establish the fungi influence on transfer of radiocesium from forest areas.

The group has met once in 1996.

The use of natural products for consumption

Finland

At STUK a consumption survey on wild food products was carried out in spring 1996. The results were reported at the 7th Nordic radioecology seminar in Reykjavik in August. A continuation of data treatment and dose assessment is in progress since October. The study is parallel with corresponding surveys carried out in Sweden and in Denmark.

The goal of the study was to collect consumption data relevant for radiation dose assessments. Normally the food consumption surveys do not distinguish between species of e.g. mushrooms. Such surveys often ignore the differences in radionuclide contents of wild food types. Also re

gional differences in consumption patterns are of importance for dose assessments, when the deposition densities of fallout radionuclides differ by regions. Information on the diet of children is of interest, and there is a special need for it. These features were considered in the design of a national consumption survey carried out in Finland during the first half of 1996.

A mail survey was sent to 1500 households. The regionally stratified random sample was weighted for population. The country was divided into four regions: metropolitan region, western, eastern and northern Finland. Questions referred only to food which was consumed at home. Surveys on food eaten outside homes are available.

The questionnaire, 22 questions with clarifying sub-questions, was focused on the consumption of game, berries, reindeer meat, freshwater fish, wild mushrooms and some other wild food products of vegetative origin. The response rate of 59 % was reached after two reminders. Filled out questionnaires were returned from 884 households and the number of persons included in the responding households were 2360. The age distribution of our sample represents quite well the age distribution of the population. In our sample the percentage of hunters exceeded that in the whole population, which had to be taken into account. Hunters seem to have been more eager to return the questionnaire than other subgroups of population. The data was therefore analysed separately for hunters and non-hunters and thereafter the figures concerning the whole country were corrected by weighing.

The main product groups consumed were berries and fish by *per capita* consumption rates of 8.3 and 7.9 kg/y. Other mean consumption rates were: wild mushrooms 1.5, game 1.2 and other wild food products of vegetative origin 0.4 kg/y. Reindeer meat was used 0.52 kg per year. For hunters the groups of berries, freshwater fish and game were all equally important with a mean consumption rate of 13 kg/y for a member of the household.

Regional differences were quite obvious. Biggest consumption of mushrooms was in eastern Finland (2.2 kg/y) and more than half of the mushrooms consumed were of *Lactarius* type. *Lactarius* is the most commonly used mushroom family also in northern Finland, where the consumption rate was the lowest in Finland, however. In this sub-region the mean consumption of wild berries was greatest, 13 kg/y , to which "lingonberry" contributed most. Freshwater fish was used most in eastern Finland in the large lake district. The consumption of game meat differed already between metropolitan regions 0.32 kg/y to northern Finland's 1.8 kg/y. The most important species was moose. The other products of vegetative origin consist of sap, nettle, herbs and lichen. The consumption of sap was surprisingly high; 0.24 kg/y in the whole country, while people in eastern Finland consumed 0.44 kg/y. The use of reindeer meat was as was expected: biggest amounts in northern Finland and least in western and eastern Finland. The consumption pattern followed the availability of the product.

In the metropolitan region it is more common to buy wild food products than in the other regions. About half of the households used berries and fish outside the season, while berries were used in most of the households (91%) throughout the year. A good harvest year would increase the consumption of mushrooms by 60% and of berries 20% compared with the year 1995, which was not a good mushroom year.

The cooking methods of mushrooms were traditional. *Lactarius* type mushrooms were parboiled or salted as were most *Russula* type mushrooms. Most of *Boletus* type of mushrooms and *Cantharellus cibarius* were cooked without any pre-treatment. In northern Finland 15%

of used berries were made into steam juice, while in metropolitan region only 3%, and in the whole country 8%.

Only 3.3% of population did not use any wild food products at home. In the group of non-hunters the most consuming households used a total of 72 kg/y of all wild products. In the group of hunters the same figure was 130 kg/y per user.

Consumption of mushrooms and berries was greater than findings of the previous studies. This was probably not a non-response error, as shown by the preliminary results of the telephone survey of the group of non-responders.

Further analysis of the data will reveal the significance of areal differences. The analysis will be done by the Kruskall-Wallis test, which is a non-parametric test and quite powerful for data which are not normally distributed. The consumption data will be connected with the regional data for radiocesium in mushrooms and the radiation doses received annually will be calculated.

The study revealed regional differences in consumption rates. It is also important to consider the different consumption patterns in rural and densely populated areas and in sub-regions of the country. The results will improve the reliability of dose estimation when wild food products are concerned.

Sweden

In the forest ecosystems fungi have a very important role both in the transfer of ^{137}Cs from soil to fruit bodies of fungi as well as in the soil-plant transfer and for both pathways further to animal and man. The direct pathway to man is that people pick mushrooms and since the ^{137}Cs activity concentrations in many species is very high quite large activities can be transferred this way.

In 1995, we sent a questionnaire to 1000 families in Avesta commune in the central part of Sweden asking about their mushroom picking habits. Based on the answer of the first questionnaire a second was sent to those families who were picking mushrooms at least two times a year. They were asked to answer in more detail how much of various species of mushrooms they were picking either 1995 (a poor mushroom year) and also asked to try to estimate how much they were picking a normal mushroom year. To the later group a similar questionnaire was also sent in 1996.

59 % of the families who answered picked mushrooms more than two times per year and to them we sent a second questionnaire. The three most frequent species in the mushroom basket were *Cantharellus tubaeformis* (0.35 kg fresh weight (fw) per capita during 1995 and 0.84 kg a normal year), *Cantharellus cibarius* (0.17 kg in 1995 and 0.54 kg in a normal year) and Boletus edulis (0.04 kg in 1995 and 0.25 kg in a normal year). Additionally 0.19 kg of other species were picked in 1995 and 0.49 kg in a normal year.

Previously we had determined the aggregated transfer factor, TF_g for *C. tubaeformis* to be 0.94 m^2/kg dw, 0.39 for *C. cibarius* and 0.28 for *B. edulis*. The TF_g for the other species was usually higher and we used the value 1.0. From this values and the mean ground deposition in Sweden - 10000 Bq/m^2 - an estimation of the mean Swedish ^{137}Cs levels in *C. tubaeformis*, *C. cibarius*, *B. edulis* and the other mushrooms in Sweden could be done. In this estimation we

assume that our research area is representative for all Sweden which of course could be questioned. The estimated mean levels were for *C. tubaeformis* 752 Bq/kg fw, for *C. cibarius* 312 and for *Boletus edulis* 224. For the other species the mean level was 800 Bq/kg.

Combining these values with the consumption data the estimated transfer of ^{137}Cs to each person in Sweden was for C. tubaeformis 263 Bq in 1995 and 632 a normal year, for C. cibarius 53 Bq in 1995 and 168 a normal year, for Boletus edulis 9 Bq in 1995 and 56 Bq a normal year. The other species contribute with 152 Bq in 1995 and 392 a normal year. All together the estimated potential transfer to the mean Swede was 477 Bq in 1995 and 1248 a normal year corresponding to 6.0 µSv in 1995 and 16 µSv a normal year. The corresponding potential collective dose in Sweden was 48 manSv in 1995 and 128 manSv in a normal year. These values correspond to the total activity in the mushroom basket which is higher than the real intake due to reduction of ^{137}Cs levels during the food processing. For example parboiling will reduce the ^{137}Cs levels in most mushroom with up to 80-90 %.

Table 1. The consumption (kg fw/y per average Swede) and transfer factors (TF_g) of the three most important species of fungi and the estimated potential transfer of ^{137}Cs (Bq/y) to average Swede. No loss of ^{137}Cs from the picking of mushrooms to intake is included in the calculation.

Species	Consumption (kg fw)		TF_g (m^2/kg dw)	transfer to man (Bq per capita)	
	1995	normal year		1995	normal year
C. *tubaeformis*	0.35	0.84	0.94	263	632
C. cibarius	0.17	0.54	0.39	53	168
Boletus edulis	0.04	0.25	0.28	9	56
Other species	0.19	0.49	1.0	152	392

The results of the 1996 questionnaire have not been processed yet, there are still coming some answers.

Denmark

The Danish survey is reported in NKS report R-EKO-2(1996)*1 "The use of natural products for consumption in Denmark*". The main conclusions are that the Danes use their natural and semi-natural ecosystems to collect or shoot food products in an average amount of approx. 2 kg/year. Berries and game animals are the most important categories, whereas mushrooms and limnic fish are less important. Besides limnic fish, marine fish not in trade, make up a part of the use of natural ecosystems that was not treated in the survey.

A total of 30% did not use consumable products from nature at all, some of the rest buy products of Danish origin at restaurants or in shops. There was, however, a great individual variation, primarily determined by geography, education and employment. The total average intake of natural products was about 1% of the total consumption of food in Denmark. Hence it could be concluded that the value of natural and semi-natural ecosystems as a food source was of minor importance in Denmark.

Norway

A Norwegian survey, following the Danish/Swedish model has been started. No results are available at this point of time.

Levels of radiocesium in roe deer and their consumption of fungi

Sweden

The ^{137}Cs levels in roe deer show a very marked seasonal variation with peak levels during the mushroom season in August to October. During this period, often 20 to 30% of the roe deer rumen content is found to be mushrooms so it is quite clear that roe deer consume large quantities of mushrooms.

In 1992 and 1993, the mean aggregated transfer factor, T_{ag} for roe deer during August to October was 0.093 m^2/kg and 0.027 during the rest of the year. The annual harvest of roe deer in Sweden has been about 300,000 animals and assuming a mean meat weight of 10 kg per roe deer the annual meat production is 3 million kg. About one third of the harvested roe deer corresponding to one million kg meat is harvested during August to October. Assuming that our research area is representative for all roe deer ecosystems in Sweden, the mean roe deer in Sweden has a ^{137}Cs level of 930 Bq/kg in August to October and during the other part of the year 270. Of this 930 Bq/ kg, 660 is due to ^{137}Cs coming from mushrooms and the rest - 270 Bq/kg - coming from intake of "normal" fodder. The total potential transfer of ^{137}Cs to man by roe deer meat is 930 MBq during August to October and 540 MBq during the rest of the year, totally 1.470 MBq. This will mean that the mushrooms were the vector for 45 % of the total roe deer based transfer. Using the ICRP dose conversion factor of 1.3×10^{-8}, the corresponding potential dose commitment is 19 manSv of which 9 manSv is due to mushroom transfer.

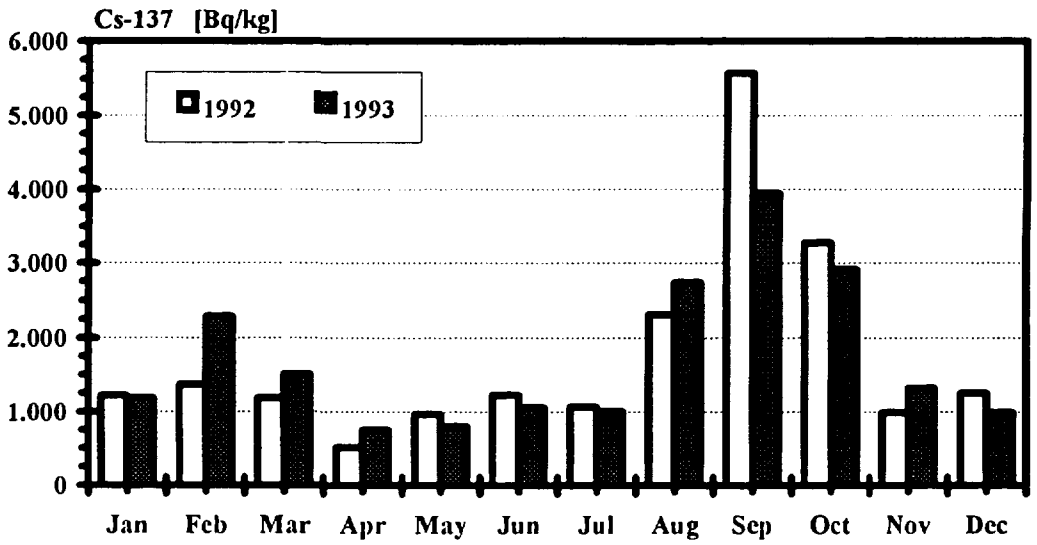

Figure 1. The seasonal variation of ^{137}Cs levels in roe deer.

One of the aims for the research in 1996 was to study which species of fungi could be found in the rumen of roe deer. The mushrooms abundance in 1996 was, however, extremely low and therefore we realized that it was not possible to obtain relevant information this year.

The mean ^{137}Cs levels in moose harvested in our research area had during the period 1986 to 1993 a mean value of about 750 Bq/kg, given an aggregated transfer factor of 0.02. In 1994 there was a small decrease in the ^{137}Cs levels in moose and in 1995 a more pronounced de

crease to about 450 Bq/kg or 40 % of the mean value of the period 1986 to 1993. In 1996 there were also rather low mean levels of 490 Bq/kg. The only reasonable explanation for this decrease is the fact that there were very few mushrooms in the research area during August and particularly during September 1995 compared to previous years. In September 1996 there were practically no fruit bodies of mushrooms in our sampling area. The ^{137}Cs levels in moose during the hunting period that started in October are mainly dependent on the intake of ^{137}Cs during September.

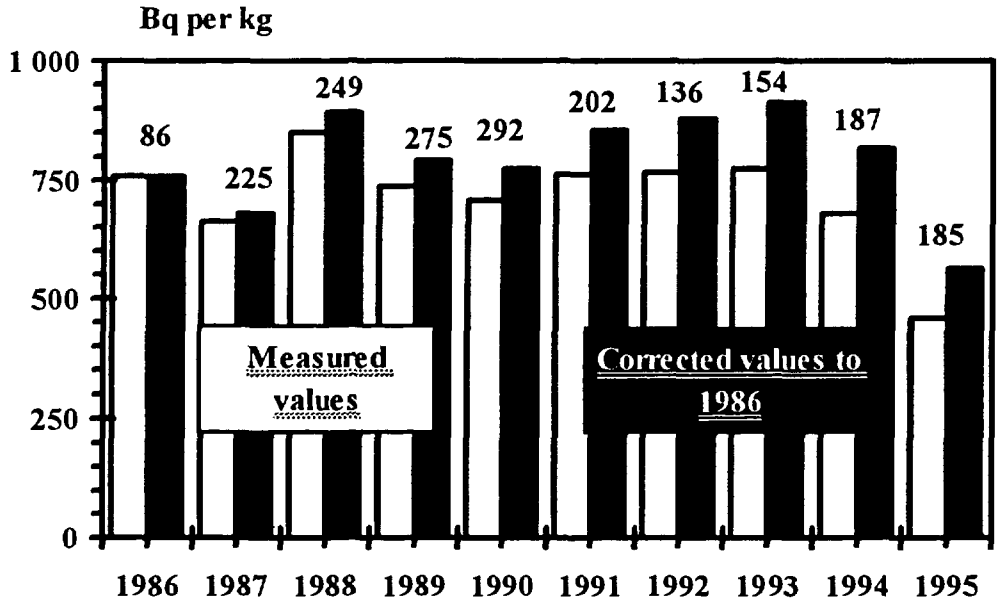

Figure 2. The mean ^{137}Cs levels in moose harvested in the Harbo-Nora-Östervåla hunting organisation during 1986 to 1995.

The annual harvest of moose in Sweden has been about 100 000 animals and the mean moose carcass weight is 135 kg or about 100 kg meat. The annual production of moose meat in Sweden is thus 10 million kg. The aggregated transfer factor for moose seems to be about 0.02 at least in the central part of Sweden. The ^{137}Cs levels in a mean Swedish October moose is about 200 Bq/kg and the total transfer of ^{137}Cs to man by moose should thus be 2 GBq. Of this roughly 40 % or 800 MBq is due to intake of mushrooms (comparing levels in good mushroom years with levels in poor mushroom years). This will correspond to a dose commitment of 10 manSv due to mushrooms and 15 manSv due to vascular plants.

Norway

The goal has been to investigate the role of mushrooms for transfer of ^{137}Cs to roe deer meat at Ytterøya in the inner part of the Trondheim Fjord.

Ytterøya is located at 63°45'N and 11°O in the Trondheim Fjord, and has since 1964 been part of Levanger municipality. The total area is 28 km^2, whereof 50% agricultural land, 25% productive pine forest, and the rest less productive forest and some mire. The annual precipitation is 750 mm and the climate is locally mild with snow covered ground only in short periods.

Roe deer biotopes are found everywhere, with a change between cultural landscapes with good autumn/winter and early spring grazing areas. Most probably the most populated roe deer areas in Norway are found on Ytterøya, with an annual hunt of 300 deer.

Biological samples have been collected both in 1995 and 1996: 45 samples of muscle, 25 rumen or faeces samples and 30 samples of main grazing plant species. At 4 locations, gammaspectrometry has been performed *in situ*. Samples from animals have been collected in the period September - December, and plant species and in situ measurements are made in September 1996. The 4 locations were chosen based on fresh roe deer tracks. Mushrooms could not be found during the field work, and both 1995 and 1996 were reported to be poor mushroom years by the local population. Results from 1995 are finished, whereas the hunting season for 1996 is not finished yet.

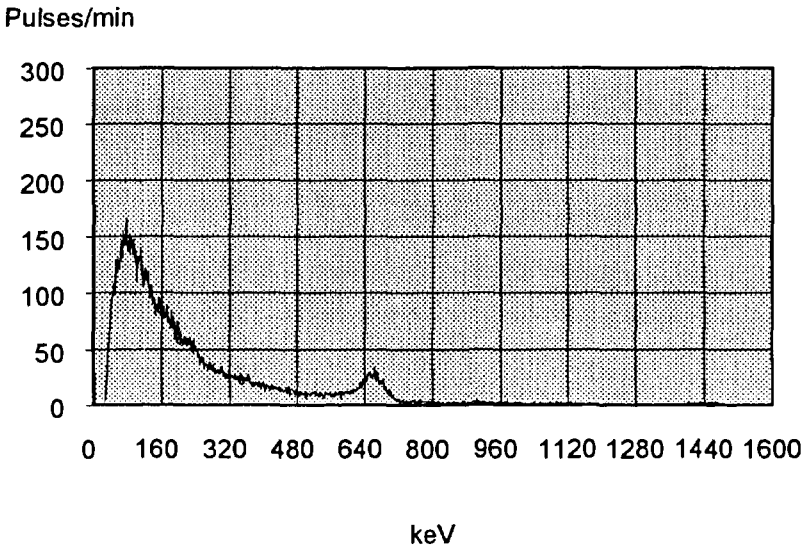

Figure 3. Example of an in situ gamma spectrum, indicating the ^{137}Cs deposition at Tangen farm 10.09.96 with a peak at 661 keV.

In uncultivated areas 800-1000 pulses/minute is found in the designated energy interval from 517 to 723 keV, while in cultivated areas (grass land) the levels are 150-250 pulses/minute. Based on calibration, the present activity of ^{137}Cs is calculated to 8 kBq/m^2 in uncultivated areas and 2 kBq/m^2 in grass land.

The meat samples from 1995 show an average concentration of ^{137}Cs of 200 Bq/kg (number of samples, n=79). There is a large variation within the group ranging from 0 to 1100 Bq/kg. Values related to time of hunting show apparently no trend connected to time of year. The variation most probably reflects the different grazing patterns. The ratio between meat and faeces samples is about 1:1. The rumen samples show lower values, and will be analysed for content of different plant species.

Planned activities in 1997
Collection of roe deer meat, faeces and fungi will be continued in 1997. Finland, Sweden and Norway will finalise the different consumption surveys, and compare the results.

Ecological half-lives in fungi, selected species in Sweden
The evaluation of the half-lives in selected species of fungi will be performed next year. From 1990 to 1996 all fruit bodies of fungi growing at three sites at the Swedish research area have been collected. Final processing of these results are not yet done, but they will certainly give the possibility to estimate the ecological half-lives for rather many species.

Two meetings, the first one in Helsinki January 8.-9. are planned in 1997.

Requested NKS funding in 1997

THE FOREST PROJECT	1997
Roe deer and fungi:	
Sweden	40.000
Norway	40.000
Questionnaire:	
Sweden	15.000
Finland	15.000
Norway	15.000
Ecological half-lives in fungi:	
Sweden	20.000
Denmark	20.000
Finland	20.000
Analysis of moose jaws: Norway	5.000
Meetings	15.000
Total	205.000

EKO-2.3 Ecological half-lives in limnic ecosystems («limnic systems»)

Markus Meili has functioned as project leader for this sub-project since the start in 1994. During 1996 there has been one working meeting in Umeå with parts of the group. Markus Meili is also in regular contact with the EKO-1 group.

The project aims at quantifying the physico-chemical mobility of radionuclides in soils and sediments, and the biological transfer to fish. The main focus of the project is on radiocesium from the Chernobyl accident in Nordic lakes.

A. Models and maps of lake susceptibility to fallout

Compilation and evaluation of aquatic field data
The main objective of this part of the project is to compile data from the Nordic countries in order to derive a Nordic map that describes the geographical variation in the transfer of ^{137}Cs

from soils to water and freshwater fish. The resulting map(s) will be based on field data and models which are derived from the other sub-projects within EKO-2. The VAMP-model (IAEA) predicted the concentration of ^{137}Cs in lake water and predatory fish using 9 components. In this project we are specially concerned about factors controlling the transport of ^{137}Cs from the catchments to the lakes and the internal loading from the sediments; these are crucial factors for the long-term temporal development of ^{137}Cs in water and fish. The variation in the transfer from water to fish is derived from the concentration of potassium in lake water.

Transfer from soil to water

The loss of radiocesium during the first 10 years after Chernobyl fallout was quantified using a model that describes the loss from 3 different soil types (wet mire, dry mire and mineral soil) and soil and fallout data. The basics of this approach was given in the technical report EKO-2.3 (1995) and a Swedish map was presented in May 1996 at the International Symposium of Ionising Radiation in Stockholm. The loss model gives a gradually changing map picture with smaller differences between different areas, due to that the most easily leachable stores (wet mires) are being emptied. However, still 10 years after Chernobyl the highest areal losses could be found in areas with a high frequency of mires. With municipalities as the smallest geographical units, the present yearly loss never comprises more than a few per mille of the initial ground deposition (it can be locally higher in small catchments). Due to a higher relative contribution from storages with a slower loss rate, the activity in stream water is now decreasing at a low rate. Empirical data shows that the activity could even increase temporarily depending on hydrological conditions.

Transfer to fish

The activity of ^{137}Cs in lake water at a certain time is obtained from the loss model connected to a lake model that accounts for hydraulic residence time and relative sedimentation. The mean activity of ^{137}Cs in fish at a certain trophic level is then calculated from a bio-accumulation factor which is dependent on the concentration of potassium in lake water. This model was used to construct map predictions of the transfer of Chernobyl fallout to fresh water fish at certain points in time and integrated over time.

The model is continuously evaluated against empirical data. Figure 4 gives the predicted and observed transfer from Chernobyl fallout to non-piscivore fish (Bq/kg fresh weight: Bq/m^2) for 41 Swedish lakes during 1991 and lakes from 7 different regions in Finland during 1994. There is a fairly good agreement between empirical and predicted data in both geographical resolutions. These data also indicates the slower rate of decrease in fish during the mid-1990's. The activity of ^{137}Cs, not only in non-piscivores such as small perch and roach but also in piscivores, seems to have reached a level during 1993 to 1995 from which the activity even could increase temporarily, e.g. during a period with a high runoff. This is a temporal development which is in accordance with the observations in stream water and lake water and which also could be predicted theoretically from a combined loss and lake process model. Potassium concentrations in water and complementary limnological data from about 1000 Finnish lakes have been compiled along with Swedish data. The compilation of Norwegian data on freshwater fish is now given high priority in order to maintain the schedule.

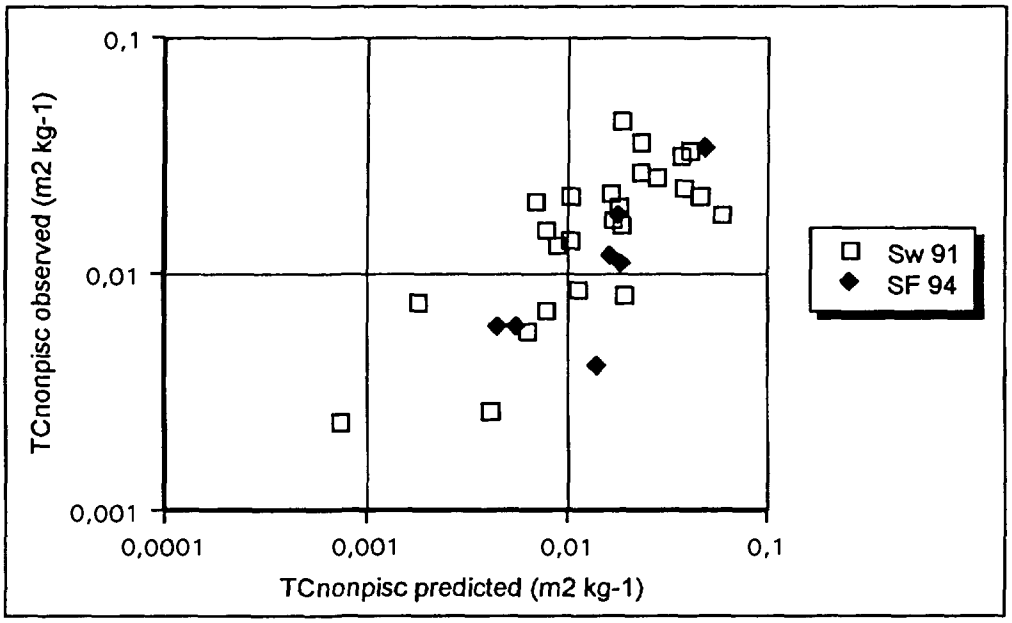

Figure 4. Observed and predicted transfer coefficients of ^{137}Cs from Chernobyl fallout to non-piscivore fish in 41 Swedish lakes during 1991 and in lakes of 7 regions in Finland during 1994.

B. Loss of ^{137}Cs from land to surface waters

The aim of this project is to quantify the discharge of radiocesium and radiostrontium from five Nordic catchments as well as to compare the contribution from subcatchments. Three size fractions have been investigated (>1mm, intermediate and <0.45Om).

During 1996 samples were taken from all of the included catchments. The classification of vegetation types was completed (Finland). Results of ^{137}Cs and ^{90}Sr together with the measured runoff have been used to calculate the transfer of nuclides from the catchments. So far we can see that radiocesium is more effectively washed out from deep organic soils than from mineral soils and that part of the discharging cesium is intercepted (via sedimentation or uptake in biota) in the small streams. In some cases the activities in streams are higher than in the corresponding lakes (see below). This is more pronounced as the fraction of catchment composed by bogs (mires) increases. The English catchment Devoke has been included as a comparison to the Nordic catchments.

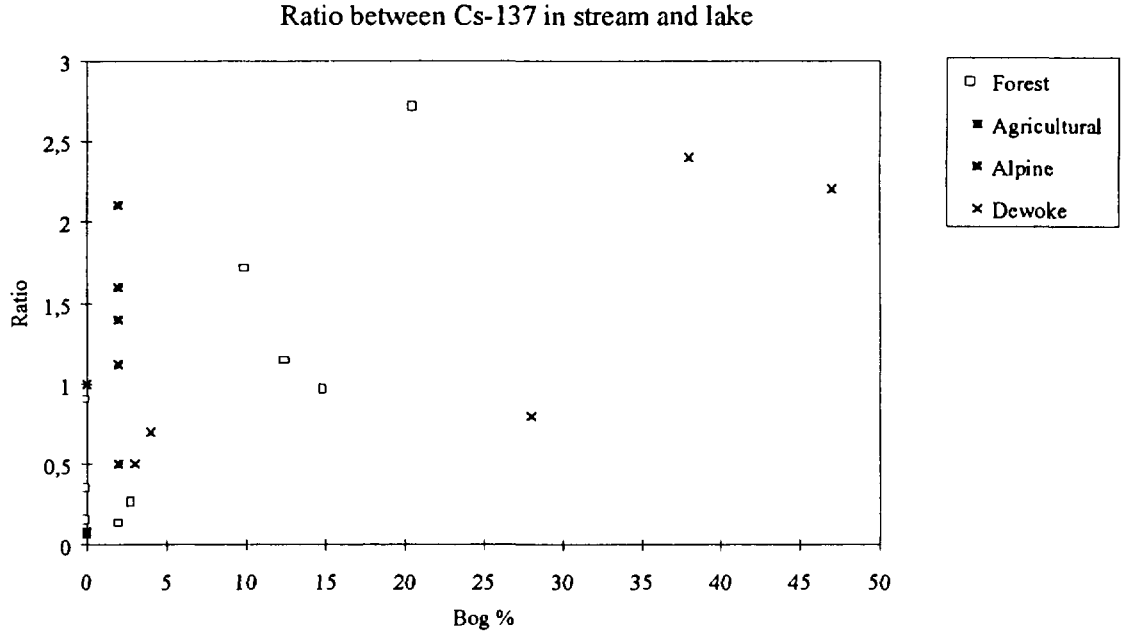

Figure 5. Ratio between Cs-137 in stream and lake related to the amount of bog in the catchment area.

The major portion of Cs in the fraction is less than 0.45 Om. The fraction of Cs associated with particles larger than 0.45 Om seems to be highest during summer and autumn. Up to 56% of the discharged activity is found in the fraction > 0.45 Om during this season.

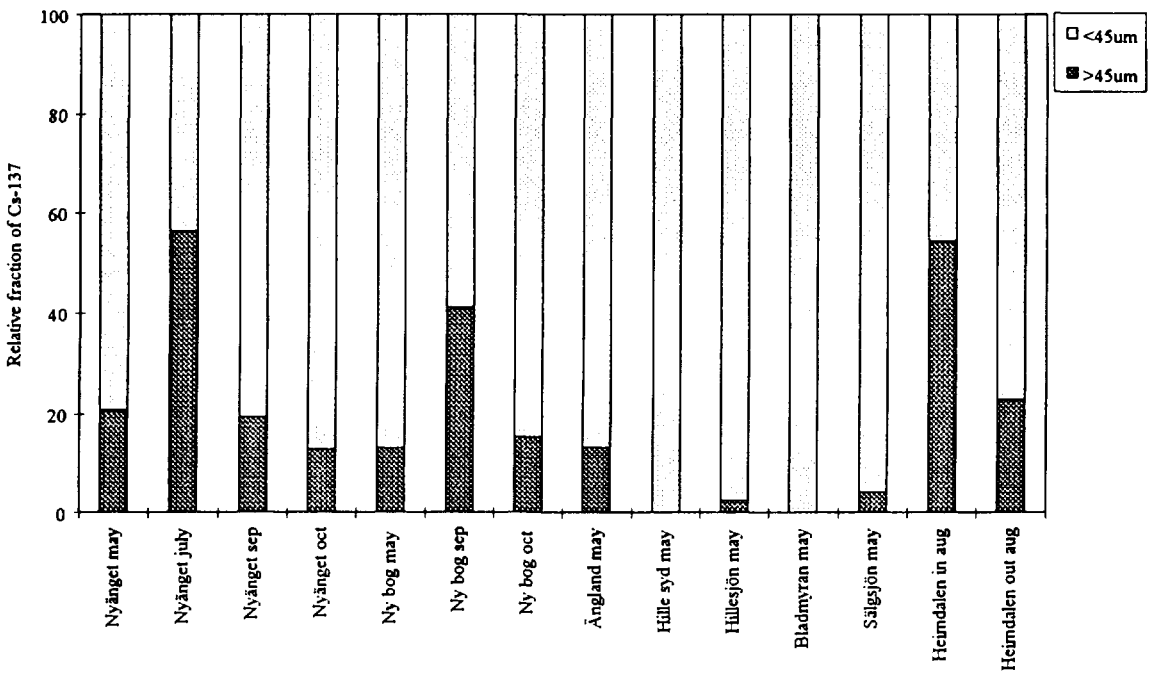

Figure 6. Composition of particulate Cs-137 in water at different times of the year.

Most of the discharge of radiocesium takes place during the spring peak, discharge associated with snowmelt. A positive influence of runoff intensity on the activity concentration of ^{137}Cs was evident, implying that surface water is the mediator for Cs discharge. This influence was not observed for strontium which may indicate that the main medium for Sr discharge is the groundwater. Furthermore, most of the Sr activity was found in the fraction < 0.45 Om. For radiostrontium there is no clear influence of the vegetation types and land-use of the catchment. However, a trend towards higher activity in stream water from forests than from agricultural land was observed. The levels for ^{90}Sr in stream water were in many cases as high as for ^{137}Cs, although the deposition was a factor 20 to 100 less. This was expected due to the higher mobility of strontium in soil (at least in mineral soils).

Presentations

Some of the results from this project were presented during the international symposium on ionising radiation: Protection of the Natural Environment held in Stockholm, Sweden at 20-24 May 1996.

C. Sediments as a secondary source of ^{137}Cs to fish

In most Nordic lakes, most radiocesium (more than 95%) is associated with sediments. It is thus likely that sediments are an important secondary source of ^{137}Cs to the lacustrine biosphere. Our aims are to determine the relative importance of sediments (versus catchments) as a secondary source of ^{137}Cs, to quantify long-term trends and to evaluate potential remedial actions. The mobility of ^{137}Cs in sediments may be controlled by fundamentally different processes: (1) Resuspension of particulate radiocesium, especially in shallow areas (shallow lakes), (2) Diffusion of dissolved radiocesium, especially in anoxic environments (deep lakes).

A Nordic database covering over 20 lakes is being compiled to study the horizontal and vertical distribution of ^{137}Cs in lake sediments, in particular the inventories of ^{137}Cs in lake sediments, the relationship of ^{137}Cs inventories with water depth, the relationship of ^{137}Cs inventories with bottom slope, and the resuspension of ^{137}Cs. In addition, a recent detailed study of 5 Swedish lakes in summer 1996, 10 years after the fallout, showed a proportional relationship within each lake between ^{137}Cs inventories and sedimentation rates based on vertical profiles of ^{137}Cs, Hg and C. This supports the initial hypothesis that sediment resuspension is the main factor controlling the turnover of bulk ^{137}Cs within lakes.

While such patterns suggest immobility of particle-bound ^{137}Cs, high levels in fish even in lakes with negligible input of ^{137}Cs from land indicate at least some mobility. This apparent contradiction was corroborated by analysing vertical ^{137}Cs profiles in sediments simultaneously showing both an immobile and a mobile fraction (Meili & Wörman 1996). Sequential chemical extraction of soils and sediments in summer 1996 showed that most ^{137}Cs is strongly bound, much of which cannot be released even with strong chemicals (Oscarson, Sandqvist & Meili, in prep.). Within lakes, binding patterns were fairly similar and suggested good reproducibility of the procedure. However, binding patterns differed strongly not only among sites, but also among grain-size fractions.

A prognostic lake recovery model based on both sediment resuspension and chemical remobilization is being developed to assess the long-term immobilisation of ^{137}Cs and to make prognoses about the state of contamination in different parts of a lake ecosystem (Meili et al., in prep.). The observed fluxes of sedimentary ^{137}Cs and their projection into the future indicate

that the initial recovery of the sediments is limited to the most shallow area. Only later, decontamination progresses towards deeper zones, where contaminated particles are slowly buried. It appears that both the physical and the chemical immobilisation have a present half-life of around a decade, which agrees quite well with half-lives observed in fish. These "half-lives" should not be treated as constants as they appear to increase over time.

The relative importance of sediments versus soils in sustaining high levels of ^{137}Cs in waters and fish of Nordic lakes will be evaluated in the final report 1997.

D. Bioavailability of particulate ^{137}Cs to invertebrates

Resuspended as well as deposited particles are taken up by planktonic or benthic invertebrates, which are likely to assimilate associated ^{137}Cs. Suspended particles are taken up by filtering zooplankton, whereby ^{137}Cs is likely to be transferred to fish. Moreover, benthic animals, which also constitute an important source of food to fish, are exposed to the ^{137}Cs at the sediment surface. Consequently, concentrations of ^{137}Cs in lacustrine food chains are likely to be controlled by the turnover and burial of contaminated sediment particles. Food chain transfer of both sedimentary and resuspended ^{137}Cs may thus substantially retard the natural decontamination of lacustrine fish communities.

In 1996, a laboratory study was initiated to study factors affecting the bioavailability of dissolved ^{137}Cs (Hagström & Meili, in prep.). Planktonic algae were chosen as test organisms, as they constitute the basis of food chains. As expected, the concentration of cations showed a major impact on the uptake of ^{137}Cs. An inverse relationship with potassium concentration was observed, but only down to a lower threshold. Also sodium and calcium had an influence, but less than potassium. Unexpectedly, the metabolic rate of the algae as controlled by the light climate showed a significant influence not only on uptake kinetics, but also on equilibrium concentrations of ^{137}Cs. The combined influence of ion type, ion concentration, and metabolic rate is presently being evaluated on a theoretical basis (Hagström & Meili, in prep.).

Another important factor is the bioavailability of particle-associated ^{137}Cs. This bioavailability was intended to be quantified partly by compiling available field data of ^{137}Cs in invertebrates and the relationship to concentrations in water and sediments (Jaakola, Forseth, Meili). In addition, laboratory experiments have been initiated to study the uptake of ^{137}Cs from contaminated lake sediments by invertebrates (Forseth et al.). Both approaches are still in progress, and results will hopefully be presented in the final report 1997.

Experiments on the turnover of ^{137}Cs in aquatic invertebrates have also been performed as basis for studies on the transport of cesium from lake sediments to invertebrates. Radiocesium retention and its temperature dependency has been described for several species with different ecological roles. Such data is necessary for the interpretation of experiments on the transport from sediments to invertebrates. In general, biological half-lives are short in aquatic invertebrates but striking differences among species have been found.
One series of experiment directly on the bioavailability of sedimentary ^{137}Cs has also been performed. *Chironimidae* sp. larvae, representing the most important aquatic insects in the freshwater ecosystem, was used. *Chironomid* larvae's live and feed in lake sediments and are probably an important link between the abiotic stores of ^{137}Cs in sediments and freshwater fishes. Experiments were performed on sediments from a lake in central Norway heavily affected by the Chernobyl fallout. Preliminary results indicate a significant accumulation of

^{137}Cs from lake sediment by chironomides. During 1997 a series of experiments will be performed on several aquatic invertebrates maintained in sediments from two Norwegian lakes and with variable vertical distributions of ^{137}Cs.

Planned activities in 1997
All sub-projects (A-D) will be running also in 1997. Fieldwork within sub-project B will be focused on supplementing the already collected samples.

One seminar in March-April and one meeting is planned in 1997. The seminar will focus on the role of organic material and their ability to adsorb radionuclides (and heavy metals). Much attention has been paid to the role of clay minerals, whereas in Nordic environments we experience that organic material and humic solutions play an even more important role. Hopefully this seminar will also give fruitful input to the next NKS period.

Requested NKS funding in 1997

LIMNIC SYSTEMS	1997
Meetings and seminar	60.000
Sub-project A	60.000
Sub-project B	60.000
Sub-project C	60.000
Sub-project D	60.000
Total	300.000

International co-operation

Within all sub-projects in EKO-2 there has been close contact with relevant EU-projects. The closest EU-projects have been:

LANDSCAPE, SAVE, MOIRA and ECOPROC.

Overview expenses in 1996 and budget for 1997

All figures are in DKK.

Funding granted in 1996 was 1.530.000,- whereas funding applied for was 1.590.000,- Some adjustments are therefore made within the three sub-projects.

Sub-project	1996-funding	1996-expenses		1997-funding requested
2.1 The Sheep project	630.000	work performed meetings reserved	565.000 11.100 46.000	600.000
2.2 The Forest project	320.000	work performed reserved	140.100 180.000	205.000
2.3 Limnic systems	330.000	work performed reserved	277.700 60.000	300.000
Project leader	250.000	work performed reserved	175.000 75.000	250.000
Total	1.530.000		1.529.900	1.355.000

The relatively large sums reserved within the forest and limnic project is due to money not being paid until the requested reports are finished.

National funding

A significant part of the work that has been performed within NKS, EKO-2 is financed by the participating institutions, or via other research programmes. On average, 75% of the finance comes from others than the NKS.

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Project participants

EKO 2.1 "The sheep project"

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EKO 2.2 "The forest project"

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EKO 2.3 "Limnic ecosystems"

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