Sweden-Japan Radioecology Workshop for Students, 2015

K. Tanoi, S. Miura,
E. Forssell-Aronsson
and C. Bradshaw Editors

Graduate School of Agricultural and Life Sciences,
The University of Tokyo

NPO Radiation Safety Forum

Department of Radiation Physics, Institute of Clinical Sciences,
Sahlgrenska Academy, University of Gothenburg

Department of Ecology, Environment and Plant Sciences
and Centre for Radiation Protection Research, Stockholm University

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THE UNIVERSITY OF TOKYO

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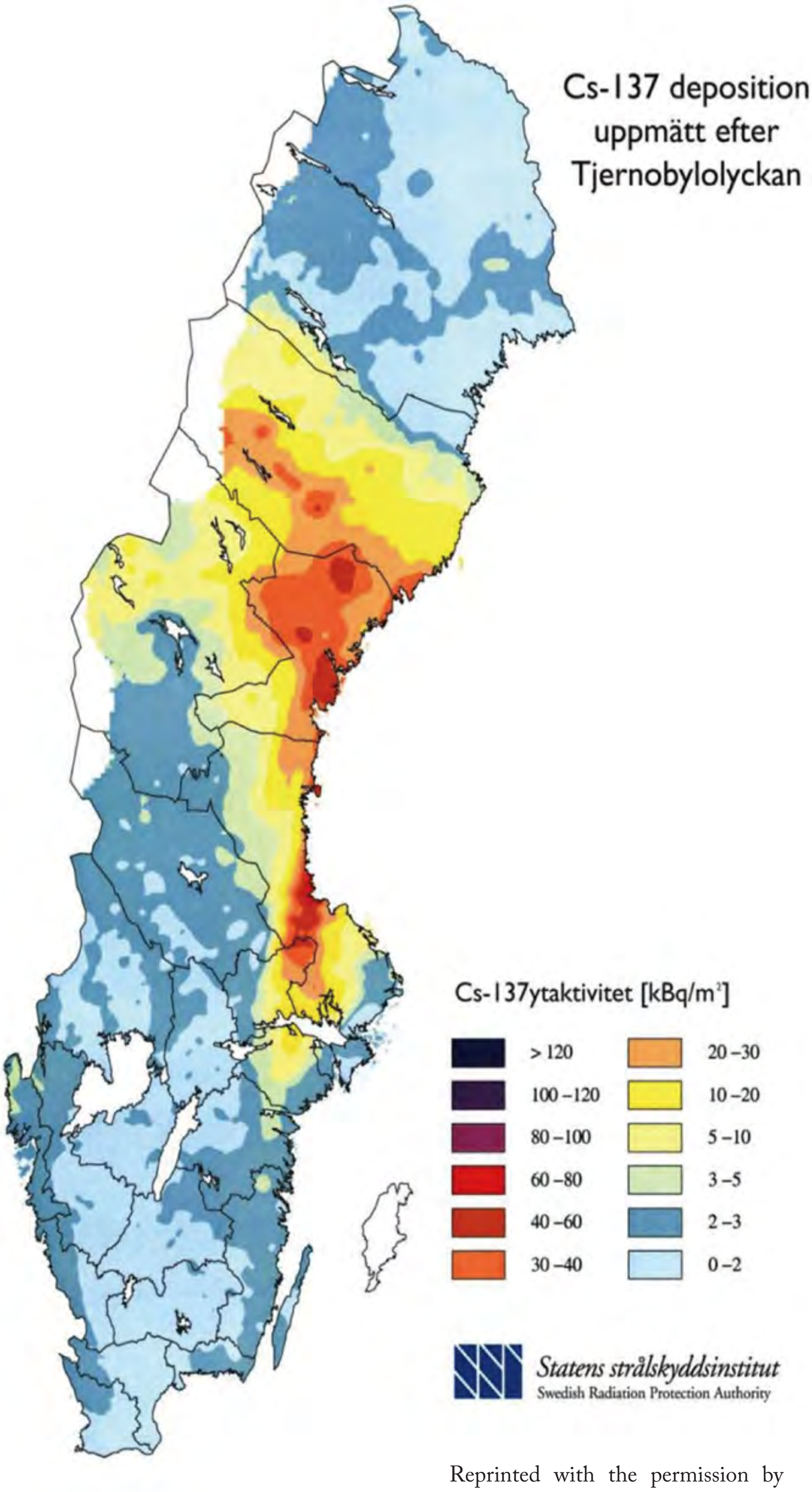

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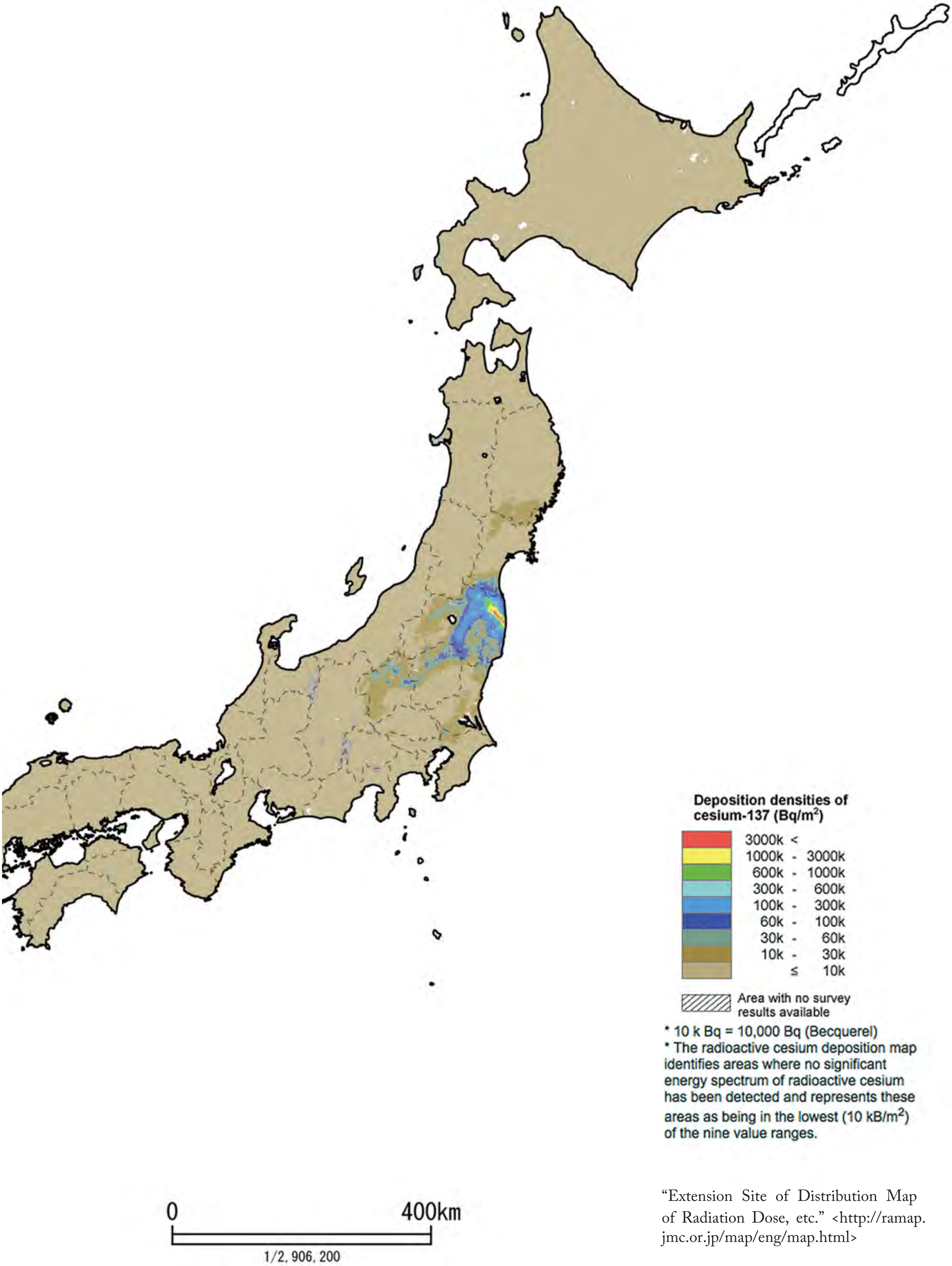

"Extension Site of Distribution Map of Radiation Dose, etc." <http://ramap.jmc.or.jp/map/eng/map.html>

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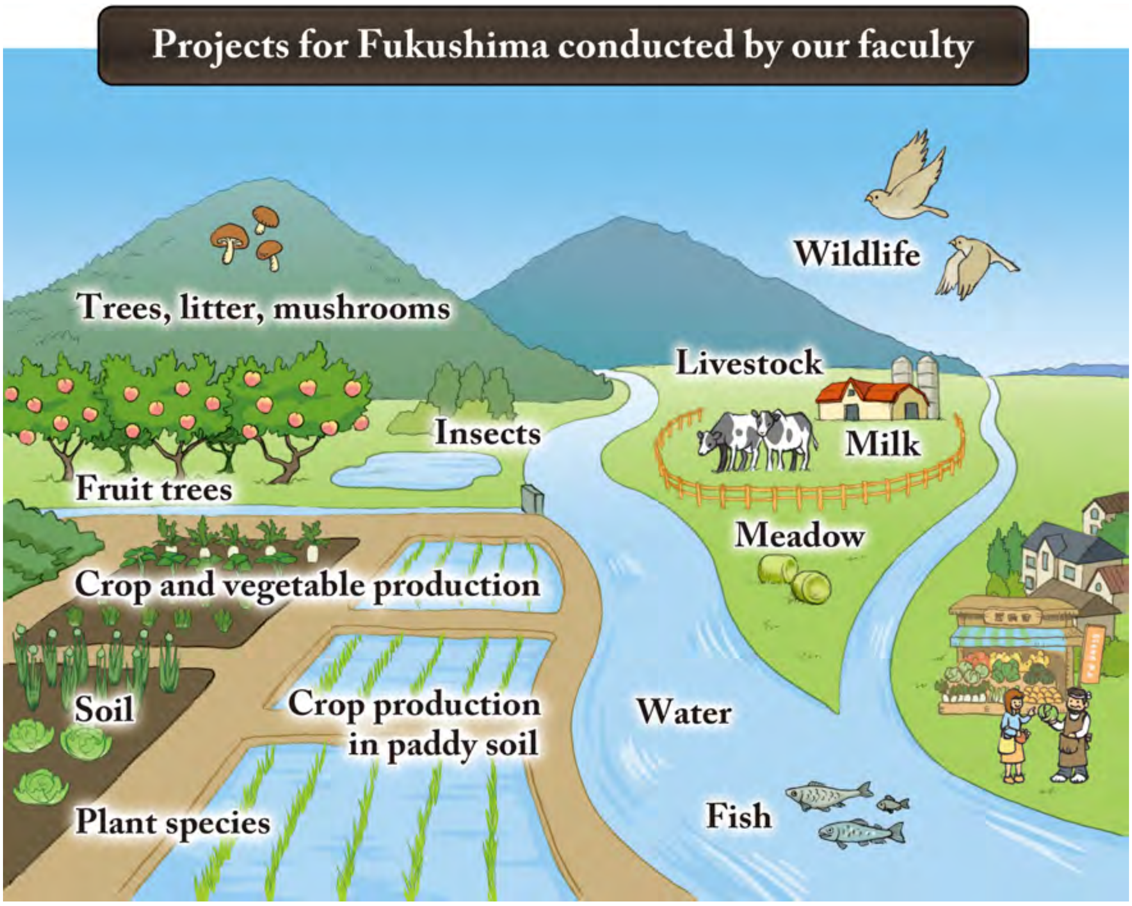
Preface

Four years have passed since the accident at the Fukushima-Daiichi Nuclear Power Plant. More than 110,000 people who were evacuated from the area remain separated from their homes. During these 4 years, the local Fukushima government set up a radiation monitoring system for all agricultural products from the area. For rice, particularly, a special radiation measuring system was developed to measure rice grain before it goes to market.

In our graduate school, 40–50 academic staff began in situ research projects immediately after the accident to trace radioactive materials. Most of these studies rely on volunteer activities. Because our graduate school includes many specialties in agricultural studies, focusing on cultivated fields, mountains, trees, animals, or fish, researchers with expertise in a variety of fields were gathered together to discuss the measures being taken to deal with the contaminated environment. For example, in addition to researchers studying rice breeding, others involved in water or soil studies also came together to discuss radioactive fallout behaviour in the field and to examine the movement of radioactive Cs in rice fields. This was the first time our graduate school has undertaken a collaborative project of such size.



Gradually, our researchers have accumulated data on the movement and accumulation of radioactive fallout in the environment. Our initial purpose, as part of our commitment to contributing to the community, was to show as many people as possible what we have learned about fallout from the nuclear accident, including how it is distributed and how it moves. Seminars open to the public have been held periodically to report the results obtained from studies in the agricultural environment. The first seminar was held in November 2011, and the eleventh and most recent was held in April 2015. Three parallel lecture series were started, for undergraduate and graduate students and for the general public, to teach how the behaviour and accumulation pattern of radioactive Cs change with time. To allow the students to learn about the behaviour of the fallout firsthand, several field studies were also carried out at mountain, agricultural, and meadow sites. The results we obtained during the first 2 years were summarised and e-published through Springer in a book titled "Agricultural Implications of the Fukushima Nuclear Accident", which has already been downloaded more than 50,000 times. A second book with the latest results will be e-published by Springer in 2016. Using these approaches, our results have been utilised effectively in various ways.

Sometimes the accident at the Fukushima-Daiichi Nuclear Power Plant is compared with the accident that occurred at Chernobyl. In the case of the Chernobyl accident, it is well known that the first radioactive measurement of the fallout was performed in Sweden. We found that the study of radio-ecology is highly advanced in Sweden, whereas before the Fukushima accident, similar research in Japan was limited to some special institutes and was not being done at the universities. Most university studies are not widely publicised, which makes understanding radio-ecology difficult for the younger generation. Therefore, we planned the Japan–Sweden joint workshop on radio-ecology not only for our academic staff but also for the students. We are very thankful to Prof. Eva Forssell-Aronsson at the University of Gothenburg for accepting our proposal and to Prof. Andrzej Wojcik and Associate Prof. Clare Bradshaw at Stockholm University for the workshop.

Among the Japanese participants, nine of the students selected were actually carrying out their radio-ecological studies of Fukushima at the university. Before visiting Sweden, they were taught how to summarise their data and present at the seminar. Project Associate Prof. Satoru Miura, who kindly accepted the leadership role for this joint seminar, planned well and, with other academic staff, enthusiastically educated each student. For most students, this was the first time they had discussed their findings with foreign researchers. As can be seen from their reports, this seminar provided them enormous stimulation and motivation to study radio-ecology. Of course, the seminar was also valuable to our academic staff, inspiring them to continue our research studies here in Japan at Fukushima.

We would like to express our sincere gratitude again, especially to Prof. Eva Forssell-Aronsson for organizing this wonderful and fruitful seminar. We all expect that we will continue the radio-ecological study of Fukushima for a long time, while also working on improvements to our educational techniques.

Tomoko M. Nakanishi
The University of Tokyo

University of Gothenburg, Sweden, 1-2 September 2015

On 2 September 2015, 35 scientists from Japan and Sweden met in a joint radioecology workshop at the Department of Radiation Physics at the University of Gothenburg. The main goal of the workshop was to exchange experiences with the nuclear power plant accidents in Chernobyl in 1986 and in Fukushima in 2011. The participants consisted of the Japanese group, researchers and PhD students from Gothenburg, researchers from Lund University (Malmo), and others interested in the topic.

The workshop included 19 presentations with related discussions and opportunities for longer discussions during the lunch and tea/coffee breaks. The day started with two longer presentations: one by Prof Tomoko Nakanishi on agricultural implications of the Fukushima accident in Japan and the second by Prof Soren Mattsson, who presented data on long-term studies of the environmental radionuclide distribution and radiology in southwest Sweden after the Chernobyl accident.

This was followed by several presentations on radionuclide distributions and kinetics in fruit, animals, and soil in Japan, Sweden, and Spain, after the Fukushima and Chernobyl accidents. Some of the presentations were related to radionuclide kinetics in forests, with important findings in Fukushima Prefecture. Most of the speakers reported both expected and unexpected findings, demonstrating the importance of future research in radioecology and the value of proper measurements and studies after a nuclear event.

The final part of the workshop consisted of presentations related to the exposure of humans to radiocaesium, the uranium levels in pit lakes, and the radiobiological effects of low doses of radioiodine.

The workshop also included more general topics. Gunnar Bengtsson, who was Director General of the Swedish Radiation Protection Institute at the time of the Chernobyl accident, gave his personal views on the radioecological competence needed at radiation accidents, based on his experiences at that time. The discussion revealed that this issue is of even greater importance in both Japan and Sweden today.

The previous day, 1 September 2015, the Japanese and Gothenburg groups held a more informal program including a general presentation on the research being conducted in Gothenburg and visits to several laboratories. The afternoon was spent in the Gothenburg Botanical Garden, one of Europe's largest at 175 hectares, and the Anggardsbergen Nature Reserve, where we compared Swedish and Japanese flora and fauna. The original plan to visit some sampling sites in the region had to be abandoned due to heavy rain.

The days we spent together demonstrated the importance of scientific exchange for students and scientists, and I am convinced that the workshop has led to new research ideas and new contacts for future collaboration.

Eva Forssell-Aronsson
University of Gothenburg

Stockholm University, Sweden, 3-4 September 2015

For two days in early September, 2015, twenty-five scientists from Japan and Sweden came together to exchange ideas, results and experiences in the field of radioecology. The two countries have in common that they have both been affected by a large accident at a nuclear power plant: in Japan, the accident at Fukushima Dai-ichi in 2011; in Sweden, the accident at Chernobyl in the former USSR in 1986. In both cases, the longer term problems are caused by the persistance of ^{137}Cs in the environment, particularly in terrestrial ecosystems. One of the main aims of the workshop was therefore to compare how these accidents have affected human and non-human populations in these two countries and to see if we could learn from each other.

The workshop started with two overviews of the post-accident radioecological situation in Japan and Sweden. Leif Moberg, former Research Director at the Swedish Radiation Safety Authority summarised spatial and temporal patterns of environmental contamination from Chernobyl, doses to the Swedish population and actions, countermeasures and dose limits that were decided after the accident. Keitaro Tanoi presented the equivalent situation after the Fukushima accident, revealing many similarities in the issues confronted by the two countries, but also some differences in the way the countries had dealt with these issues. He also gave an overview of the impressive amount of radioecological research now being carried out in the Fukushima area to understand radionuclide transfer in the environment and to humans.

The rest of the workshop was divided into the two broad themes of 'Wildlife' and 'Plant Uptake'. The main issue for wildlife was 137Cs contamination, and talks ranged from moose, boars, bears and frogs in Sweden to fish and other marine species in Japan. In most cases, a central concern was consumption of contaminated wildlife by humans, although doses to the animals themselves was also considered important. After lunch, there were a series of talks about uptake of radionuclides to crops and other plants. Here the focus was more on mechanistic uptake studies and different types of remediation. The quality of the talks was very high, and the Masters and PhD students should particularly be congratulated for their excellent presentations.

During the day there was plenty of time for discussions, which ranged from detailed scientific issues to broader questions to do with the communication of post-accident decisions and radiation risks, something both countries have grappled with.

On the last day, the group visited the Forsmark Nuclear Power Plant to learn about the Swedish system of nuclear waste management and the 10-year site investigation programme being carried out prior to the building of a geological repository for high level nuclear waste.

I hope that this workshop will lead to future exchange of ideas and even collaborations between the two countries; we have much to learn from each other!

Clare Bradshaw
Stockholm University

Contents

Chapter 1
Introduction

Introduction

Satoru Miura
The University of Tokyo

Purpose of the workshop

This report is a record of the "Sweden-Japan Radioecology Workshop for Students, 2015" organised by the University of Tokyo and the NPO Radiation Safety Forum and co-hosted by the University of Gothenburg and Stockholm University. The workshop was held 4.5 years after the Fukushima Daiichi nuclear power plant accident so that Japanese researchers working on restoring agriculture and the environment after a radiation disaster could exchange information with Swedish researchers with experience in demining radioactive contamination caused by the Chernobyl nuclear power plant accident. We thought that it would be good for scientists to think and talk outside Japan in an objective manner during the transition from the initial emergency to a steady state following the accident. The second goal was to provide educational opportunities for students. In 2013, the Graduate School of Agricultural and Life Sciences, at the University of Tokyo (one of the organisers), launched a practical education program on radiation in the 'agricultural environment' and 'food safety' after the Fukushima disaster. We emphasise field work at Fukushima and the program mission, which is to educate students who are interested in environmental radioactive contamination and are motivated to help restore agriculture and the environment after such disasters. We have prioritised the need to foster human resources with a broad knowledge of radiation to ensure a precise response to the issues of long-lasting radiation contamination and to prepare for any future radiation accident. The number of nuclear power plants worldwide is still increasing. We thought that a research workshop of this kind would be effective for teaching researchers to act collaboratively with scientists in other countries, since radioactive contamination is spread trans-nationally. The workshop, entitled "Sweden–Japan Radioecology Workshop for Students, 2015", was made possible by the whole-hearted cooperation of the University of Gothenburg and Stockholm University and was held in Gothenburg and Stockholm. We are proud of this unique opportunity for research exchange with European countries after the Fukushima nuclear power plant accident, targeting education for young students.

History of man-made radiation

Henri Becquerel and Pierre and Marie Curie were the first to recognise radiation, with their discoveries occurring at the end of the nineteenth century. Early in the twentieth century, mankind discovered the enormous energy retained invisibly within the atom nucleus. The use of energy as a weapon was first conceived in the 1930s, and some 50 years after the discovery of radiation, nuclear weapons were first used in 1945, and large amounts of radiation were released into the natural environment. Enormous amounts of radiation continued to be released into the atmosphere, commensurate with the escalated competition to develop nuclear weapons. Ten years after the use of atomic bombs at Hiroshima and Nagasaki, atomic power generation technology was put into practice. In the 50 years since then, mankind has experienced two severe (Level 7) nuclear power plant accidents. If we include less serious accidents that could easily have been worse, then accidents that released artificial radiation on a large scale could have occurred approximately every 10 years. Although the instantaneous explosion of nuclear weapons is terrible, the damage caused by prolonged exposure to radiation from nuclear power plant accidents is also serious and no fundamental mitigation countermeasures have been developed.

The radioactive accident at the Fukushima Daiichi nuclear power plant happened 25 years after the accident at Chernobyl. Japanese society had not learned the valuable lessons experienced in Europe. Listening to the talks by senior people who led the countermeasures in Sweden in 1986, I felt a sense of deja vu with respect to our struggles in Fukushima in 2011. Although this situation is undesirable, human society has still not learned how to address radiation issues even after experiencing several extremely severe radioactive disasters. Consequently, I have realised how important it is for us in Japan to share the lessons of Fukushima with the international community, which experienced the Chernobyl disaster.

In 2011, immediately after the Fukushima Daiichi nuclear power plant accident, the Ministry of Agriculture, Forestry and Fisheries of Japan and the local government of Fukushima Prefecture, many research institutes, universities, and private companies launched full-scale efforts to combat radiation contamination, and they have succeeded in decontaminating areas and establishing practical countermeasures, such as upside-down deep tillage to bury radiocaesium below the rhizosphere and potassium application to reduce caesium uptake by paddy rice. These measures have enabled farmers to recommence agricultural production of many crop plants to a considerable extent. Nevertheless, radioactive contamination of the natural environment, including forests and the ocean, still affects extensive areas. We have not developed fundamental countermeasures for environmental rehabilitation. We believe that it is impossible to recover radiocaesium from the open ocean. It might also be impossible to decontaminate radioactive materials from forests because of the very large area involved and the need to dispose of vast amounts of decontaminated materials removed from forests. Therefore, we have to prepare to deal with a radiation-contaminated environment on a long-term basis.

Japan has a high population density and there are many residents in intermountain regions, where people depend on agriculture or forestry. In April 2014, the evacuation order for a small town within 20 km of the Fukushima Daiichi nuclear power plant was lifted and people have started to return home. However, to resume their lives, they will need to learn how to utilise cropland and forests that have residual radioactive contamination. Many questions that require scientific knowledge and technological countermeasures remain to be solved. The radioactive exhaust from the Chernobyl nuclear power plant was first detected by the Forsmark nuclear power plant in Sweden, as discussed below. I can only imagine the extent of the social chaos in Sweden at that time. Although environmental radioactive contamination from the accident remains, Sweden seems to have adapted to the situation successfully. Japanese society is in a transitional phase, between the state of emergency right after the Fukushima radiation disaster and a future steady-state, and must learn from the experience of Swedish society, which has dealt with radiation and radioactive contamination for more than 25 years.

Education program for students

Another aspect of the student education program was based on a long-held motivation. Although mankind has been able to make practical and effective use of atomic power for only 70 years, we have experienced large-scale nuclear accidents roughly every 10 years, as mentioned above. Ten years is a long time in the modern world, in which everything changes very quickly. Many people who did not experience the radiation disaster from the Fukushima nuclear power plant first-hand might forget the severity of the nuclear accident in 10 years. However, the numbers of nuclear power plants and their cumulative production of electrical energy are still increasing. History tells us that we cannot avoid unanticipated accidents or human error, no matter how thorough the measures we take to prevent accidents. I think that this is the most important lesson from both the Chernobyl and Fukushima radiation accidents. I cannot count how often I heard newscasters use the word "unanticipated" in 2011. Atomic power produces a great deal of concentrated energy compared with hydroelectric power or combustion and it also produces large amounts of radioactive material; these factors underlie the severity of nuclear accidents and represent the reason why careful, thorough preparation is needed. This is true for both off-site environmental contamination and on-site contamination around the nuclear power plant.

I sincerely hope that the students participating in this workshop will serve in a bridging capacity by transferring the experience and wisdom that they gain to the next generation when they are faced with a nuclear power plant accident. In fact, many leading researchers from Europe and the International Atomic Energy Agency have visited Fukushima over the last 5 years to pass on the lessons they learned from the Chernobyl accident to the Japanese. Some of them were graduate students, postdoctoral fellows, or up-and-coming educators in 1986. We believe that a discussion of the common challenges faced in terms of radioecology and radiation protection, through sharing the 30-year experience of the Chernobyl accident gained in Sweden and the 5-year experience of the Fukushima accident gained in Japan, would be valuable for young people and educators from both countries.

Program outline

This workshop report has six sections. The next chapter outlines the program and schedule, and lists the people involved. Chapter 3 consists of the abstracts and presentation slides from the workshop seminar in Gothenburg and Chapter 4 contains the same material from the Stockholm session. Some authors did not submit some or all of the presented material because their data are pending publication. I thank the 25 authors who agreed to make their contributions public.

Our plans were ambitious, because the party from Japan would visit universities in Gothenburg and Stockholm, which are 400 km apart, in 4 days while also fitting in a 1-day workshop seminar and another day of observation activities in each city. The University of Gothenburg and Stockholm University were the leading education and research centres in Sweden after the Chernobyl accident, and thus provided the optimal program. The seminar titles indicate that, although the focus was on radioecology, a wide range of topics on radiation were included.

On Day 1 in Gothenburg, we had the opportunity to observe various radiation research facilities in the Department of Radiation Physics at the University of Gothenburg. We found the story of the whole-body radiation counter in the basement of the Sahlgrenska Cancer Centre to be very interesting. The shield for the whole-body counter was made from very old iron, which was first used in the construction of HMS Vanguard, the last English battleship made (in the middle of the 20th century), and then reused to build a destroyer that was sunk during the Falkland Islands War in 1982. The need for mobile, car-borne radiation-measuring instruments carried in a small pick-up truck was demonstrated. Dr. Juan Mantero Cabrera gave an interesting talk on studies using state-of-the-art alpha-ray spectrometry to determine natural radiation from uranium and thorium in pit lake water, which is a current radiation issue in Sweden. The half-day excursions to Gothenburg Botanical Garden, one of the largest botanical gardens in Europe, and to Änggårdsbergen Nature Reserve, helped us to relax while walking in natural environments that are not very different from those in Japan (albeit that Swedish gardens are very different from Japanese gardens).

Finally, on Day 4 in Stockholm, we were able to observe the sub-marine, final repository of low- and intermediate-level radioactive waste, which has been in operation since 1988, as well as the environmental monitoring sites above the planned construction site of the final geological repository for high-level radioactive waste. Both of these sites are located near the Forsmark nuclear power plant. I was very impressed to learn that the final storage facility has been in operation for more than 25 years. In Japan, we cannot avoid this "backend issue" of atomic power utilisation. Dr. Sara Nordén, an ecologist at Svensk Kärnbränslehantering Aktiebolag (SKB) a Swedish nuclear fuel and waste management company, kindly showed us the monitoring sites in an old spruce forest, as well as a reserve for frogs and orchids in the Labbo Forest wetland. Since my research examines forest environments, I found the old spruce forest and its fluffy understory vegetation to be especially interesting. The detailed monitoring results of the initial environmental conditions are available to the public on the SKB web page (http://www.skb.se/publication/2222643/TR-10-01.pdf). Chapter 6 consists of photographs that outline some of the observation activities undertaken. There are no photographs of the final repository for low- and intermediate-level radioactive waste because no photography is allowed at the site.

Acknowledgements

It was my great pleasure to lead this challenging mission. I was able to give more than a passing thought to advising students and facilitating interactions between Swedish educators and scientists – from the perspective of a scientist – as well as advise on the social responsibility that goes with the utilisation of atomic power given its potential consequences.

I sincerely thank Dr Tomoko M. Nakanishi and Dr Keitaro Tanoi for granting me this invaluable opportunity to plan and coordinate this workshop, which would not have been successful without the unqualified cooperation of the universities involved. I am profoundly grateful to Dr Eva Forssell-Aronsson, (University of Gothenburg), as well as Dr Andrzej Wojcik and Dr Clare Bradshaw who planned and hosted the workshops at their respective universities. We appreciate the many participants of each university, the academic staff from neighbouring universities, and the individuals formerly in charge of the Swedish Radiation Safety Authority (SSM) who willingly responded to calls from the hosts. We also thank all of the staff and students who helped the hosts to prepare and manage the workshops. The names of all of the contributors are listed in the following outline and I thank them all.

Finally, I would like to thank the students who participated in the workshop in such a positive manner. They appeared to benefit from it substantially. Chapter 5 contains their reports and summarises what they learned together with their feelings and thoughts. They were stimulated by their exchanges with both senior leading scientists and young scientists in Sweden. I have no doubt that this workshop gave the students an opportunity to learn beyond the laboratory setting. Hopefully, this successful exchange is the first step towards continuous international education and collaborative research activities to combat radiation problems after nuclear power plant disasters and to prepare for future radiation accidents. Society in Sweden and Japan will continue to strengthen measures against nuclear disasters based on their experiences in recovering from the worst ever disasters at Chernobyl and Fukushima. I am convinced that both countries and their respective universities could become a core group with respect to education and research on radioecology and radio-agriculture. I hope that this is the beginning of a strong partnership between universities in Sweden and Japan.

Chapter 2
Programme and Participants

Sweden-Japan Radioecology Workshop for Students, 2015

Overview

Date:
September 1-4, 2015

Venue:
University of Gothenburg, Stockholm University

Outlines of programme:

Sep 1st	Orientation Facility tour at Department of Radiation Physics, Institute of clinical sciences, University of Gothenburg and discussions on sampling etc. Half day field walk in Gothenburg botanical garden and Änggårdsbergen Nature Reserve Dinner with seminar participants
Sep 2nd	Workshop Seminar on Radioecology at University of Gothenburg
Sep 3rd	Workshop Seminar on Radioecology at Stockholm University – Wildlife and plant uptake – Welcome dinner at Centre for Radiation Protection Research
Sep 4th	Field trip to Forsmark radioactive waste repository and the surrounding ecosystems guided by Dr. Sara Nordén, an ecologist at Forsmark, SKB

People involved

Coordinator and academic staff of mission from Japan:
Project Associate Professor Satoru Miura* (Leader of Japanese visiting group)
Associate Professor Keitaro Tanoi
Associate Professor Naoto Nihei
Assistant Professor Natsuko I. Kobayashi
Laboratory of Radio-Plant Physiology, Radioisotope Center
Graduate School of Agricultural and Life Sciences, the University of Tokyo

Host coordinators in Sweden:
Professor Eva Forssell-Aronsson
Department of Radiation Physics
Institute of Clinical Sciences, Sahlgrenska Cancer Center
Sahlgrenska Academy at University of Gothenburg

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* Currently at Dapartment of Site Environment, Foresry and Forest Products Research Institute

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Special adviser:

Professor Tomoko M. Nakanishi
Laboratory of Radio-Plant Physiology, Radioisotope Center
Graduate School of Agricultural and Life Sciences, University of Tokyo

Participants list in Workshop Seminars in Gothenburg and in Stockholm

Japan side (participated in both workshops) :

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Faculty of Integrated Arts and Sciences,
Hiroshima University

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Dan Aronsson, Dr
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Gunnar Bengtsson, Dr
Former Director general of Swedish Radiation Protection Institute (SSI)

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Robert Finck, Dr
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Stockholm, Sweden:

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Swedish Radiation Safety Authority

Stefan Bengtsson, Dr
Formerly at Swedish University of Agricultural Sciences and Fukushima University

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Robert Weimer, PhD student
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Chapter 3
Workshop at the University of Gothenburg

Orientation of Joint Japan Sweden Radioecology Workshop at the University of Gothenburg

Date:

September 1, 2015

Venue:

Sahlgrenska Cancer Center, Sahlgrenska Academy at University of Gothenburg

1. Overview of department activities

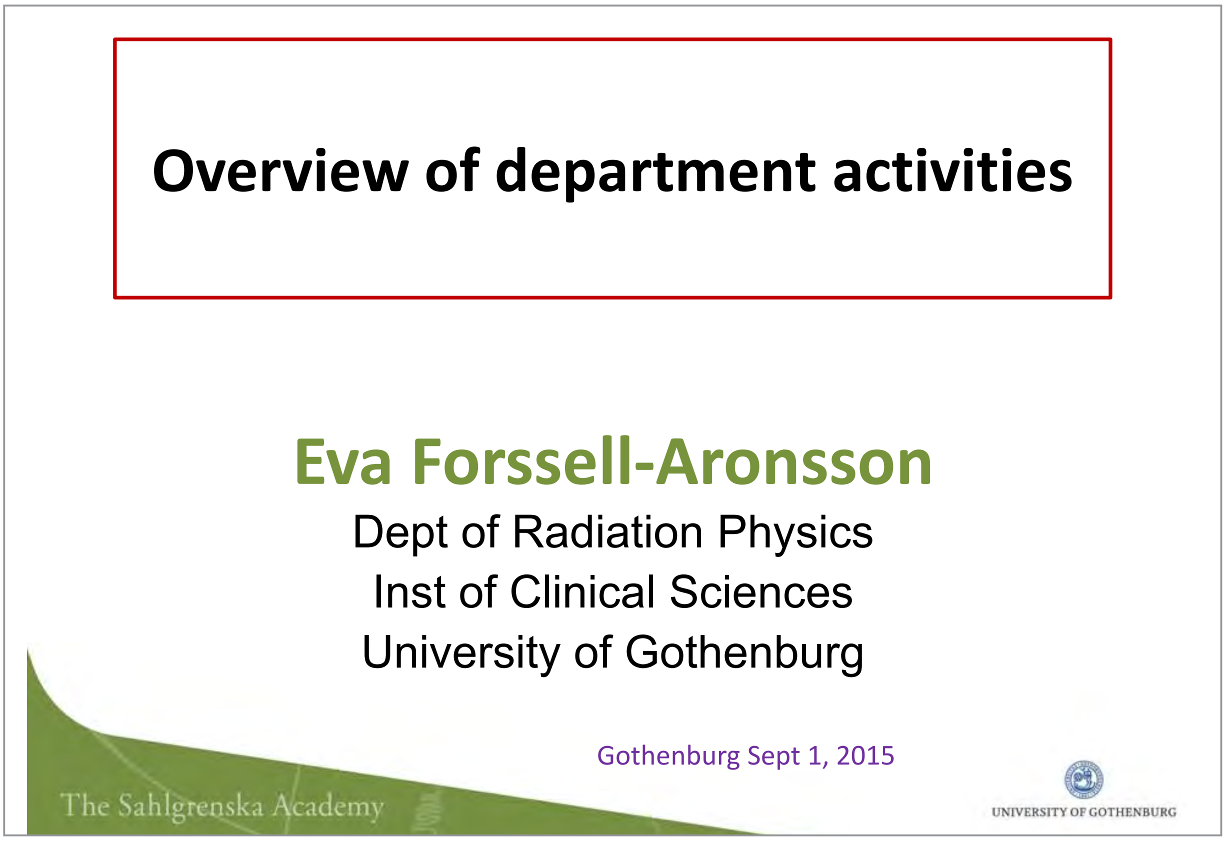
Eva Forssell-Aronsson, proffessor
(Department of Radiation Physics, Institute of Clinical Sciences)

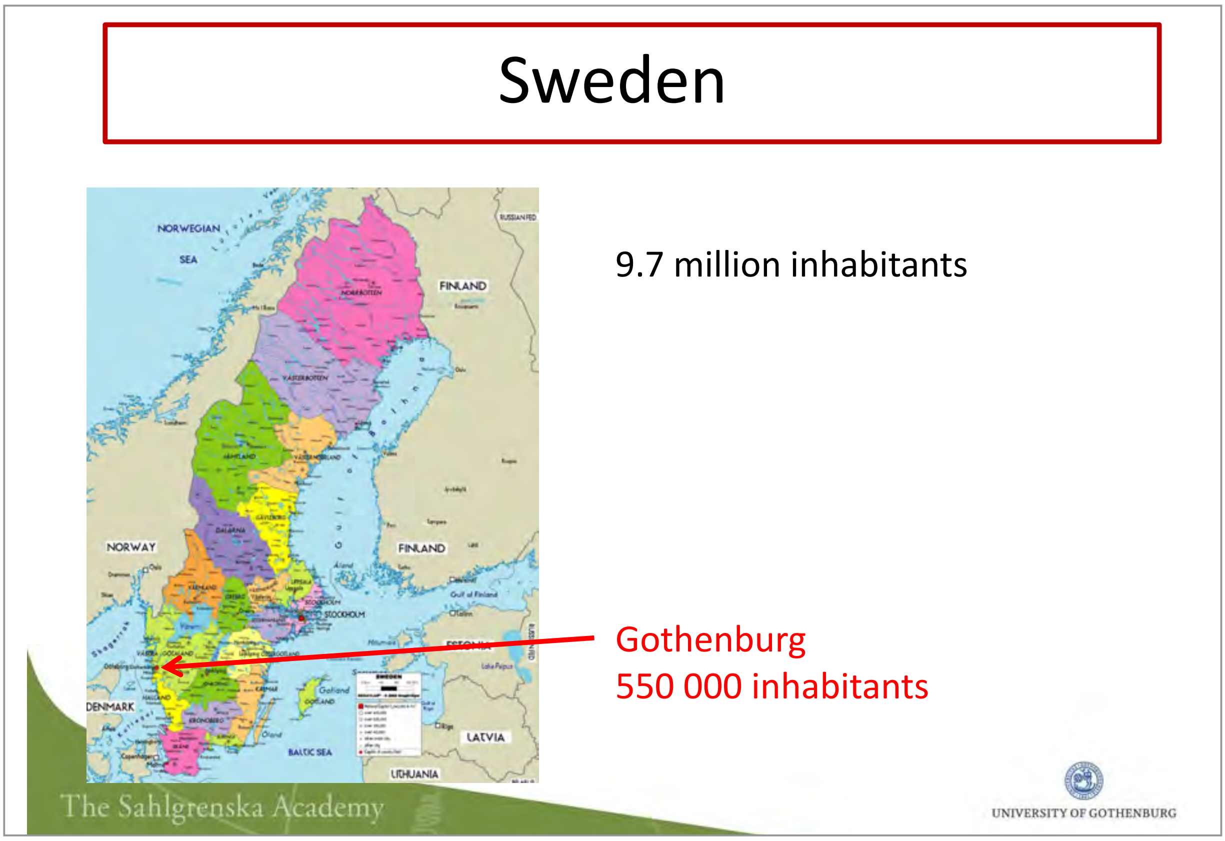
2. Environmental radioactivity research at the department of radiation physics – Introduction to Joint Japan Sweden Radioecology Workshop –

Mats Isaksson, proffessor
(Department of Radiation Physics, Institute of Clinical Sciences)

1. Overview of department activities

Eva Forssell-Aronsson





Sahlgrenska Academy at the University of Gothenburg
Sahlgrenska University Hospital

The Sahlgrenska Academy

UNIVERSITY OF GOTHENBURG

Sahlgrenska Academy at the University of Gothenburg
Sahlgrenska University Hospital

The Sahlgrenska Academy

Staff

Professors/senior lecturers	6 (2 part-time)
Researchers	3
Postdocs	4
PhD students	20
Assistant researchers	4
Technicians	1
Assoc researchers at univ. hospital	10
Adjunct senior lecturer	1

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Education

Medical physics program, 5 y (300 credits)

- Mathematics and general physics (2 y)
- Basic radiation physics (1 y)
- Applied radiation physics (1 y)
- Clinical radiation physics (0.5 y)
- Master thesis (0.5 y)

Master program in radiation safety, 2 y (60 credits)

Radiology technicians (15 credits)

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Education - subjects

Radiation sources (Ionozing and non-ionizing radiation)
Nuclear physics
Interaction of radiation with matter
Detectors and measurement techniques
Dosimetry of ionizing radiation
Radiation biology
Environmental radiology
Radiation protection
Emergency preparedness and radiation protection
Medicine for physicists
Nuclear magnetic resonance imaging
Nuclear medicine (imaging and therapy)
Radiology (imaging)
Radiotherapy

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2. Environmental radioactivity research at the department of radiation physics

Mats Isaksson

UNIVERSITY OF GOTHENBURG

Environmental radioactivity research at the department of radiation physics

Introduction to Joint Japan Sweden Radioecology Workshop 1 Sept. 2015, Gothenburg

Mats Isakson, prof.

Dep. of Radiation Physics

The Sahlgrenska Academy

http://battleshiphmsvanguard.homestead.com/

ASSESSMENT OF INTERNAL DOSES IN EMERGENCY SITUATIONS

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Whole body counting 1

Palmergeometry

Partly shielded detector

Totally shielded detector

3

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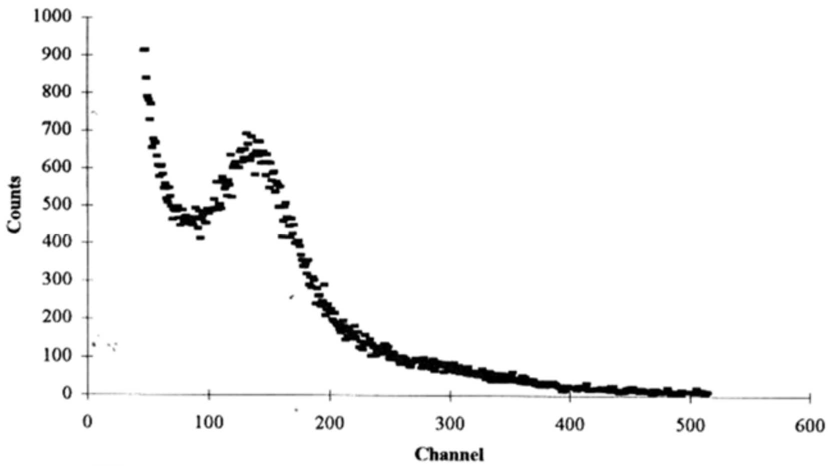
Whole body counting 2



4

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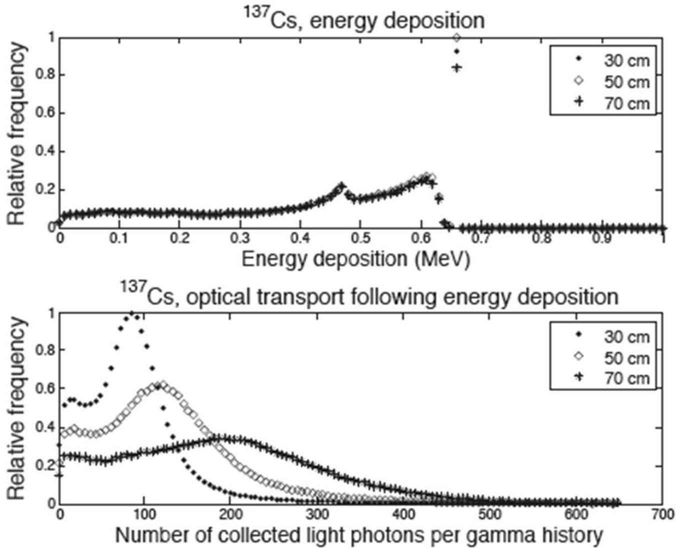
Whole body counting 3



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5

UNIVERSITY OF GOTHENBURG

Whole body counting 4

Geometry dependent!

BOMAB - BOttle MAnnikin ABsorber phantom (Bush 1949)

Mathematical calibration is an alternative

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6

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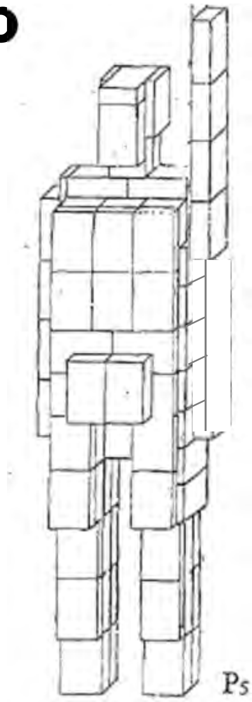
Whole body counting 5

This is the
IRINA
phantom



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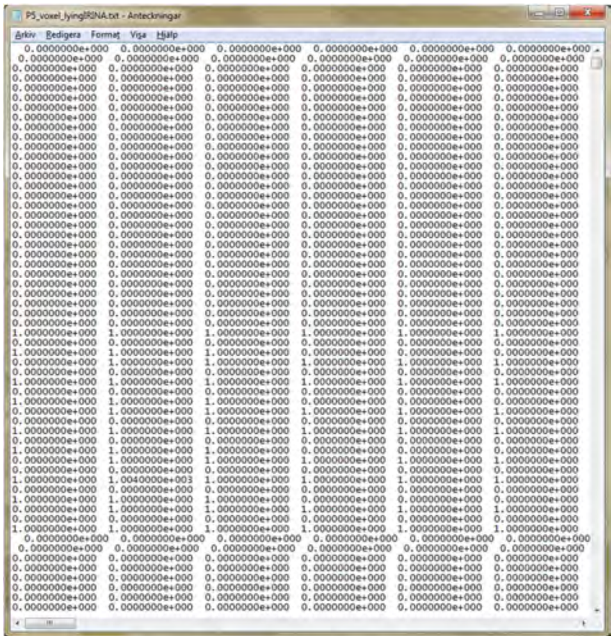
Whole body counting 6

This is also the
IRINA phantom



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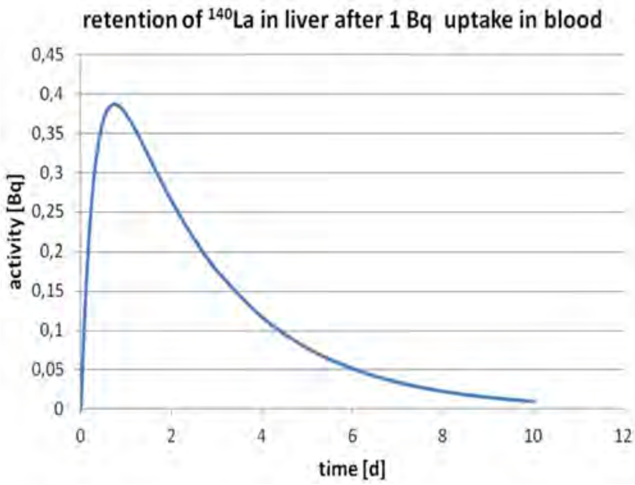
Effects of biokinetics 1



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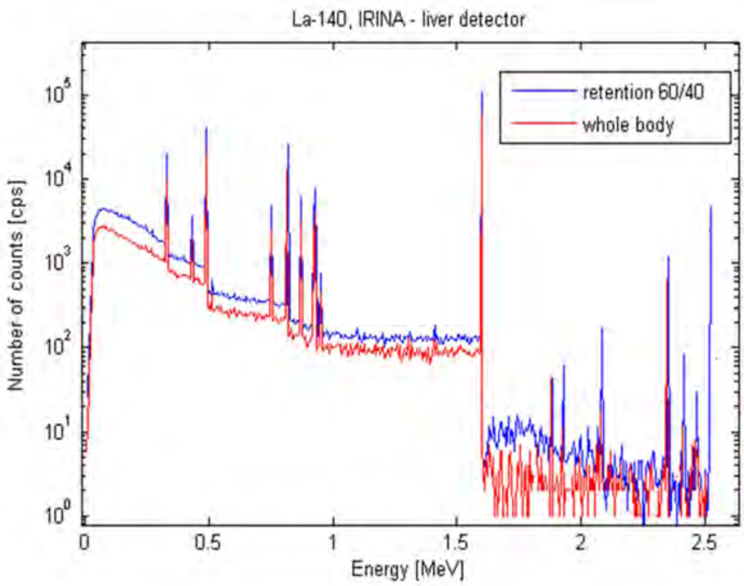
Effects of biokinetics 2



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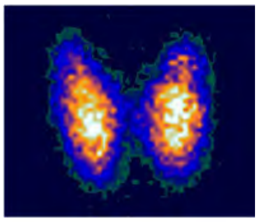
Thyroid uptake measurements

Intercomparison exercises

Applications in emergency preparedness

Calibration of uptake meters

Dose assessments



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MOBILE MEASUREMENTS

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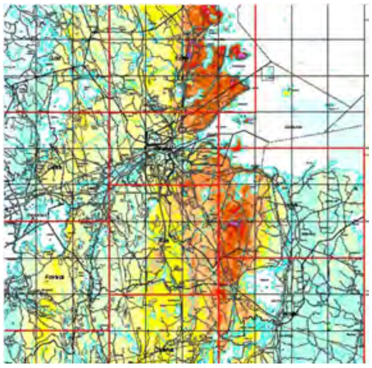
Activities

Field gamma spectrometry

Car borne measurements



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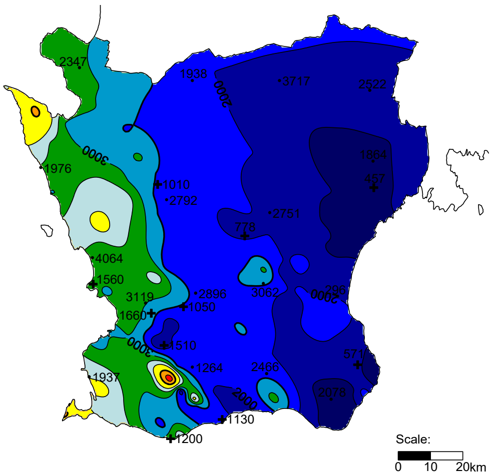

MODELLING AND FIELD STUDIES

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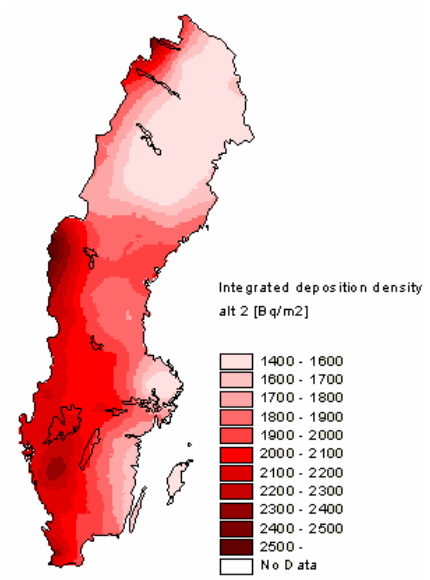
Deposition modelling



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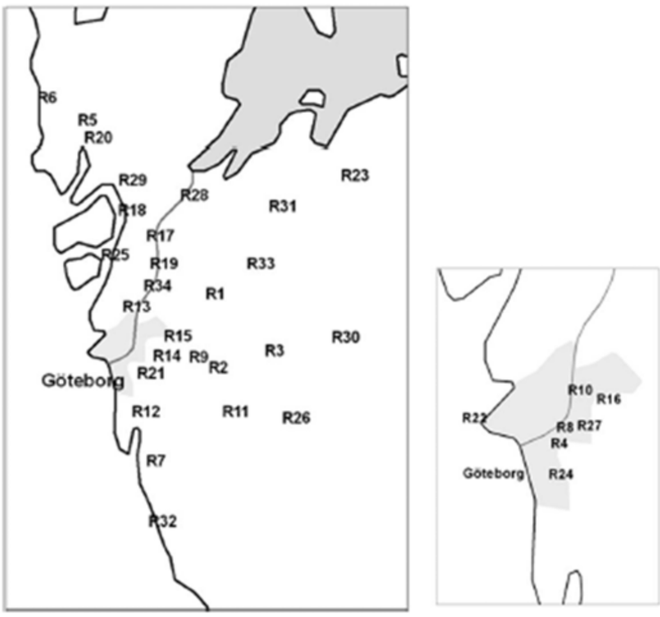
Reference sites 1



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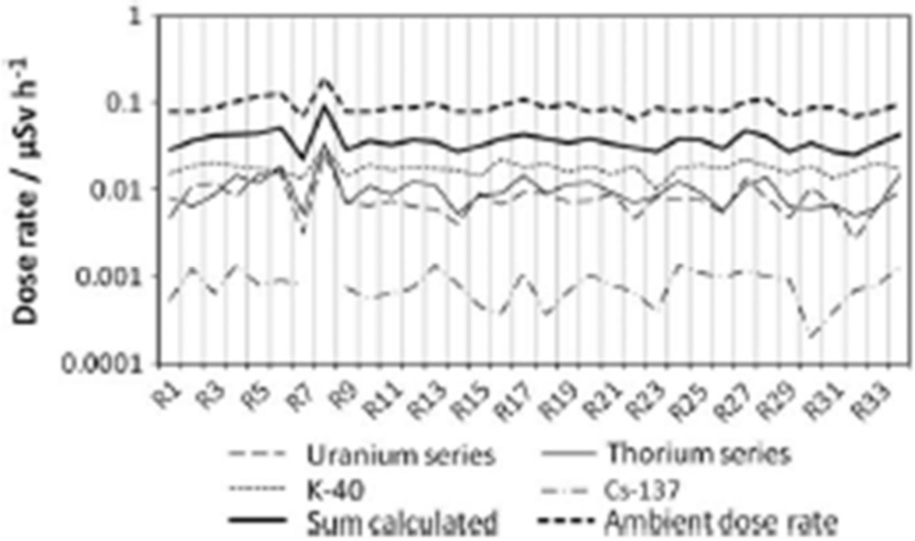
Reference sites 2



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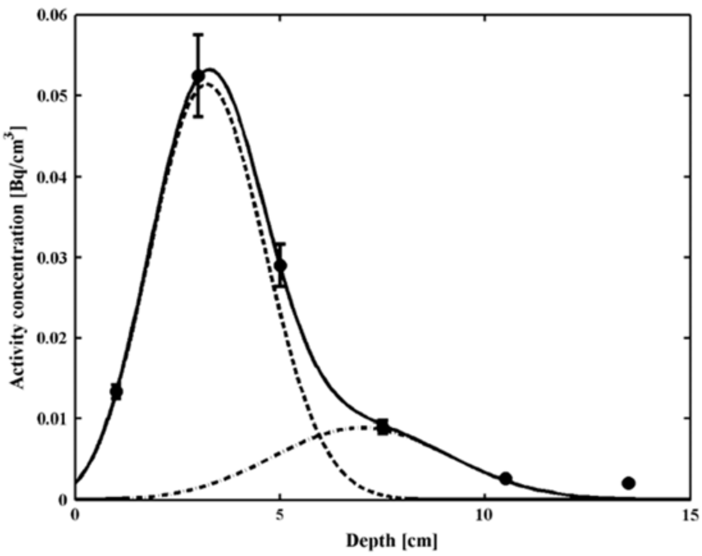
Vertical migration



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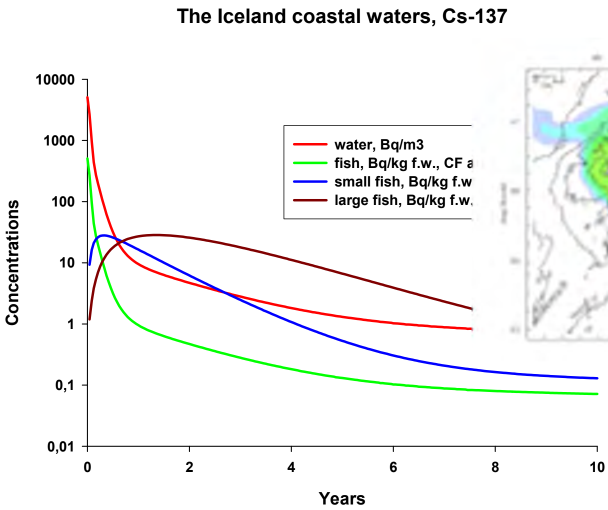
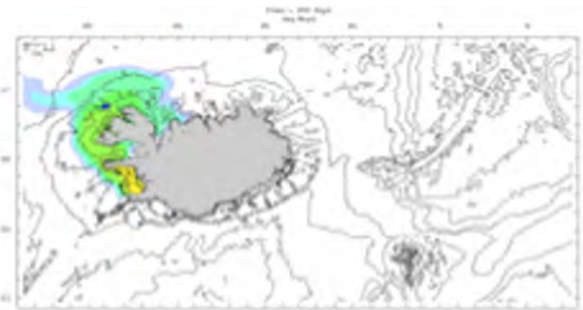
Marine modelling





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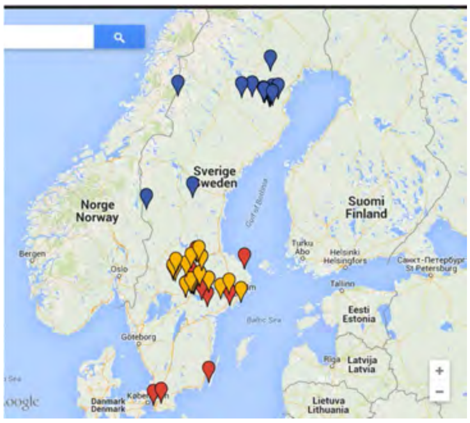
Pit lakes



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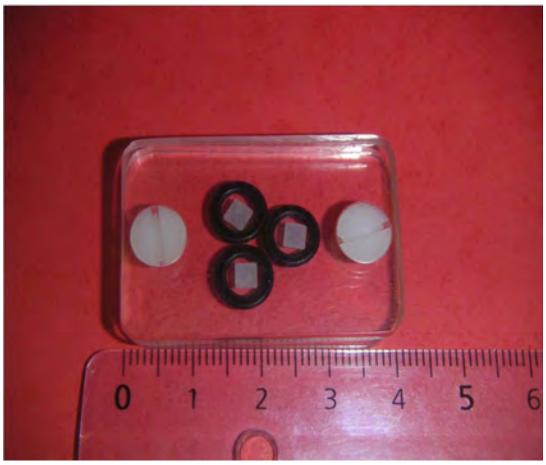

ENVIRONMENTAL DOSE ASSESSMENTS

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EMERGENCY PREPAREDNESS

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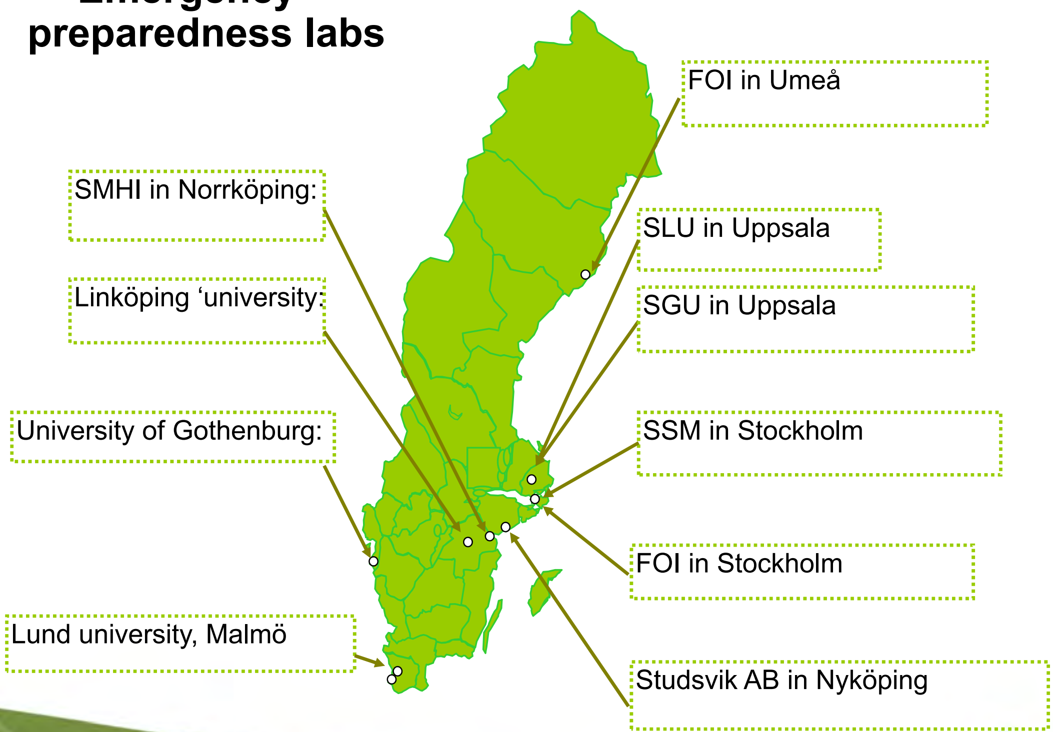
Emergency preparedness labs



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Pasture sampling

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Thank you!
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Joint Japan Sweden Radioecology Workshop

at University of Gothenburg

September 1-2, 2015

Location: Department of Radiation Physics (Radiofysikhuset)

Gula Stråket 2 B, Sahlgrenska University Hospital

UNIVERSITY OF GOTHENBURG

September 2, 2015

Time	Activity	Speaker
08:30	Welcome and introduction	Eva Forssell-Aronsson
08:45	Agricultural implications of Fukushima nuclear accident	Tomoko Nakanishi
09:15	Studies in environmental radiology in South-West Sweden after the Chernobyl accident	Sören Mattsson
09:45	Radiocesium fixation process to soil analyzed by monitored radioactivity data of spinach in Fukushima	Nobuko Mitsuoka
10:05	Tea/coffee break	
10:30	Temporal change of radiocesium concentration of peach fruits cultivated in Fukushima Prefecture	Kyoko Ichikawa
10:50	Monitoring inspection for radiocesium in agricultural, livestock, forest and fishery products in Fukushima Prefecture	Naoto Nihei
11:10	Penetration of cesium, silver and other metals in soils with examples from the Fukushima accident	Gunnar Bengtsson
11:25	Spatial and vertical distribution of fall-out ^{137}Cs in Sweden	Mats Isaksson
11:45	Caesium contamination in the Swedish town Gävle ten years after the Chernobyl accident and some unexpected findings	Robert Finck
12:05	Influence of the Fukushima Dai-ichi nuclear accident on Spanish environmental radioactivity levels	Juan Mantero
12:25	Radioecology competence needs at radiation accidents – the case of the Chernobyl accident management in Sweden	Gunnar Bengtsson
12:40	Lunch	
13:40	Application of the in-growth core method for understanding cesium absorption of tree roots in Fukushima northern forest	Osamu Hashimoto
14:00	Spatio-temporal variation of radiocesium on forest floors in mixed deciduous forests in Fukushima	Momo Takada
14:20	Predicting the future radiocesium distribution in Fukushima from the global fallout distribution in forest area in Japan	Satoru Miura
14:40	Mappings of the deposition around the Fukushima NPP	Karl Östlund
15:00	Modelling the radioecological transfer of ^{134,137}Cs to the Swedish population	Christoffer Rääf
15:15	Spatial variability of the dose rate from ^{137}Cs and its influence on the human exposure – examples from Chernobyl contaminated areas in Russia and Belarus.	Christian Bernhardsson
15:30	Tea/coffee break	
16:00	The effect of dialysis on ^{137}Cs and ^{131}I in man	Elis Holm
16:20	Uranium levels in mining lakes in Southern Sweden	Rimon Thomas
16:40	Biokinetics and radiobiological effects of low dose exposure from radiohalogens in rodents	Johan Spetz/Britta Langen
17:00 –	General discussion	

3.1 Agricultural implications of Fukushima nuclear accident

Tomoko M. Nakanishi†,[1]
† Presenter: atomoko@mail.ecc.u-tokyo.ac.jp
1 Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1, Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan

More than 4 years have passed since the Fukushima Daiichi nuclear power plant accident. More than 110,000 people who were evacuated from the area remain at locations different from where they used to live. Immediately after the accident, the Graduate School of Agricultural and Life Sciences at Tokyo University created an independent team from a wide variety of research specialties including soil, vegetation, animal life, fishing, and forestry. This team entered sites in the affected areas immediately after the accident and initiated research studies. They are continuing their research to determine the effects of the accident on agricultural fields. Our Graduate School includes many research areas, and many facilities such as meadows, experimental forests, and farming fields are associated with the school. Employing these facilities, many on-site research studies have been conducted in Fukushima Prefecture.

It was important to the Graduate School of Agricultural and Life Sciences that the results of these research studies contribute to the recovery of the affected area; therefore, we have endeavoured to officially publish the results. For example, 11 meetings have been held since November 2011 to report research results. The objective of these meetings was to provide a simple explanation of the results of the research studies so that the general public could understand them. We published two books about the research on Fukushima, one through Springer Publishing Company and the other as an easy-to-understand book written in Japanese. The books were published to allow a wide range of ordinary people to have a correct understanding of the impact of radioactive material on agricultural, forestry, and fishing products and the countermeasures taken against radiation exposure.

Based on the scientific data from these studies, we initiated lecture classes for students and for the general public to explain the behaviour and movement of radioactivity in the environment and to provide basic knowledge about radioactivity. To provide firsthand experience of radio-ecology in the environment for students, we periodically hold open lectures in the contaminated fields or mountains.

A major feature of the radioactive fallout is that radioactive caesium (Cs) has remained at the initial contact sites and has moved very little since the initial event. In animals, metabolic activity has reduced the radioactivity level over time at a much faster rate than the physical half-life. The biological half-life in animals was estimated to be less than 100 days. Soil plays a major role in immobilising fallout. When fallout nuclides are absorbed into the soil, little of the radioactive Cs is taken up by plants growing there. In the mountains, radioactive Cs was transferred gradually from vegetative litter to soil and subsequently moved very little, even when the soil was washed with heavy rain. The mechanism of contamination by radioactive nuclides is completely different from that of heavy metals.

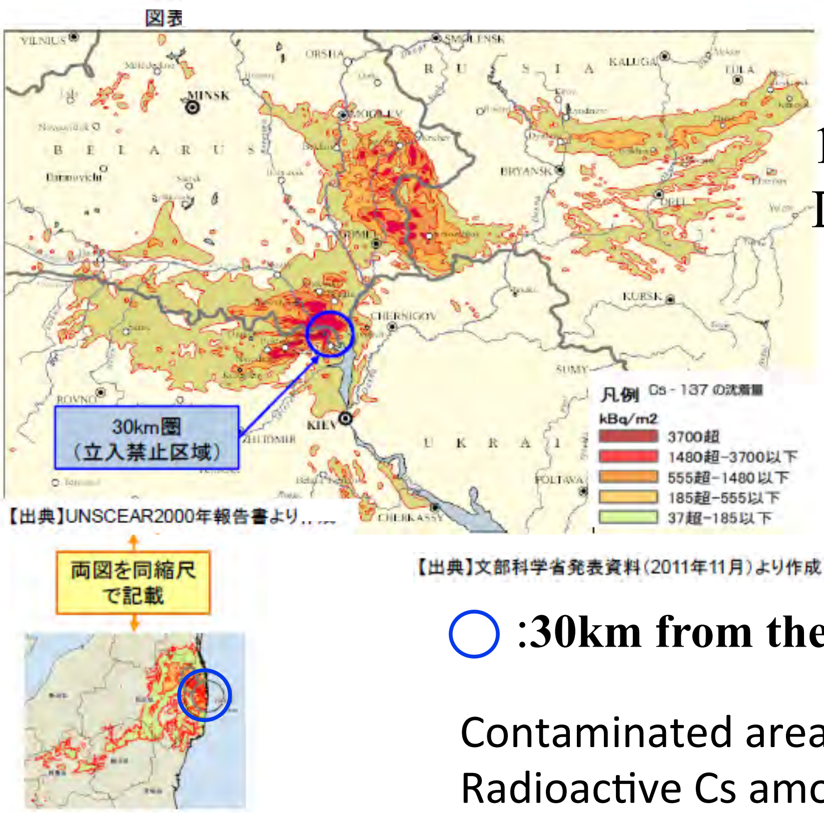
Similar to the agricultural environments of other Asian countries, Japan is located in a monsoon area, with many paddy fields used to grow rice. However, the climate and agricultural environment in Japan differ from those near Chernobyl; therefore, it is important to gather information regarding the movement and features of fallout that are specific to Japan from an agricultural point of view.

It appears that the recovery of the agricultural, forestry, and fishing industries in Fukushima Prefecture will take quite some time, but the Graduate School of Agricultural and Life Sciences at Tokyo University will continue to support the recovery of these industries in the future.

Keywords:
Fukushima Daiichi nuclear power plant accident, radiation contamination, agriculture, radio-ecology

Agricultural Implications of Fukushima Nuclear Accident

Tomoko M. Nakanishi
Graduate School of Agricultural and Life Sciences, The University of Tokyo

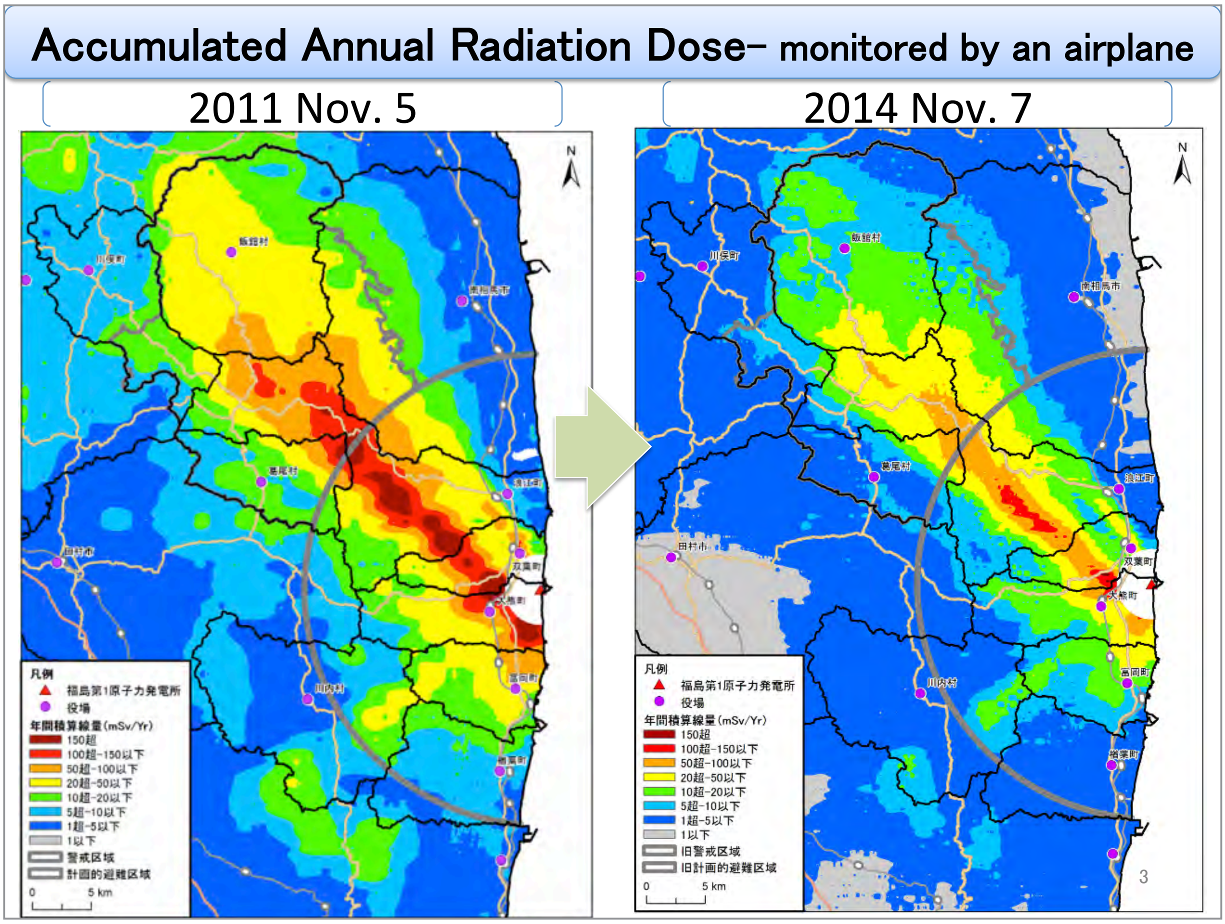


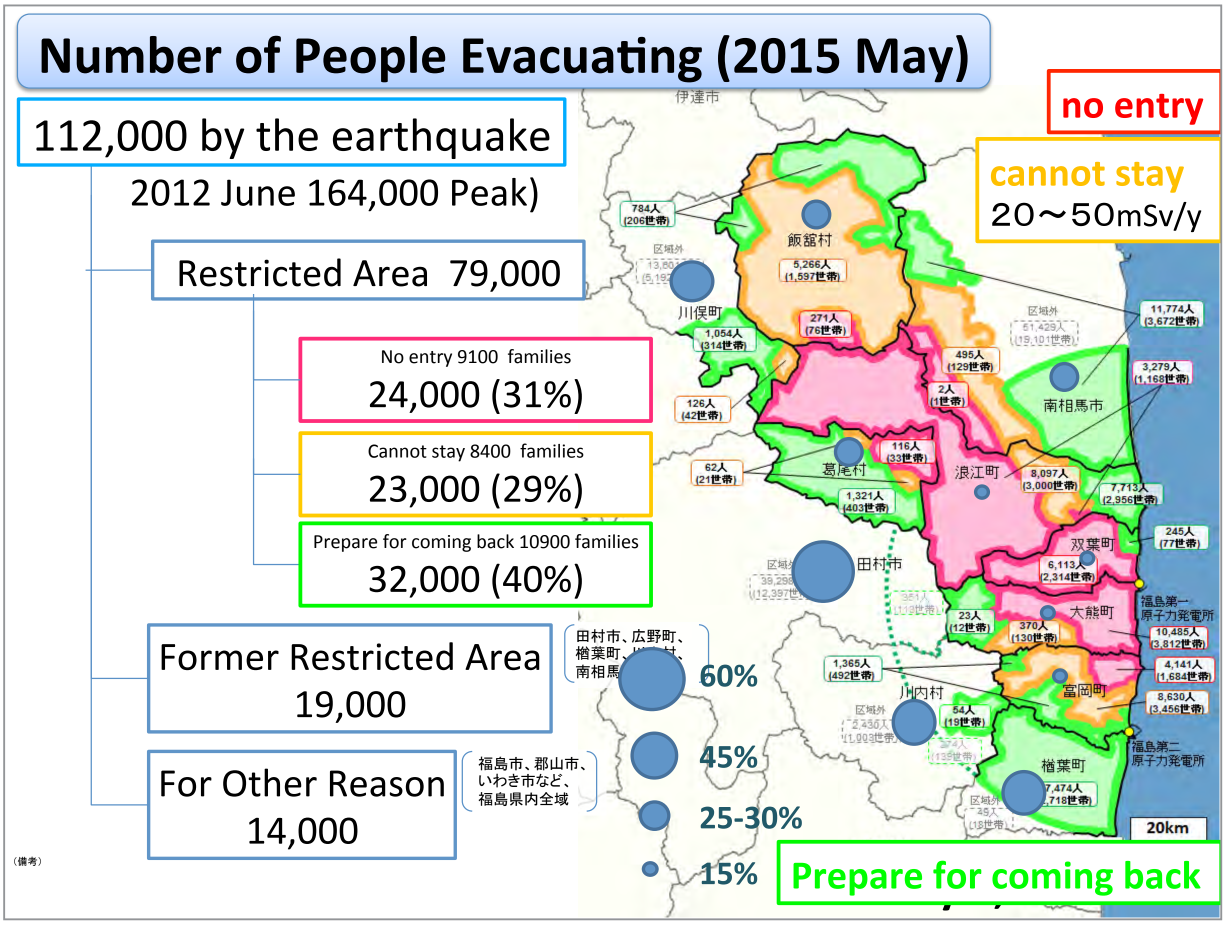
1989 December

2011 November

◯ **:30km from the reactor**

Contaminated area:〜6%
Radioactive Cs amount: 〜1/6
Fall out distance:〜1/10


Accumulated Annual Radiation Dose– monitored by an airplane
2011 Nov. 5
2014 Nov. 7
凡例
福島第1原子力発電所
役場
年間積算線量(mSv/Yr)
150超
100超~150以下
50超~100以下
20超~50以下
10超~20以下
5超~10以下
1超~5以下
1以下
警戒区域
計画的避難区域
旧警戒区域
旧計画的避難区域
5 km


Number of People Evacuating (2015 May)
112,000 by the earthquake
2012 June 164,000 Peak)
Restricted Area 79,000
No entry 9100 families
24,000 (31%)
Cannot stay 8400 families
23,000 (29%)
Prepare for coming back 10900 families
32,000 (40%)
Former Restricted Area
19,000
For Other Reason
14,000
福島市、郡山市、いわき市など、福島県内全域
no entry
cannot stay
20～50mSv/y
Prepare for coming back
60%
45%
25-30%
15%
飯舘村
川俣町
南相馬市
葛尾村
浪江町
田村市
双葉町
大熊町
富岡町
川内村
楢葉町
20km

Project for Fukushima at Graduate School of Agricultural and Life Sciences

The academic staffs are participating in the following research group to contribute the damaged agriculture by east Japan great earthquake.

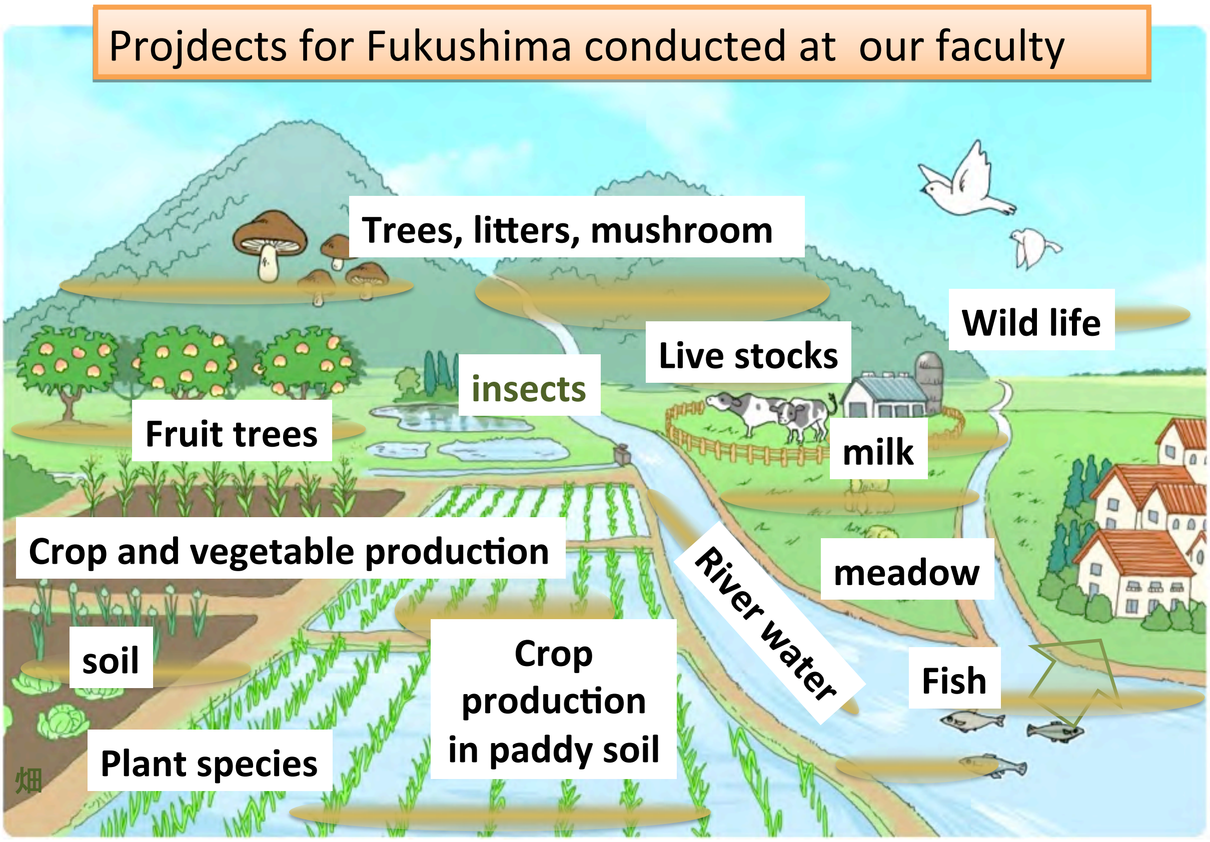
（1）The influence of high radioactivity o agricultural products and the possible way fo ery .

① crop production and soils
② stock raising & dairy ts
③ fishery
④ radiation m ment & radiochemistry
⑤ field m g & science communication

40-50 academic staffs

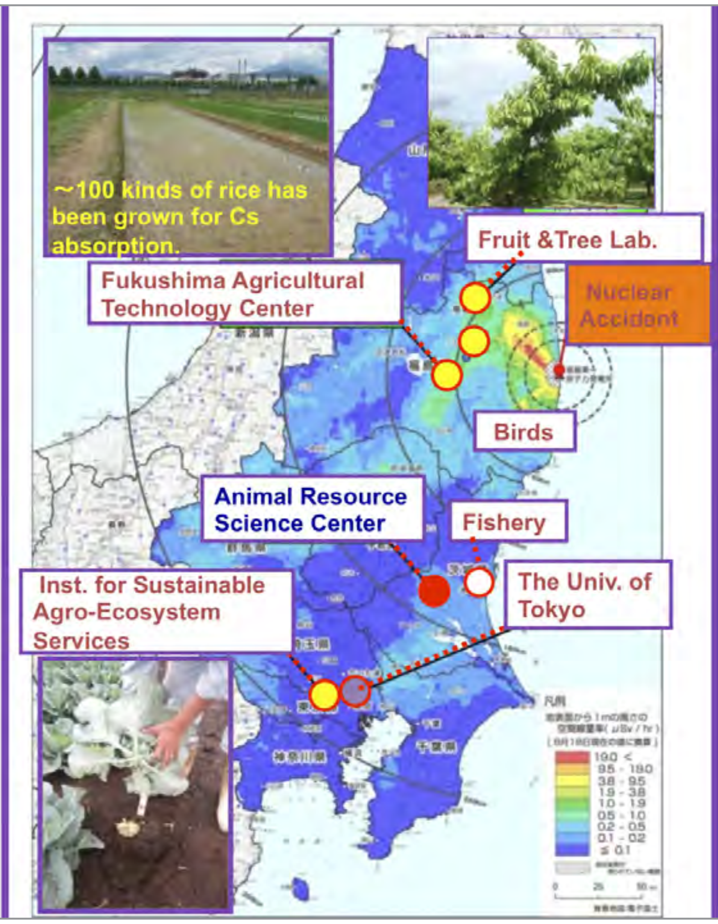
（2）Recov suffered agriculture

① crops production and soils (salt damage, farmland maintenance, etc.)
② biomass production



Our study for Fukushima

40-50 academic staffs began their research right after the accident and still performing.

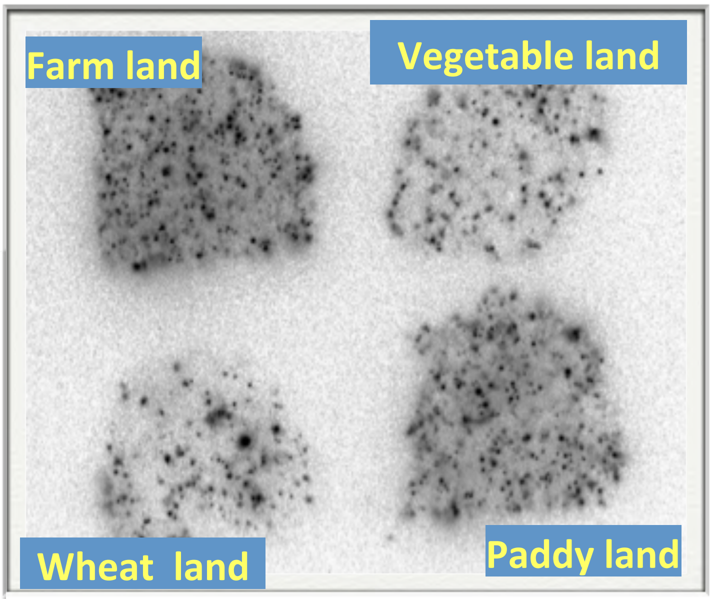


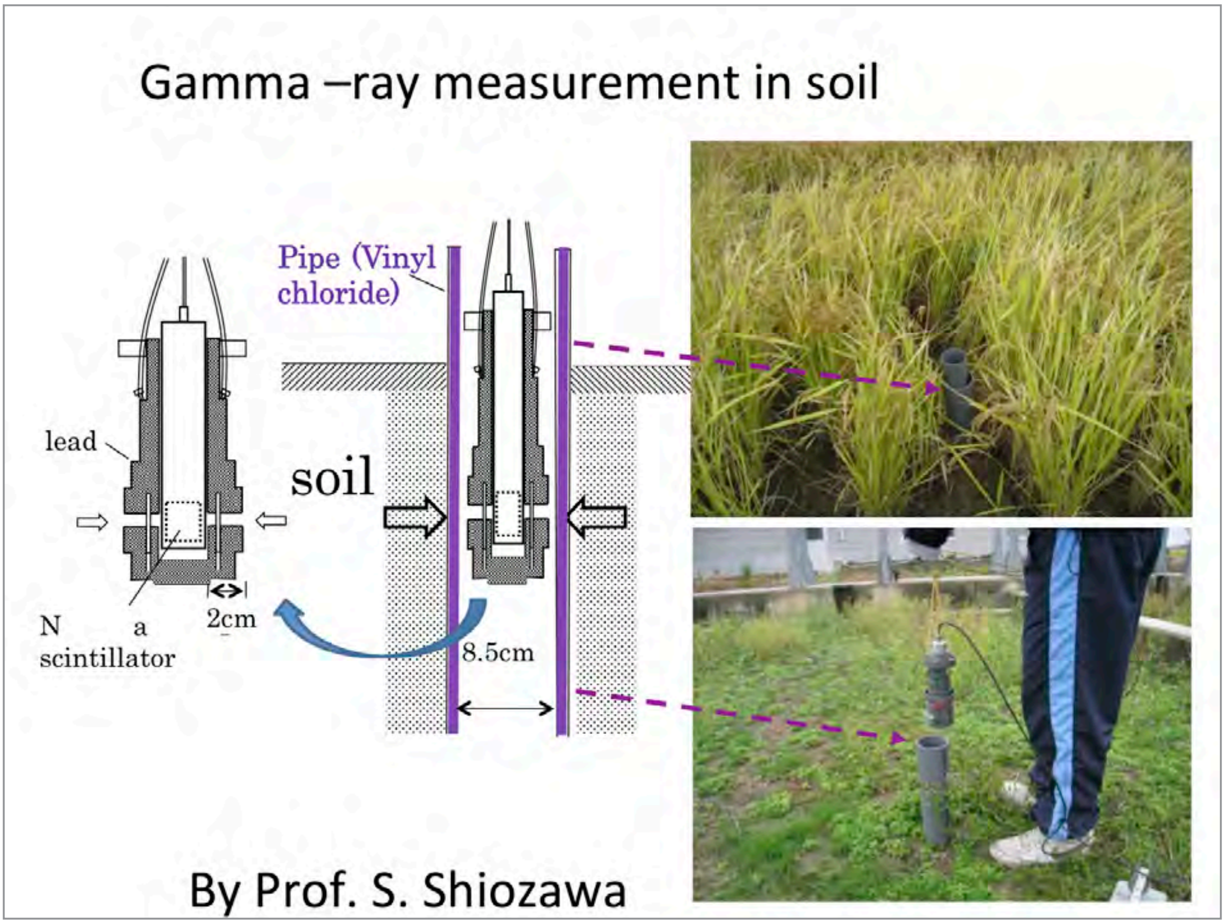
Soil contamination

Farming land

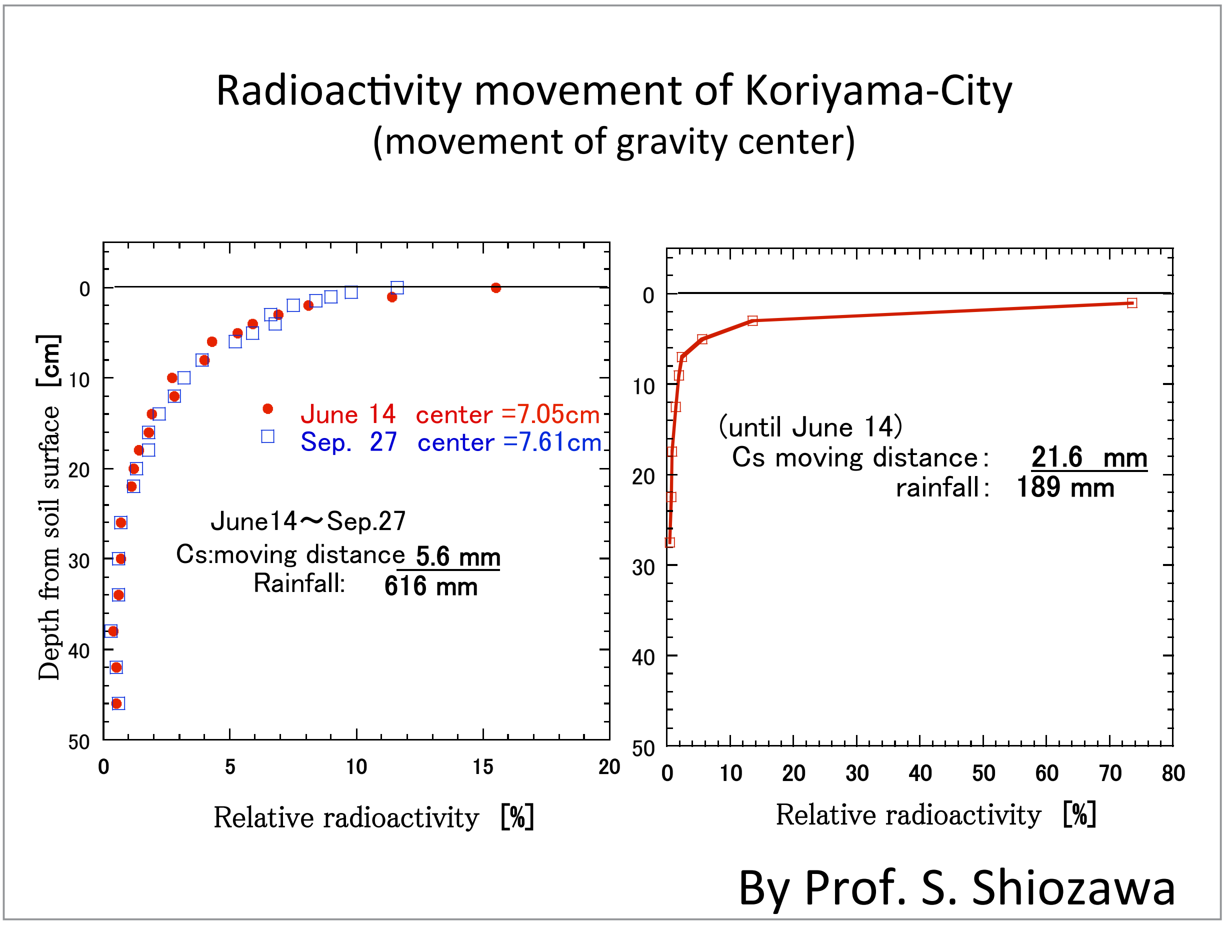
Wheat field

April 21, 2011





Gamma –ray measurement in soil
Pipe (Vinyl chloride)
lead
soil
N a scintillator
2cm
8.5cm
By Prof. S. Shiozawa

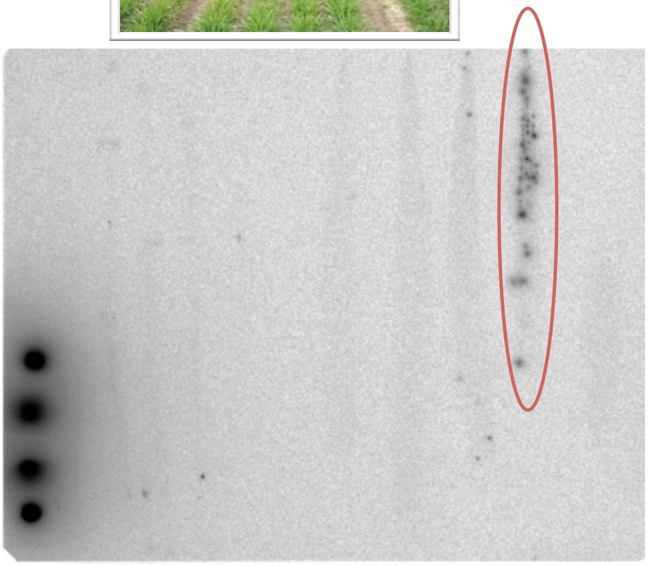


Radioactivity movement of Koriyama-City
(movement of gravity center)
June 14 center =7.05cm
Sep. 27 center =7.61cm
June14～Sep.27
Cs:moving distance 5.6 mm
Rainfall: 616 mm
Depth from soil surface [cm]
Relative radioactivity [%]
(until June 14)
Cs moving distance : 21.6 mm
rainfall : 189 mm
Relative radioactivity [%]
By Prof. S. Shiozawa

A wheat grown in Fukushima

Wheat field early in March

Picture of the sample（2011/05/16）

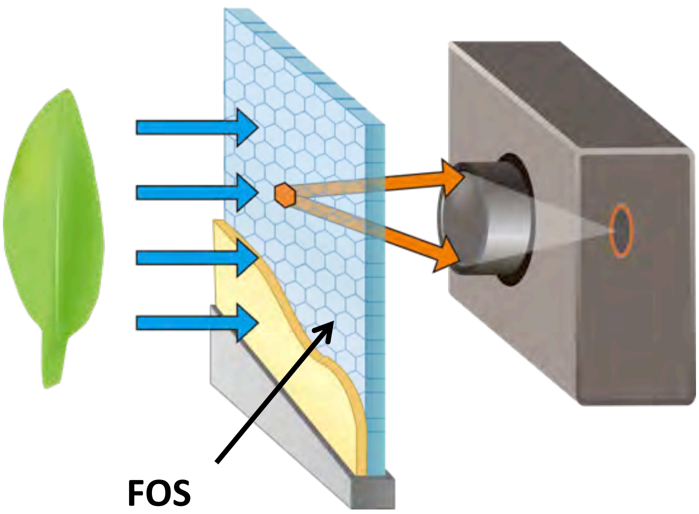


Radioactivity image by an imaging plate (2011/05/20)

By A. Prof. K.Tanoi

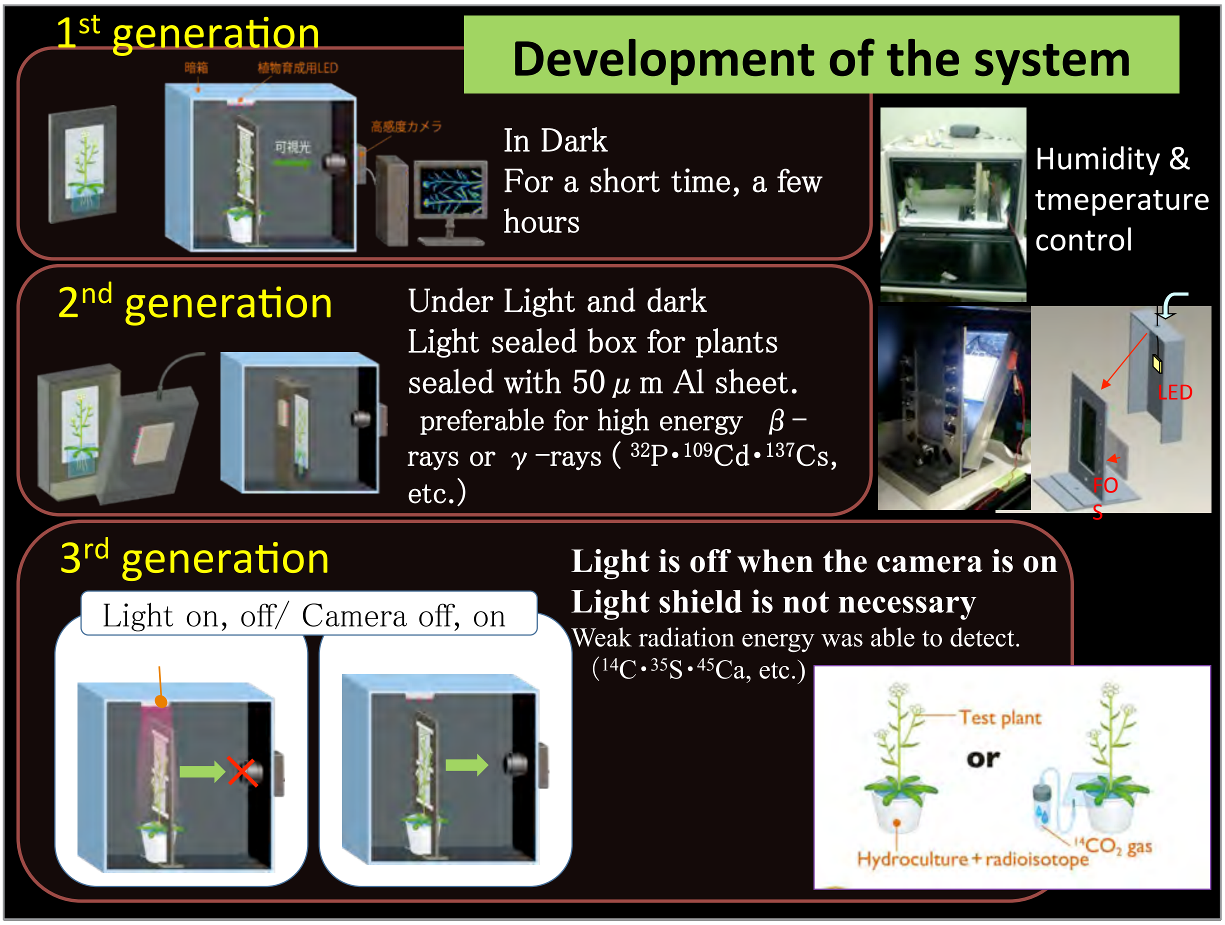
Schematic Illusgration of Real–time Radioisotope Imaging System (RRIS)

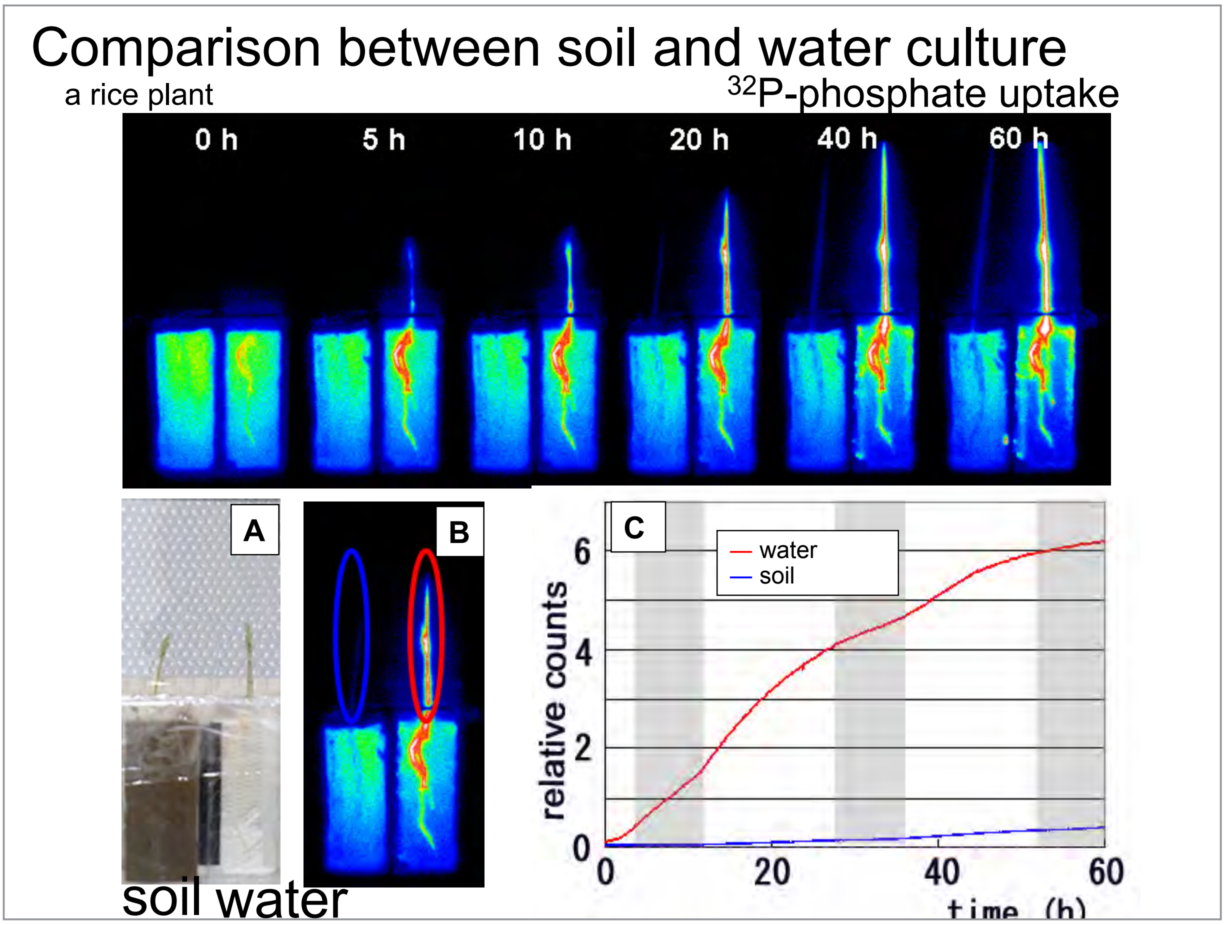
radiation → light → CCD camera

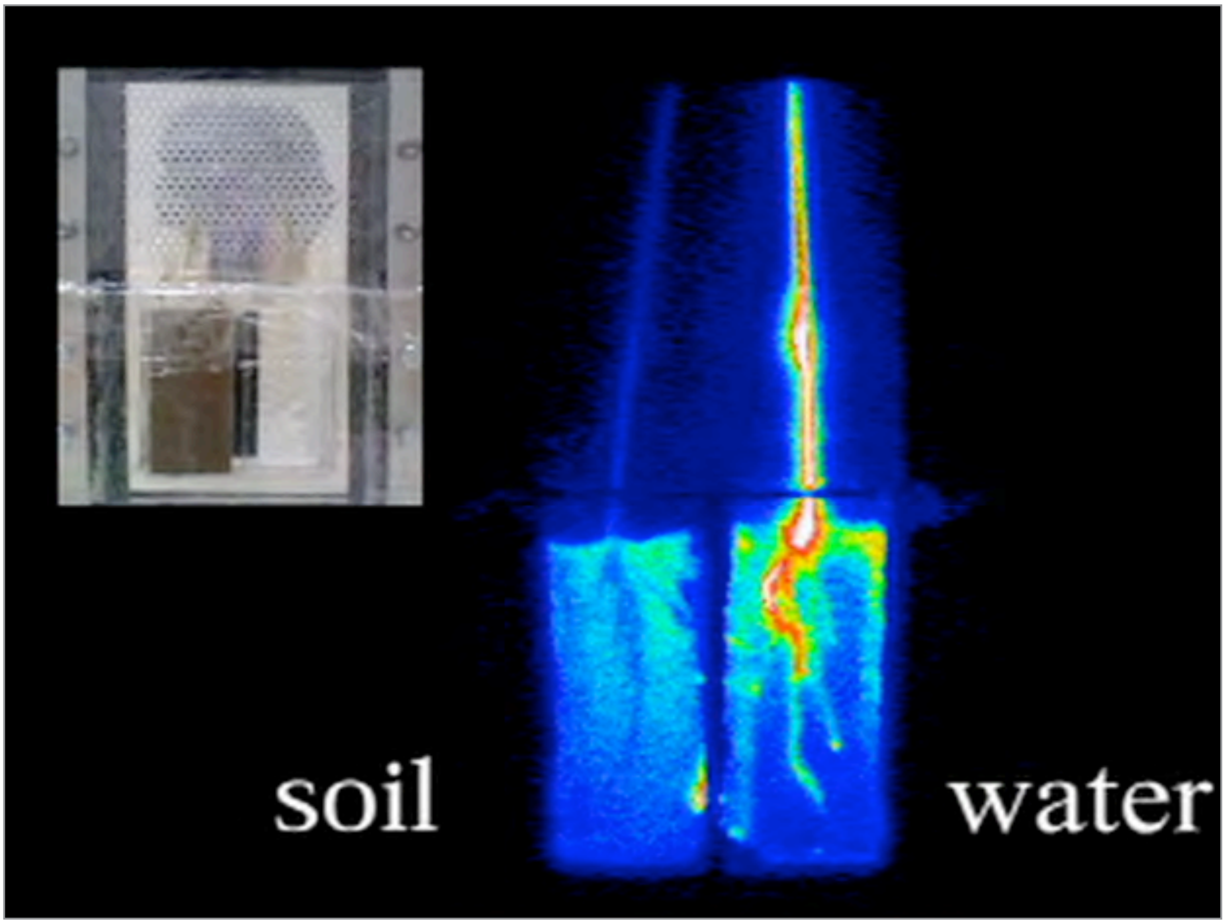


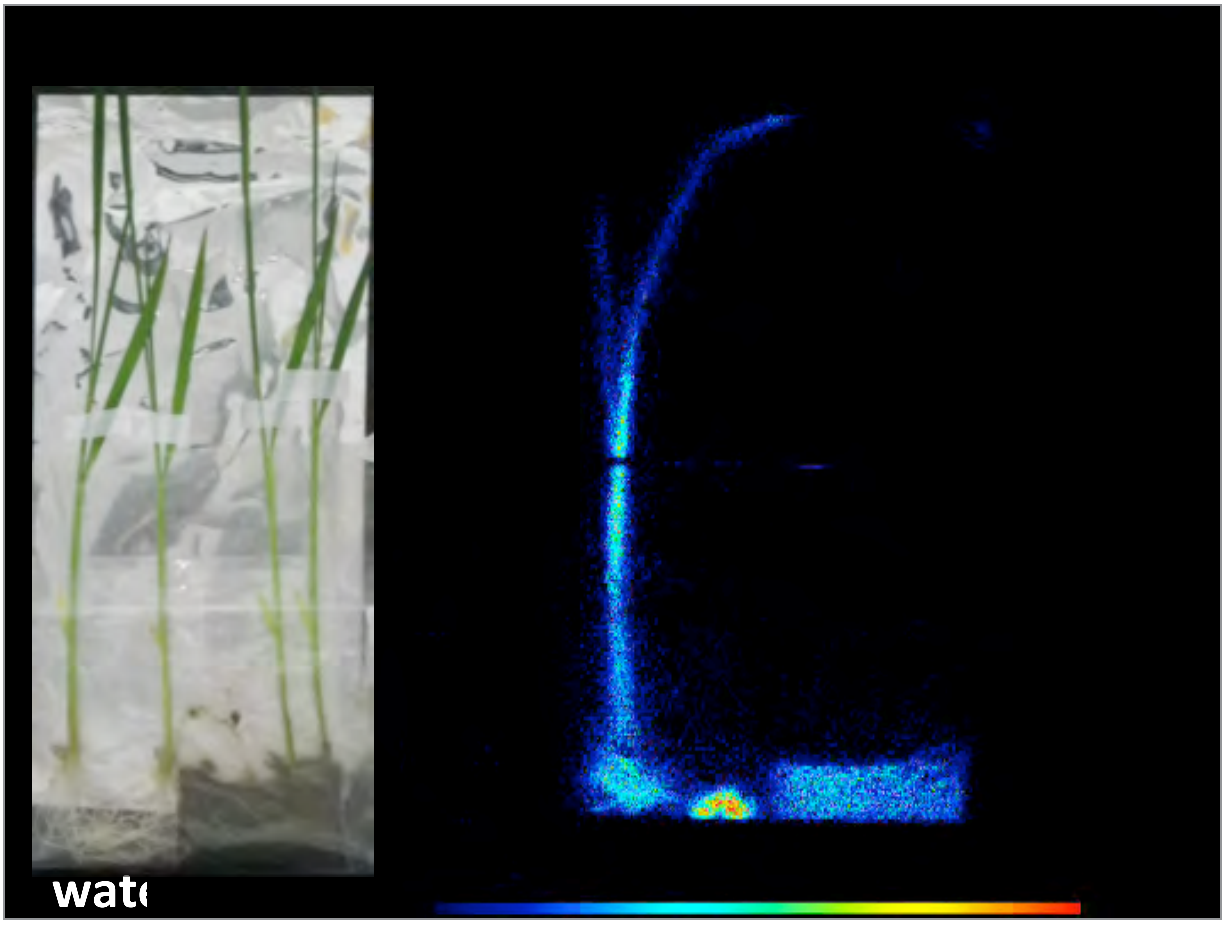
FOS
（Fiber optic plate with CsI(Tl) Scintillator）

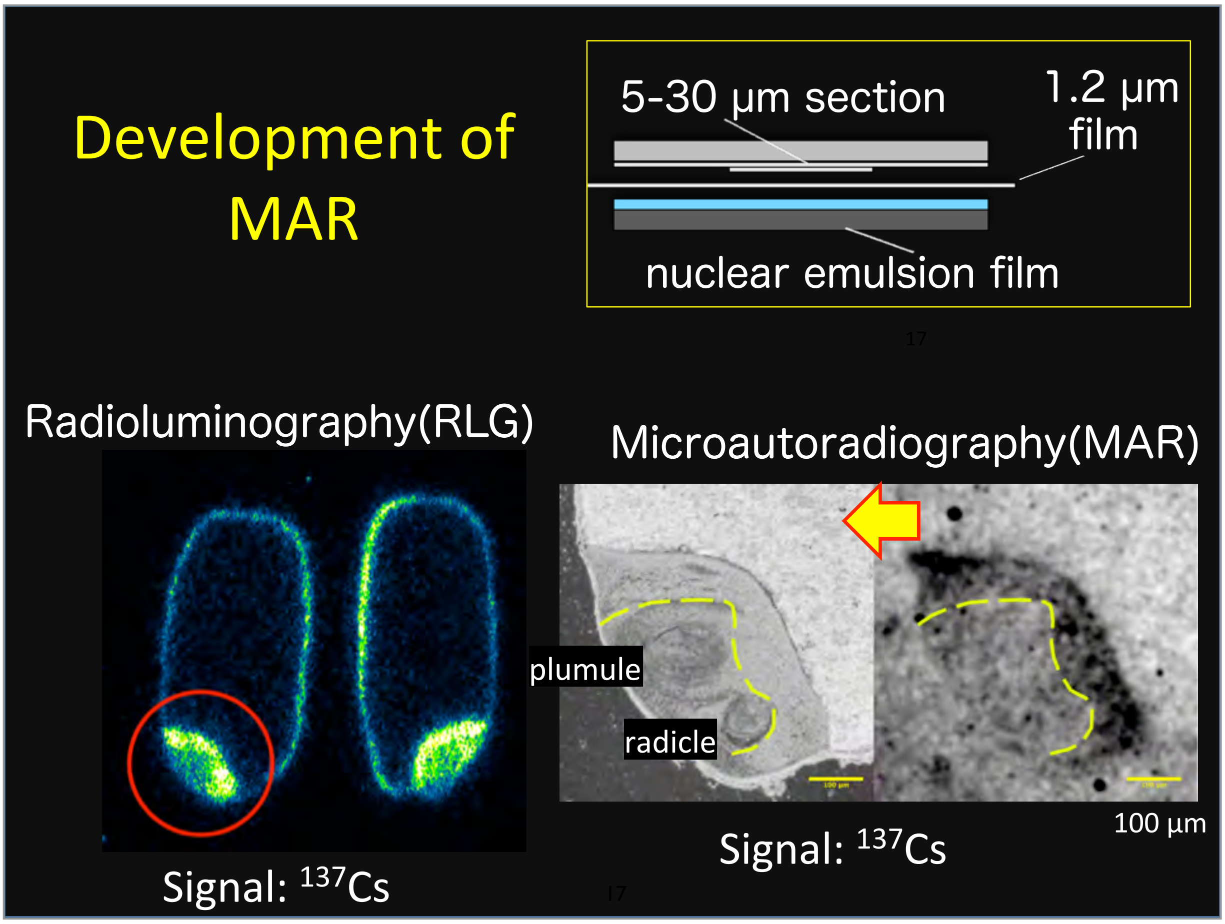
Sugita et al. Physics in Medicine and Biology 2014;59:837-851
Sugita et al. Journal of Radioanalytical and Nuclear Chemistry 2013; 298: 1411-1416
Kanno et al. Philosophical Transactions of The Royal Society B 2012;367:1501-1508

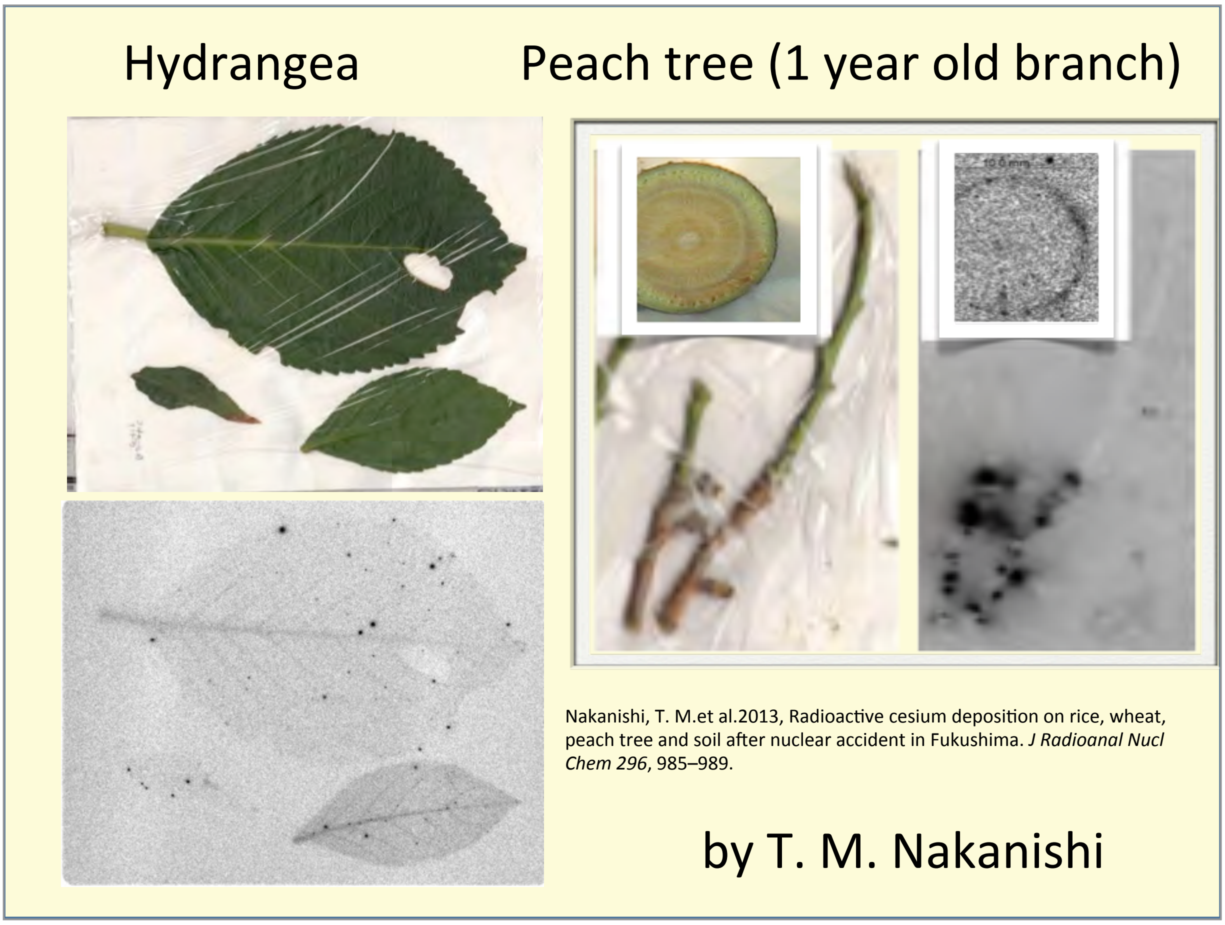

1st generation
Development of the system
暗箱
植物育成用LED
可視光
高感度カメラ
In Dark
For a short time, a few hours
Humidity & tmeperature control
2nd generation
Under Light and dark
Light sealed box for plants sealed with 50 μm Al sheet.
preferable for high energy β−rays or γ−rays (32P・109Cd・137Cs, etc.)
LED
3rd generation
Light on, off/ Camera off, on
Light is off when the camera is on
Light shield is not necessary
Weak radiation energy was able to detect.
(14C・35S・45Ca, etc.)
Test plant
or
Hydroculture + radioisotope
14CO2 gas

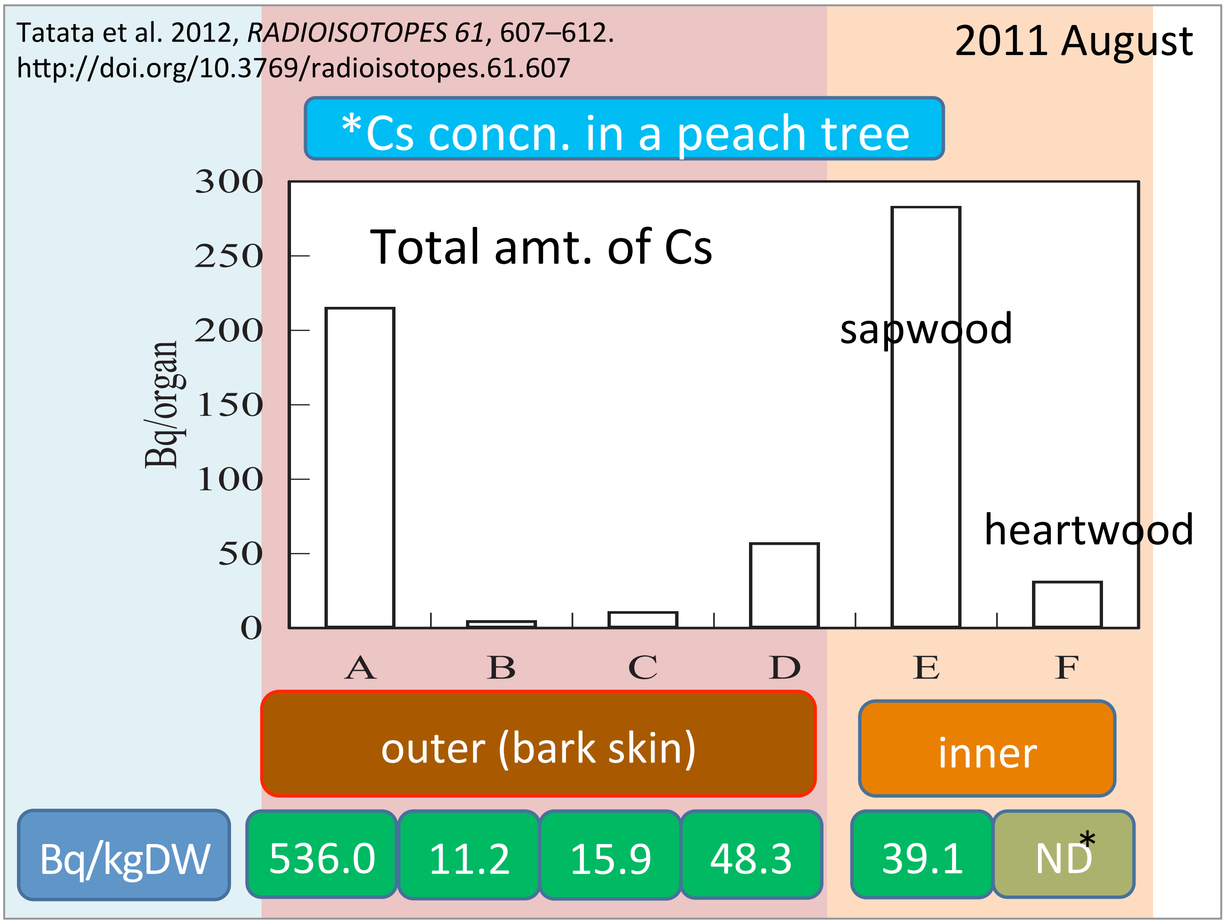

Comparison between soil and water culture
a rice plant
32P-phosphate uptake
0 h
5 h
10 h
20 h
40 h
60 h
A
B
C
water
soil
relative counts
time (h)
soil water

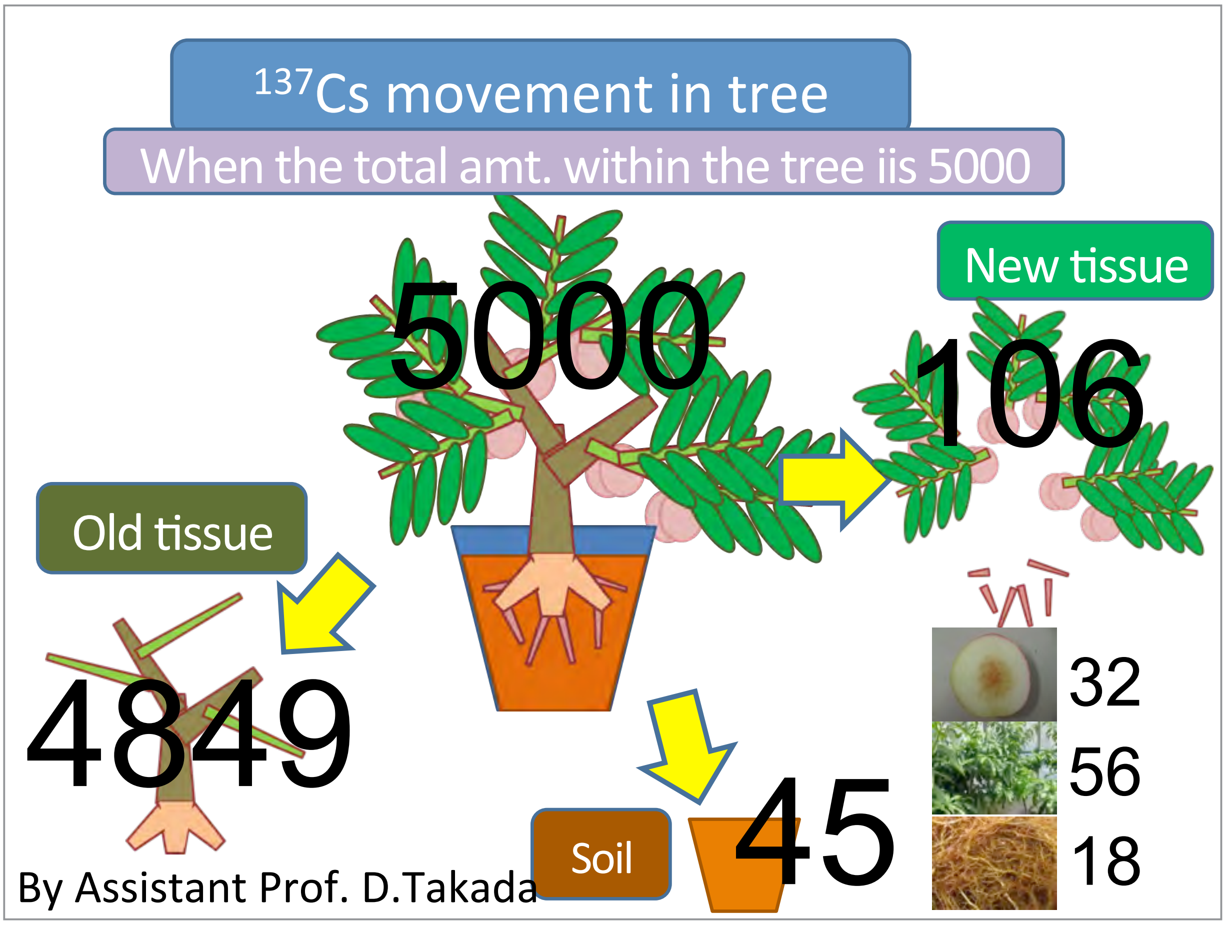

soil
water


wat


Development of MAR
5-30 μm section
1.2 μm film
nuclear emulsion film
Radioluminography(RLG)
Microautoradiography(MAR)
plumule
radicle
100 μm
Signal: 137Cs
Signal: 137Cs

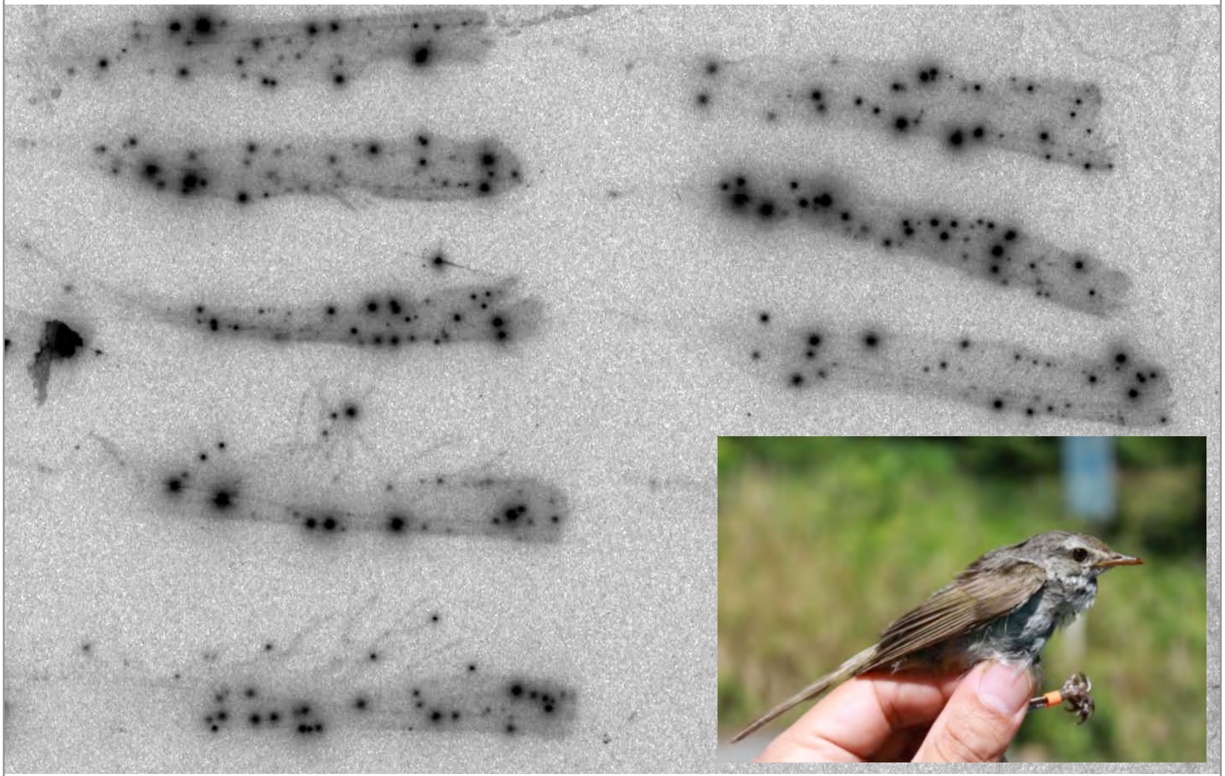

Hydrangea
Peach tree (1 year old branch)
Nakanishi, T. M.et al.2013, Radioactive cesium deposition on rice, wheat, peach tree and soil after nuclear accident in Fukushima. J Radioanal Nucl Chem 296, 985–989.
by T. M. Nakanishi


Tatata et al. 2012, RADIOISOTOPES 61, 607–612.
http://doi.org/10.3769/radioisotopes.61.607
2011 August
*Cs concn. in a peach tree
Total amt. of Cs
Bq/organ
300
250
200
150
100
50
0
sapwood
heartwood
A
B
C
D
E
F
outer (bark skin)
inner
Bq/kgDW
536.0
11.2
15.9
48.3
39.1
ND*


137Cs movement in tree
When the total amt. within the tree iis 5000
5000
New tissue
106
Old tissue
4849
32
56
18
Soil
45
By Assistant Prof. D.Takada

Bird feather (*Cettia diphone*)

By Prof. Ken Ishida



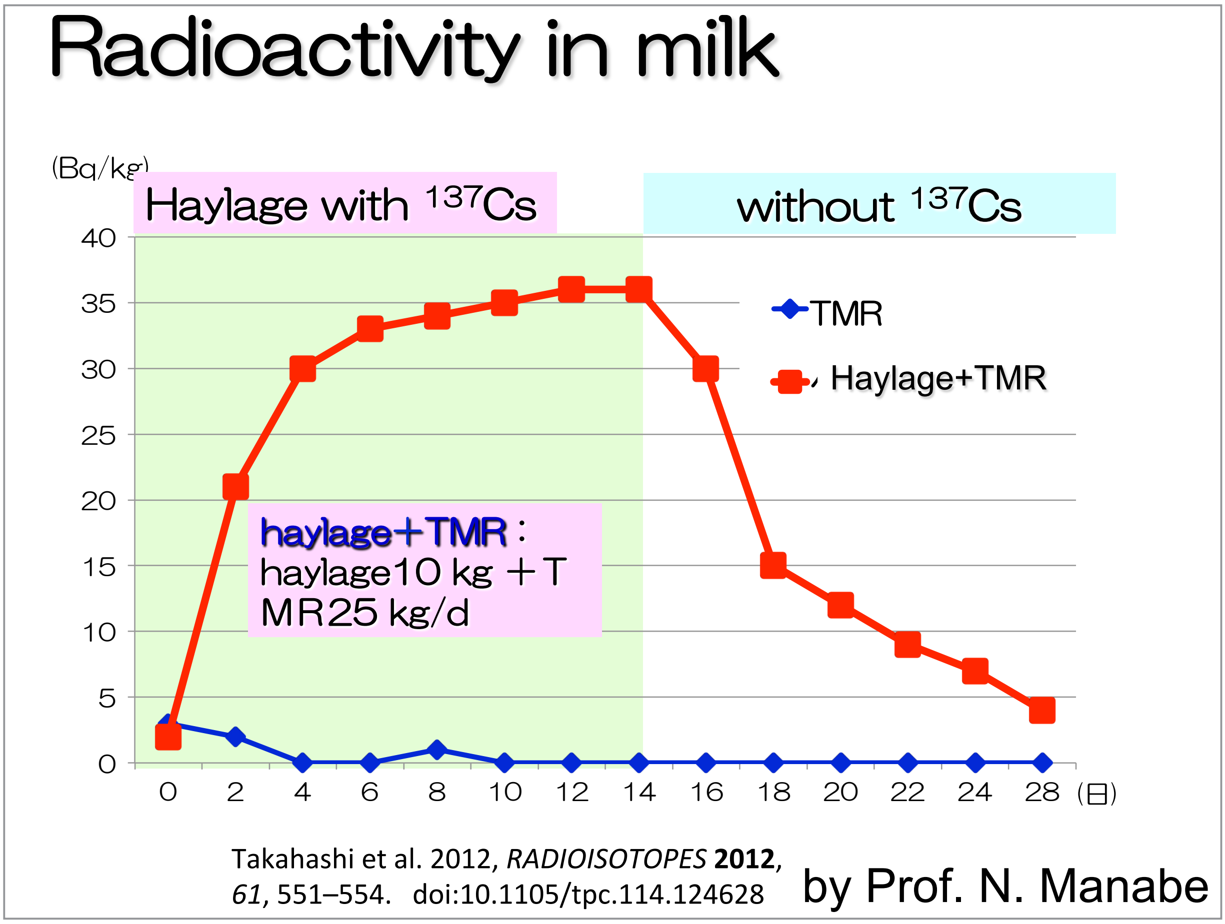
by A.Prof. K. Ishida

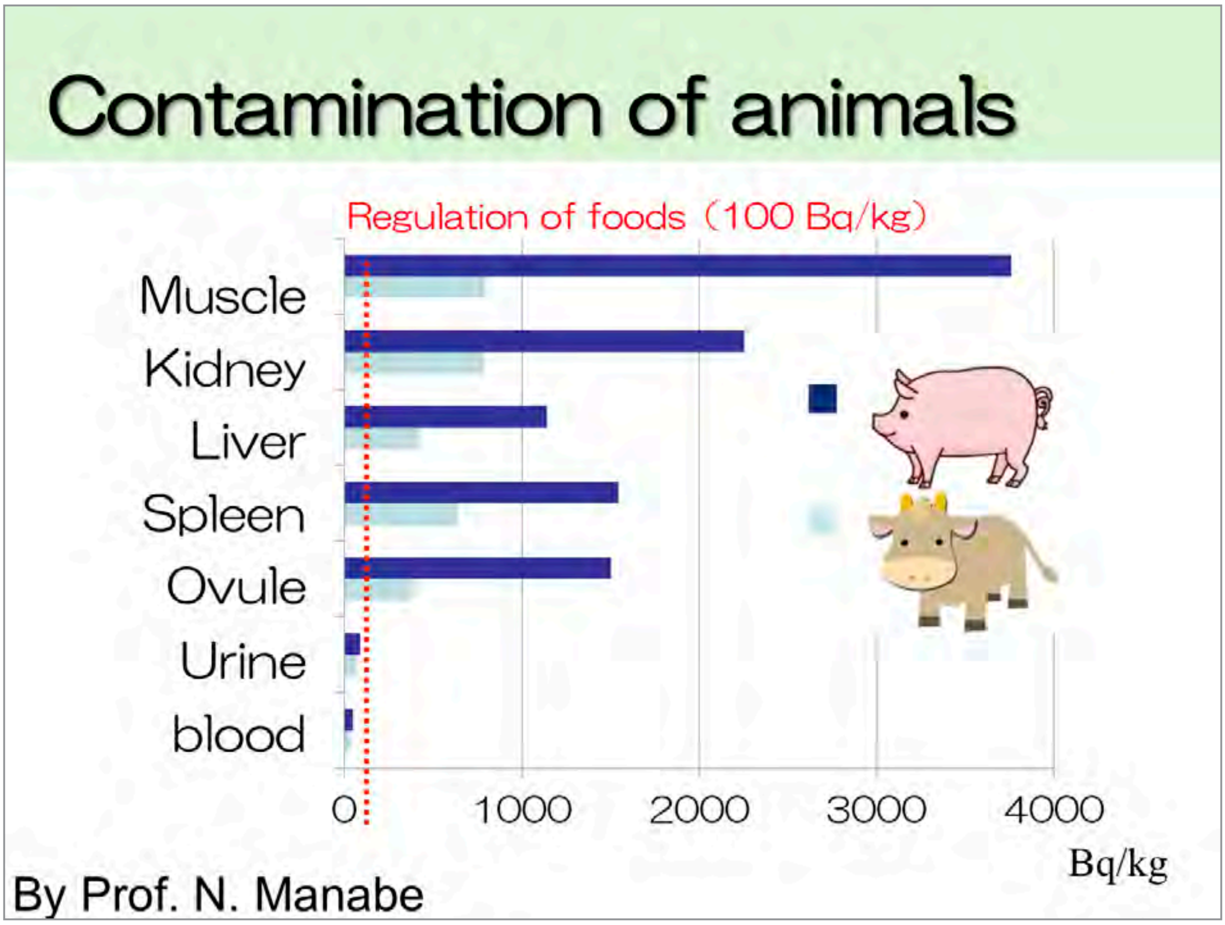
Experiment

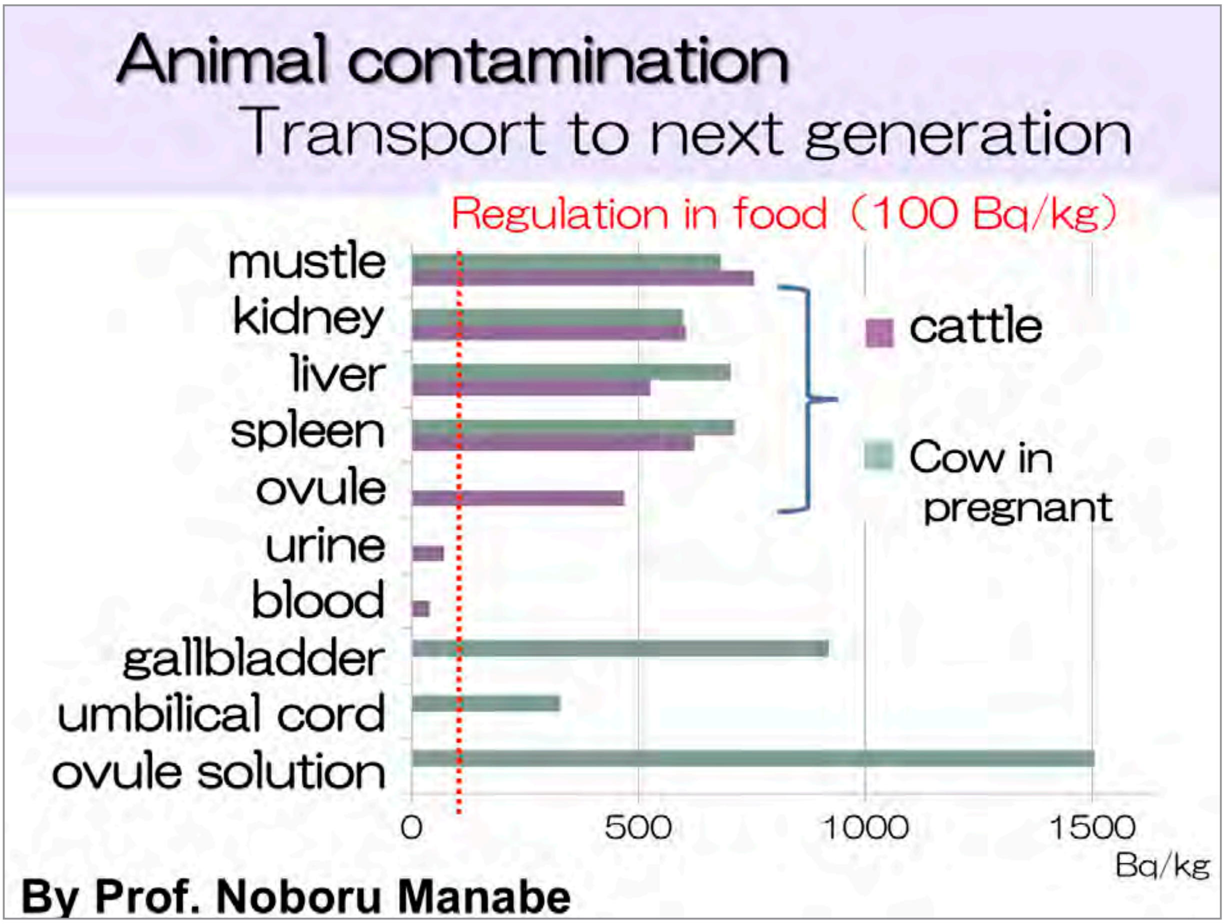
TMR 14d	TMR 14d	TMR 14d
TMR 14d	haylage+TMR 14d	TMR 14d

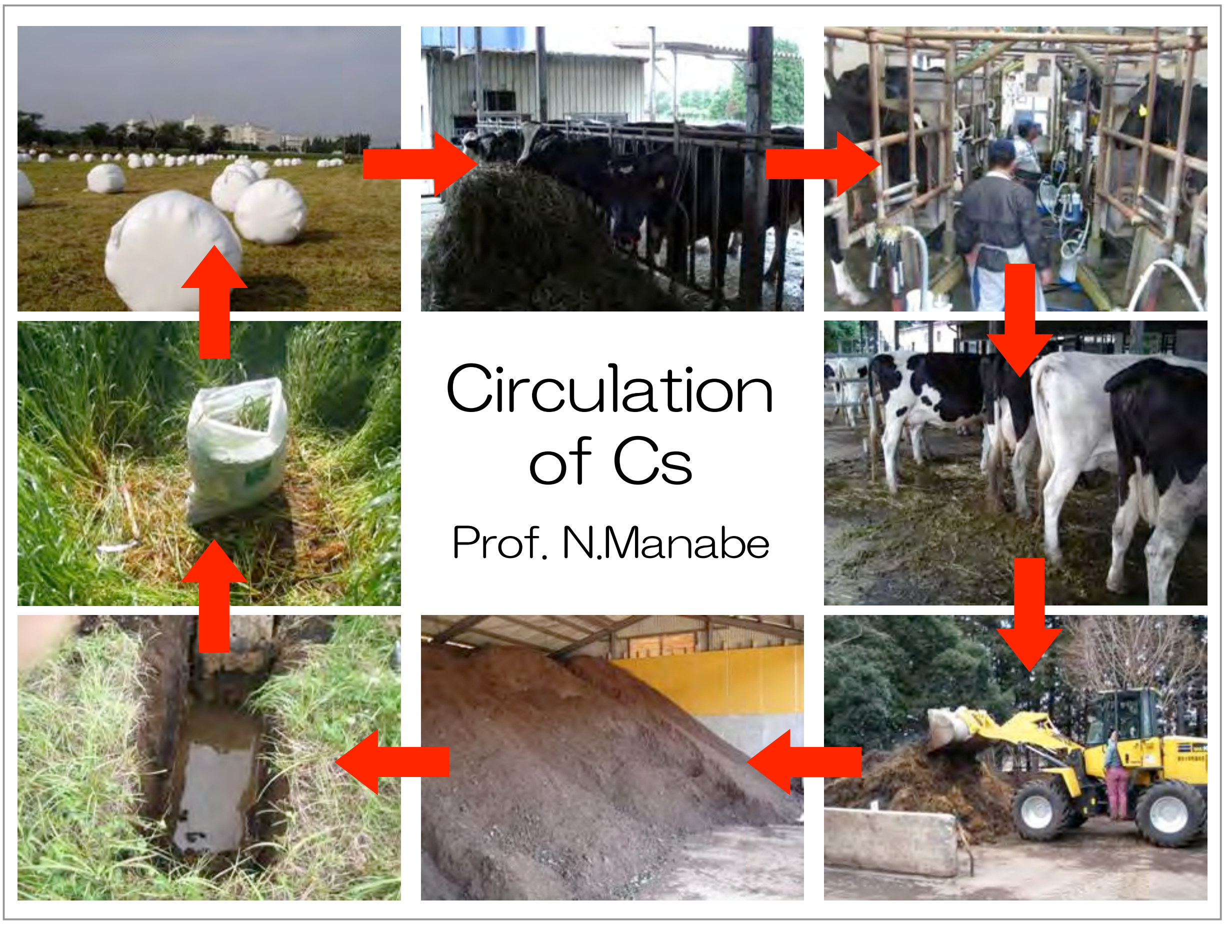
- TMR : 35kg/d
- haylage + TMR :
  haylage10kg + TMR
  25 kg /d
  (total 35 kg)

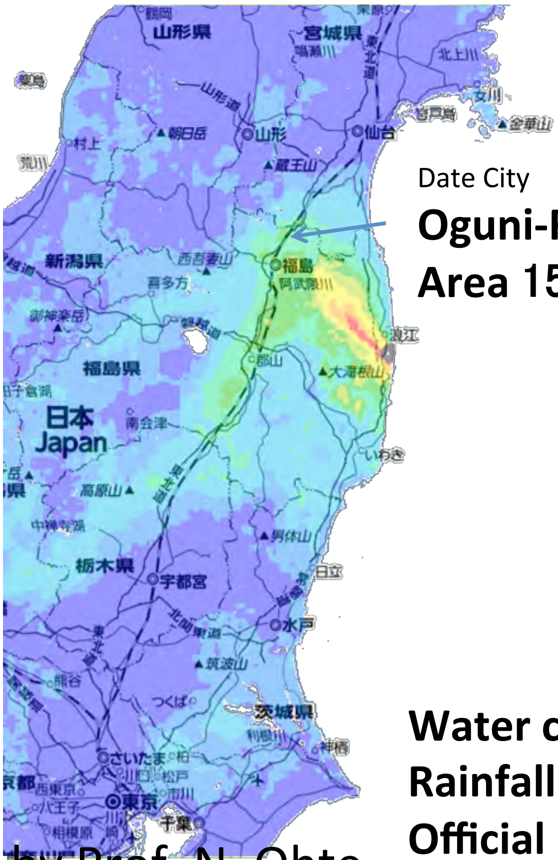
by Prof. N. Manabe


Radioactivity in milk
(Bq/kg)
Haylage with 137Cs
without 137Cs
40
35
30
25
20
15
10
5
0
TMR
Haylage+TMR
haylage+TMR：
haylage10 kg ＋T
MR25 kg/d
0 2 4 6 8 10 12 14 16 18 20 22 24 28 (日)
Takahashi et al. 2012, *RADIOISOTOPES* **2012**,
61, 551–554. doi:10.1105/tpc.114.124628
by Prof. N. Manabe

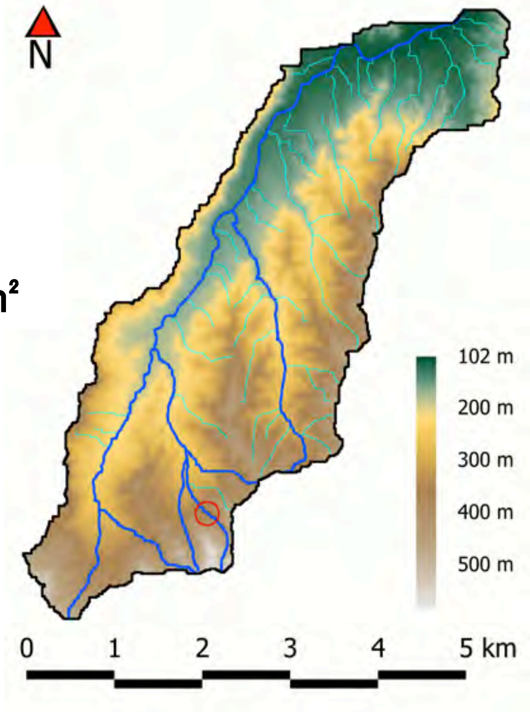

Contamination of animals
Regulation of foods（100 Bq/kg）
Muscle
Kidney
Liver
Spleen
Ovule
Urine
blood
0
1000
2000
3000
4000
Bq/kg
By Prof. N. Manabe


Animal contamination
Transport to next generation
Regulation in food（100 Bq/kg）
mustle
kidney
liver
spleen
ovule
urine
blood
gallbladder
umbilical cord
ovule solution
cattle
Cow in pregnant
0
500
1000
1500
Bq/kg
By Prof. Noboru Manabe


Circulation of Cs
Prof. N.Manabe



Date City
Oguni-River
Area 15.6km²

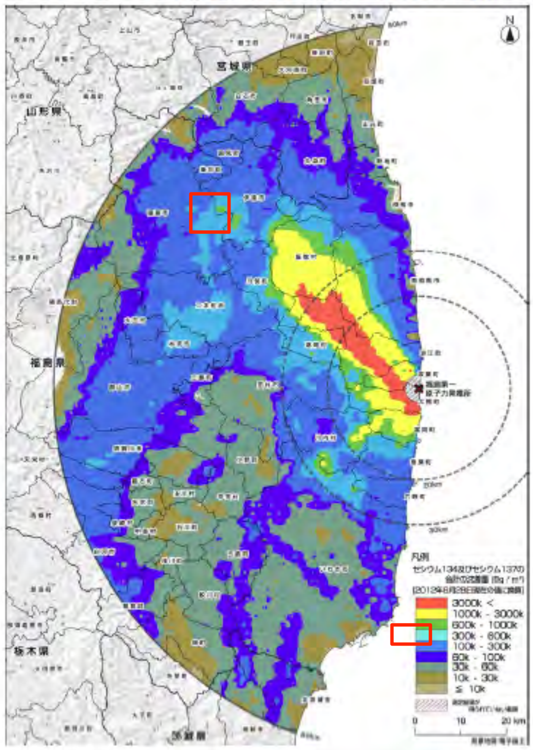


Water collecting area 0.189km²
Rainfall 437mm (2012/7- 12)
Official rainfall 953mm (2012)

by Prof. N. Ohte

Accumulation of radioactive Cs:
300000-1000000 Bq/m²

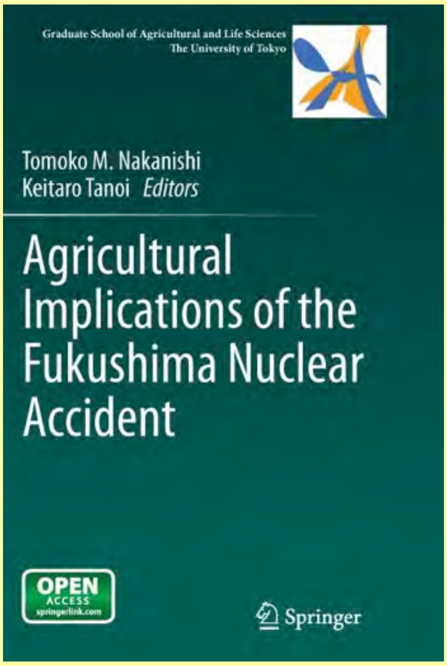
文部科学省による第5次航空機モニタリングの結果 別紙2
（福島第一原子力発電所から80km圏内の地表面への
セシウム134、137の沈着量の合計）（平成24年6月28日時点）



27.7Bq/m²/112days
→～ 90Bq/m²/year
Corresponds to
0.01-0.03% of accumulated Cs（1 in several thousand)

28

by A. Prof. N. Ohte

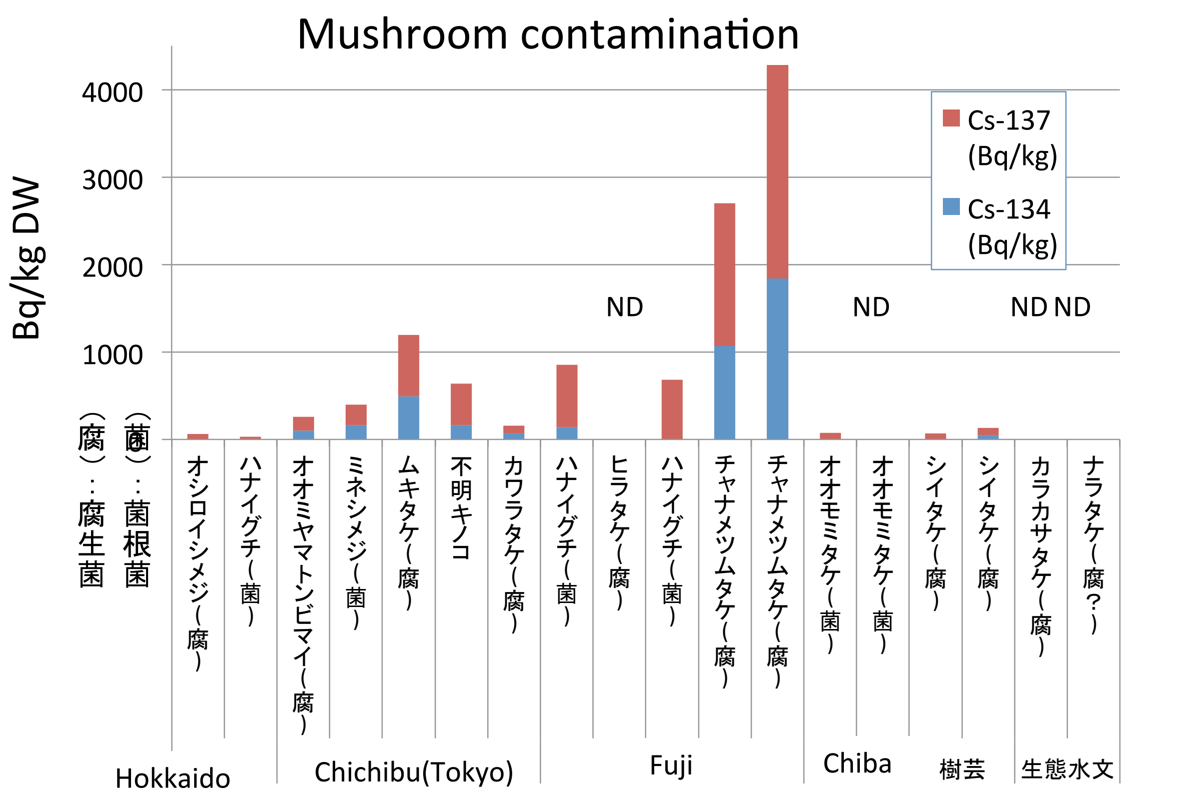


Chapter 1. Overview(T.M.Nakanishi)
2. Wheat (K.Tanoi)
3. Rice breeding (K. Nemoto)
4. Rice species (T.Fujiwara)
5. ^{137}Cs absorption in rice (N.I.Kobayashi)
6. Soil (S.Shiozawa)
7. Low level contamination (S.Ohshita
8. Products monitoring (N.Nihei)
9. Live stocks (N.Manabe)
10. Fish meet processing (S.Watabe)
11. Cs outflow in fish (T.Kaneko)
12. Wild birds (K.Ishida)
13. Field Decontamination (M.Mizoguchi)
14. Fruit tree (D.Takada)
15. Mushroom (T.Yamada)
16. Mountain (N.Ohte)
17.Science communication (H.Hosono

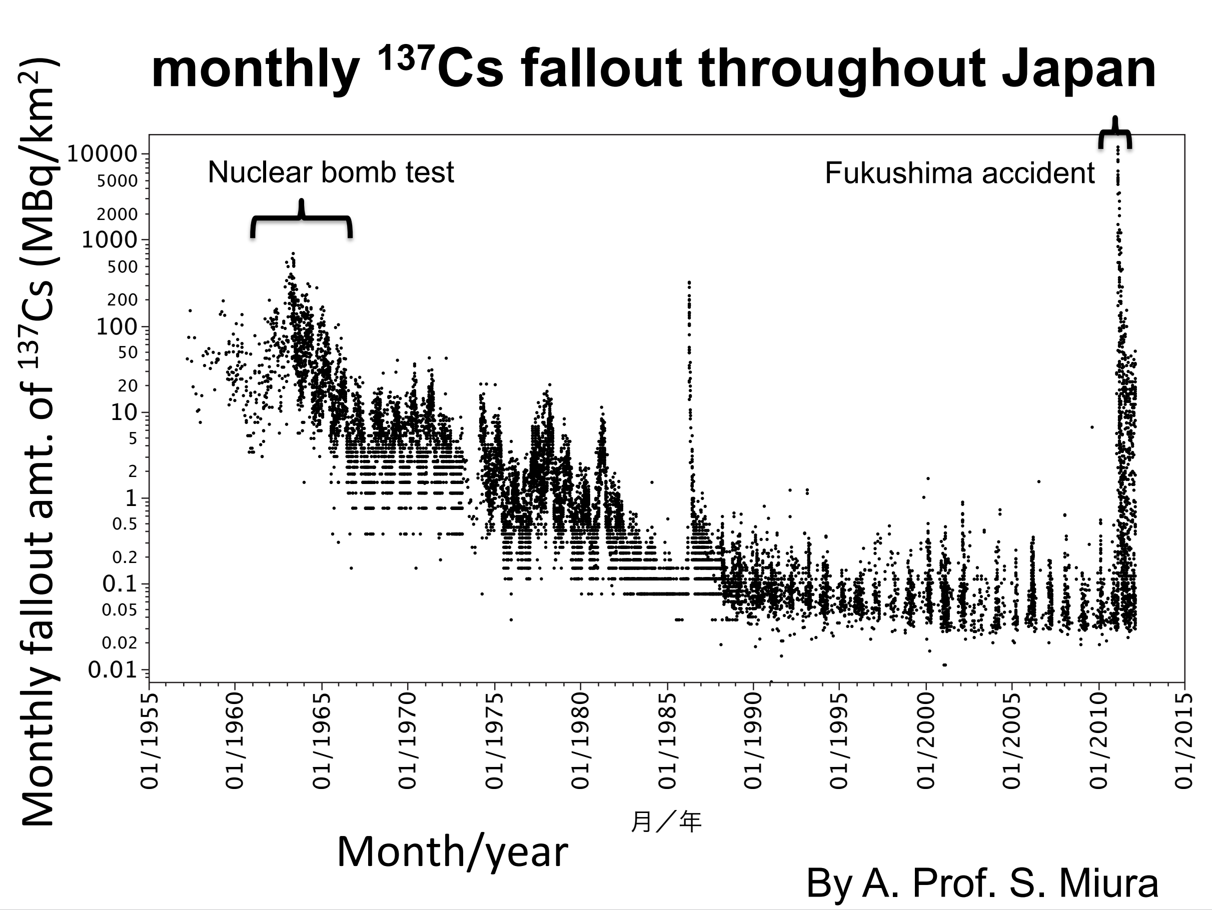
e-publish

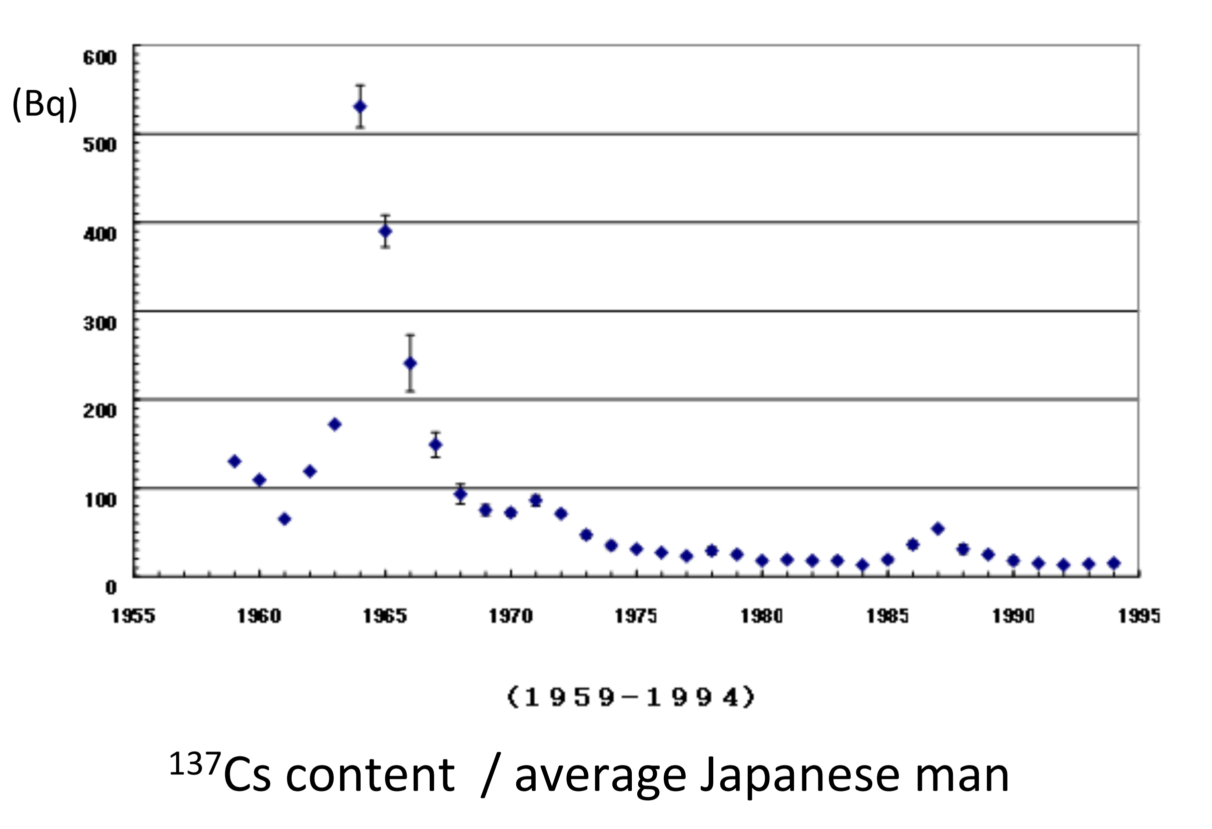
40-50 academic staffs

Yamada et al. 2013 *RADIOISOTOPES* **2013**, *62*, 141–147. http://doi.org/10.3769/radioisotopes.62.141

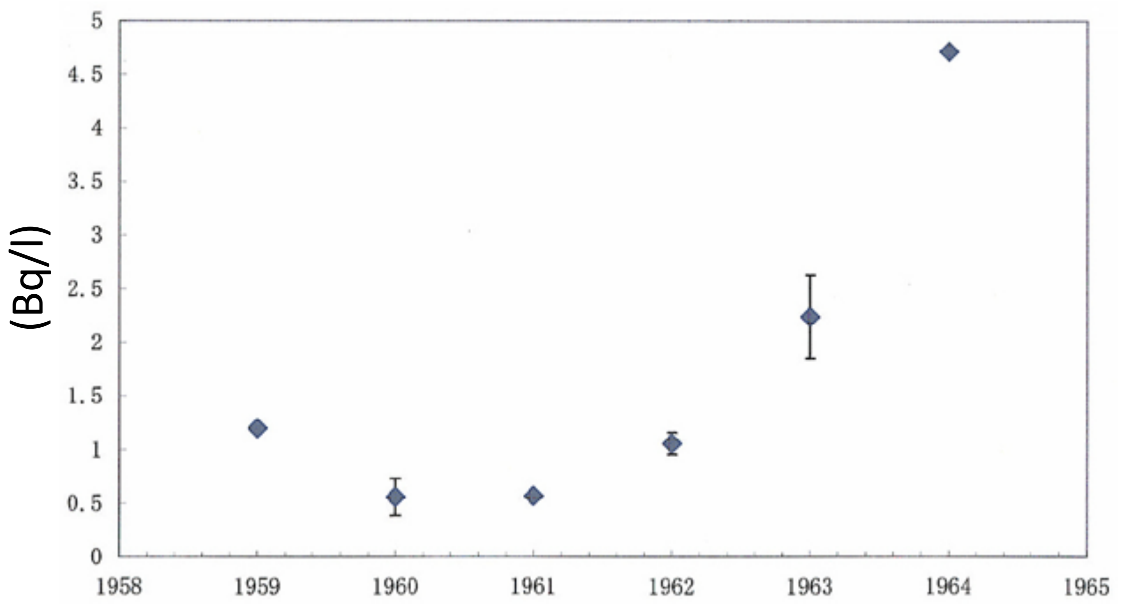


By Prof. T. Yamada





[出典]Health Physics 71, 322 (1996)



^{137}Cs concn. in urine of junior high school student

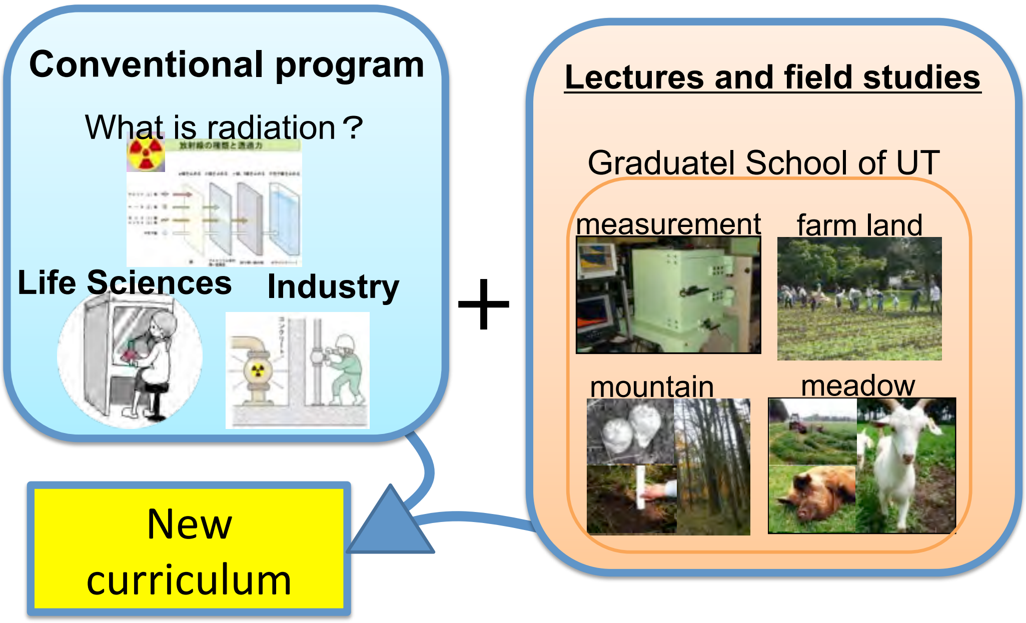
（1959−1964年）

[出典] Journal of Radiation research 3(1962), Survey Data in Japan 3(1964)、ibid. 6(1965)

http://www.rist.or.jp/atomica/data/pict/09/09010411/03.gif

New educational program: effect of radiation in agriculture

Lecture + Field Study

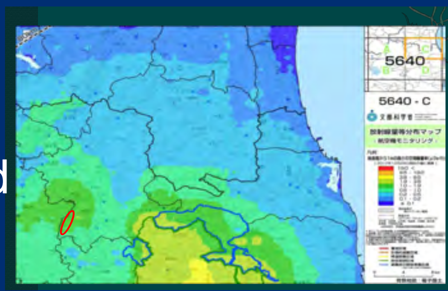


Examples of field study

Farming land : Iidate village

Mountain : Date City

Measurement of the tree growth
Sampling the plants, animals and water



Field study (medow)


Thank you

3.2 Studies in environmental radiology in South-West Sweden after the Chernobyl accident

Sören Mattsson†, [1]

† Presenter: soren.mattsson@med.lu.se

1 Medical Radiation Physics Malmö, Lund University, Skåne University Hospital Malmö, SE-205 02 Malmö, Sweden

The talk will shortly summarize results of some of the studies which were initiated immediately after the Chernobyl catastrophe. The studies included investigations of radionuclide deposition, penetration in soil, transport in the food chain grass-cow-milk, and measurements of 131I and 134, 137Cs in persons. The removal of activity from hard urban surfaces was studied in sewage sludge from waste water treatment plants. Already ongoing studies of radionuclides in brown algaes and pine needles were expanded.

It was possible to quickly launch these measurement programs because there were ongoing measurement programs with the appropriate detectors in other ongoing research projects and an experience of sampling and measurements in the environment since the studies of fallout from the atmospheric nuclear weapons tests.

Some references:

S. Mattsson and R. Vesanen. Patterns of Chernobyl fallout in relation to local weather conditions. Environment. International 14, 177-180 (1988).

E. Wallström, N. Drugge, R. Vesanen, Å. Cederblad, L. Larsson, B. Arvidsson, M. Alpsten and S. Mattsson. Radiological studies in western Sweden after the Chernobyl accident. In: The Chernobyl fallout in Sweden. Results from a research programme on environmental radiology. Ed by L. Moberg. The Swedish Radiation Protection Institute, Stockholm, Sweden, 1991, pp. 373-388.

S. Mattsson. B. Hemdal, E. Håkansson, L. Ahlgren, M. Alpsten, Å. Cederblad and N. Drugge. Radioactive iodine and cesium in persons from Southern and Western Sweden after the Chernobyl accident. In: Proc. XVth Regional Congress of IRPA, Visby, Gotland, Sweden, 10-14 September, 1989 (Ed by W. Feldt). Fachverband für Strahlenschutz e.V. FS-89-48-T, ISSN 1013-4506, pp 397-402

B. Erlandsson and S. Mattsson. Uptake of dry-deposited radionuclides in Fucus. A field study after the Chernobyl accident. J. Environ. Radioactivity 6, 271-281 (1988)

S. Mattsson and B. Erlandsson. Variations of the Cs-137 levels in Fucus from the Swedish westcoast during a 25 year period. In: The Chernobyl fallout in Sweden. Results from a research programme on environmental radiology. Ed by L. Moberg. The Swedish Radiation Protection Institute, Stockholm, Sweden, 1991, pp. 143-149.

B. Erlandsson, B. Bjurman and S. Mattsson. Calculation of radionuclide deposition by means of measurements on sewage sludge. Water, Air and Soil Pollution 45, 329-344 (1989)

B. Erlandsson, M. Isaksson, S. Mattsson and B. Hemdal. The urban contamination after the Chernobyl accident studied in sewage water and sludge from Lund and Gothenburg. On the validity of environmental transfer models". In: Proceedings BIOMOVS, Swedish Radiation Protection Institute, Stockholm, Sweden, pp 169-179, 1991 .

S. Mattsson and L. Moberg. Fallout from Chernobyl and atmospheric nuclear weapons tests. Chernobyl in perspective. In: The Chernobyl fallout in Sweden. Results from a research programme on environmental radiology. Ed by L. Moberg. The Swedish Radiation Protection Institute, Stockholm, Sweden, 1991, pp. 591-627.

P. Roos, C. Samuelsson and S. Mattsson. Cs-137 in the lichen Cladonia Stellaris before and after the Chernobyl accident. In: The Chernobyl fallout in Sweden. Results from a research programme on environmental radiology. Ed by L. Moberg. The Swedish Radiation Protection Institute, Stockholm, Sweden, 1991, pp. 389-400.

P. Roos, E Holm, C. Thornberg, S. Mattsson. Long-term trend of $^{239+240}$Pu and ^{99}Tc in brown algae from the Swedish west coast. In: Umweltradioaktivität - Radioökologie - Strahlenwirkungen. Band 2, Fachverband für Strahlenschutz e.V , 1993.

R Hedvall, B Erlandsson and S Mattsson Cs-137 in fuels and ash products from biofuel plants in Sweden. J Environ Radioactivity 31, 103-117, 1996.

CL Rääf, B Hemdal, S Mattsson. Body burden and excretion of ^{137}Cs and ^{40}K in subjects from the south of Sweden. J Environ Radioactivity 47(1), 83-100, 2000.

CL Rääf, B Hemdal, S Mattsson. Ecological half-time of radiocesium from Chernobyl debris and from nuclear weapons fallout as measured in a group of subjects from the south of Sweden. Health Physics 81, 366-78, 2001.

M Isaksson, B Erlandsson, S Mattsson. A 10-year study of the ^{137}Cs distribution in soil and a comparison of Cs soil inventory with precipitation-determined deposition. J Environ Radioact 55(1), 47-59, 2001.

P Lindahl, C Ellmark, T Gäfvert, S Mattsson, P Roos, E Holm, B Erlandsson. Long-term study of ^{99}Tc in the marine environment on the Swedish west coast. Environ Radioact 67(2), 145-156, 2003.

S. Mattsson, C. Bernhardsson and B. Erlandsson. Chernobyl influences in southwest Sweden as indicated by a colony of brown algae. Joint meeting in Radiation Biology and Radioecology Two decades after Chernobyl - summing up the consequences of the accident, Marstrand, Sweden, 25-28 April, 2006.

C. Bernhardsson, B. Erlandsson and S. Mattsson. Chernobyl influences in southwest Sweden as indicated by needles of spruce. Joint meeting in Radiation Biology and Radioecology Two decades after Chernobyl - summing up the consequences of the accident, Marstrand, Sweden, 25-28 April, 2006.

Joint Japan Sweden Radioecology Workshop 2015
2 September, 2015, University of Gothenburg, Sweden

Studies in environmental radiology in south-west Sweden after Chernobyl

Sören Mattsson

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Skåne University Hospital Malmö
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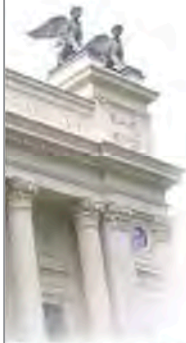
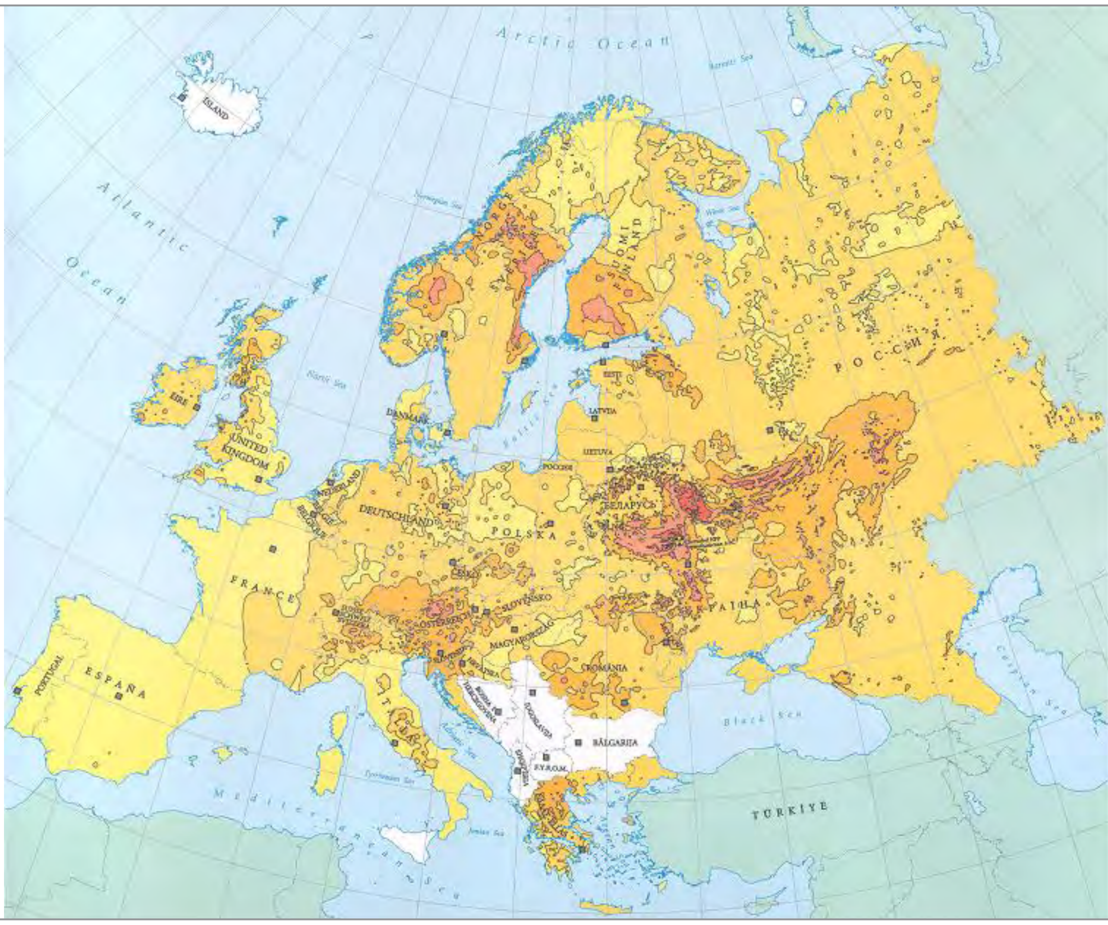


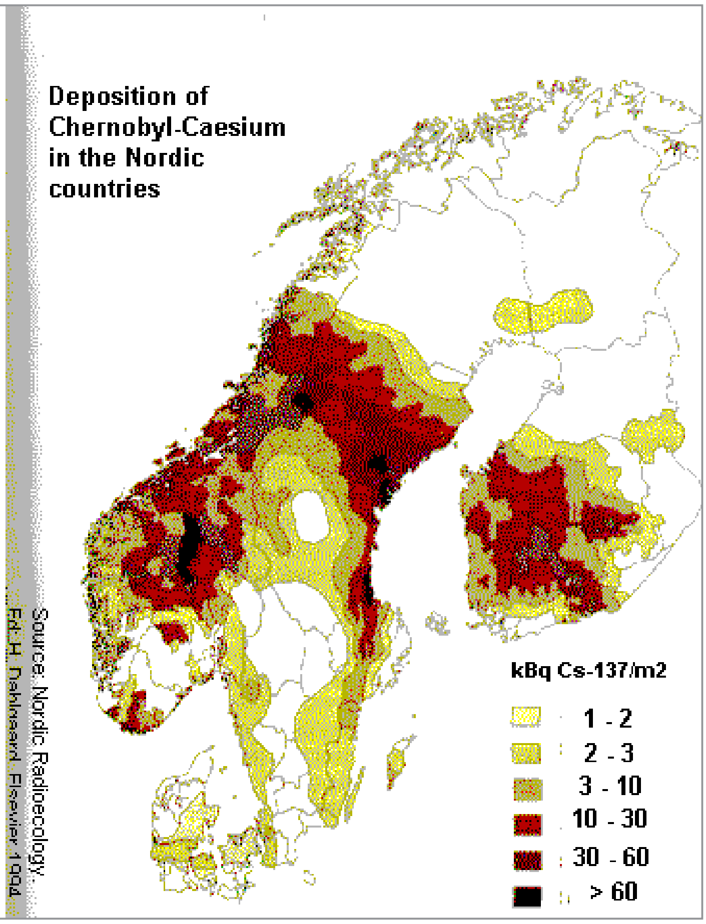
LUNDS UNIVERSITET

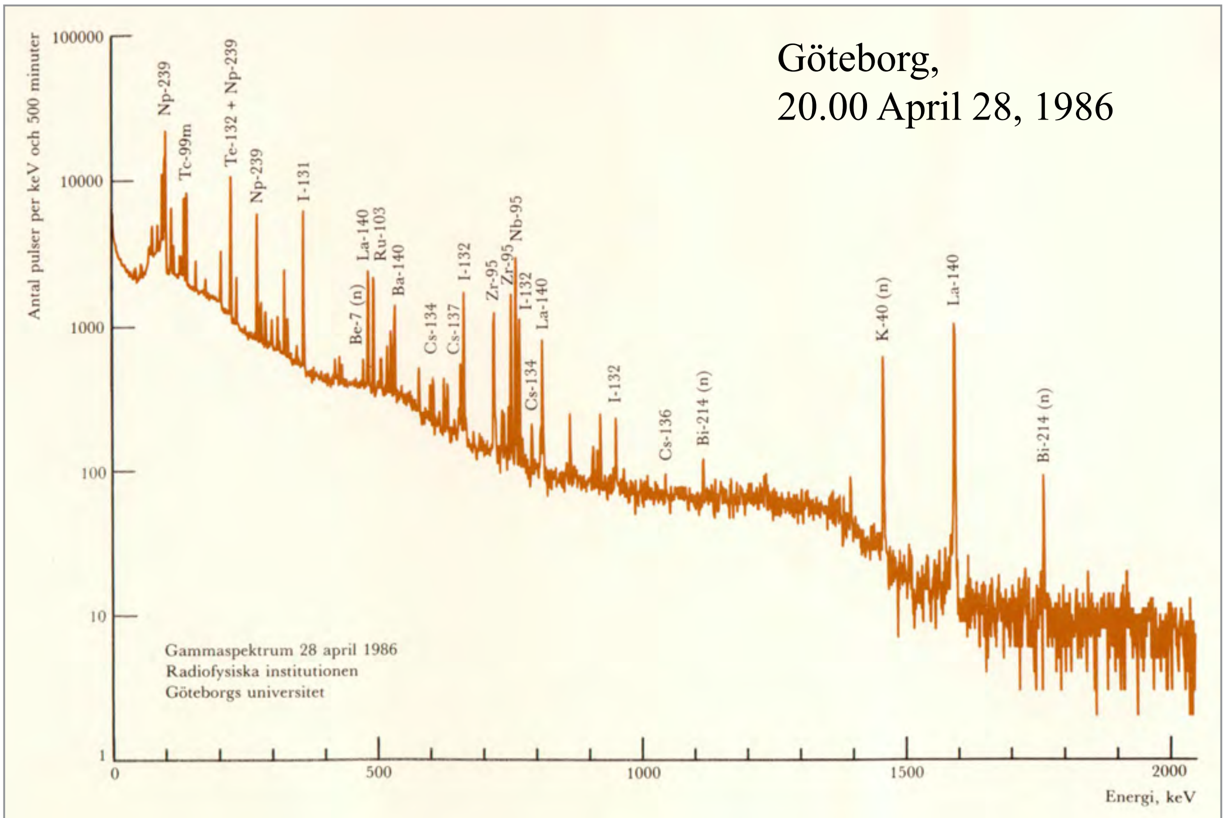
GÖTEBORGS UNIVERSITET

… the ”foremost nuclear catastrophe in human history”(IAEA)


The Impossible Happens
Chernobyl, 1986
ASIA
Pacific Ocean
Arctic Ocean
Chernobyl
EUROPE
AFRICA
Pacific Ocean
N AMERICA
Atlantic Ocean
radioactive cloud
27 April
by 6 May
Source: Lawrence Livermore National Laboratory







Mattsson och Vesanen, 1986 (published on official Christmas card from Göteborg University 1986)

Extra kontroll efter olyckan i Sovjet!

Nu mäts radioaktiviteten på alla fordon från öst

TRELLEBORG: Kärnkraftolyckan i Sovjet orsakade skärpt kontroll i Trelleborgs hamn på tisdagen.
Varje lastbil och järnvägsvagn som kom med färjan från Östtyskland testades av speciell personal från länsstyrelsen.

— Radioaktiviteten på fordonen mäts, berättar Bruno Nilsson, bevakningschef vid trelleborgstullen.

— Många bilar och vagnar kommer från Österrike, Ungern, Tjeckoslovakien och andra platser relativt nära olycksplatsen så man kan inte utesluta att de för med sig radioaktivitet till högre värden än normalt.

Alla mäts

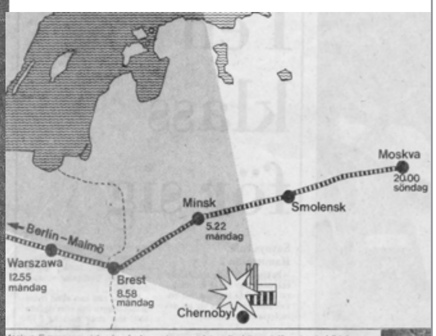
Två man från länsstyrelsen turas om att mäta värdena på samtliga anlädnande fordon. Under tisdagen uppmättes endast mycket svaga värden.

— Länsstyrelsen fortsätter kontrollen till och med onsdag morgon. Skulle en bil eller järnvägsvagn visa för höga värden måste den saneras. Det blir brandkårens och i viss mån polisens uppgift, säger Bruno Nilsson.

Arbetet var med när 14.30-färjan kom in till Trelleborg. Endast en lastbil fanns med i lasten den turen och den klarade sig vid Lars Ahlgrens testmätning.

● Den här bilen som körde i land i Trelleborgs hamn från Östtysklandsfärjan klarade sig. Lars Ahlgren fixerar mätaren men upptäcker inga förhöjda radioaktiva värden. Bilen fick rulla vidare in i landet. Foto: ERLAND ANDERSSON

Arbetet 30 april 1986



Sydsvenskan
30 april 1986

- **Authorities want information**
- **Journalists want quick answers**
- **The public is very worried and asks questions**
- **You want to do systematic studies to learn more**

- **Deposition**
- - dry
- - wet
- **Grass**
- **Milk**
- **Humans**

Bioindicators

- Sewage sludge
- Brown algaes
- Pine needles
- Lichen (-reindeer-man)

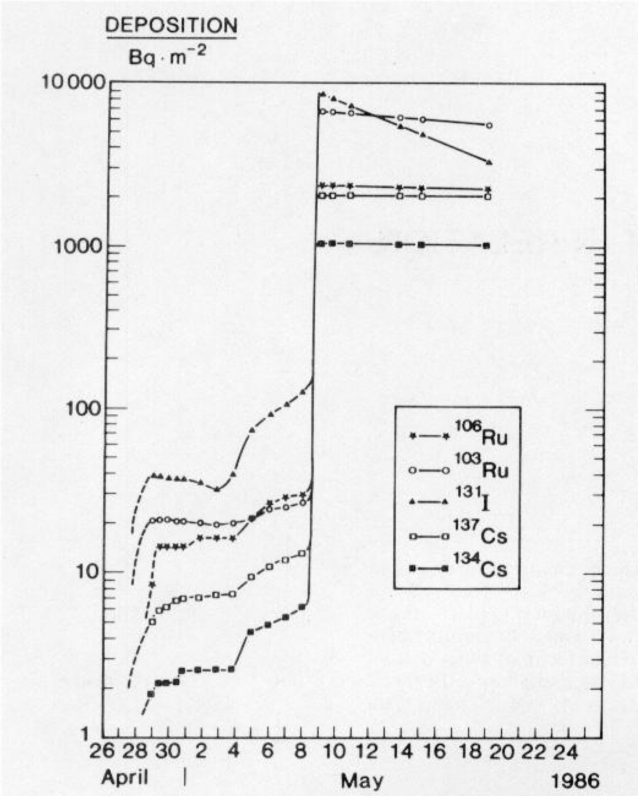
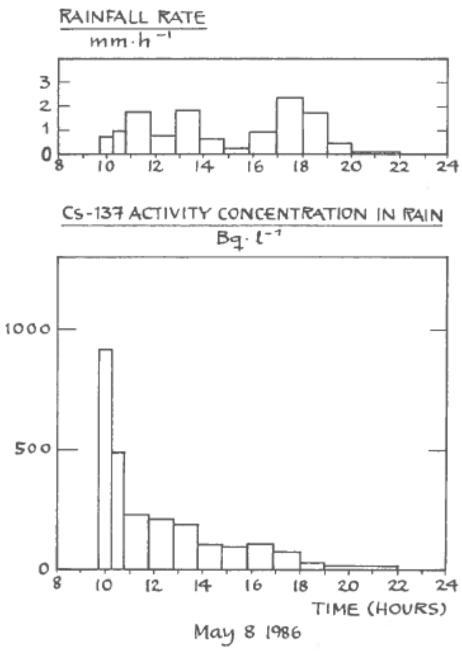


Fig. 1. The deposition on ground of ^{137}Cs, ^{134}Cs, ^{131}I, ^{106}Ru and ^{103}Ru in Göteborg after the Chernobyl accident.

Mattsson and Vesanen, 1988



Figur 2

Variation i nederbörd och i regnvattnets Cs-137 koncentration under den 8 maj 1986

Mattsson and Vesanen, 1988

Table

Deposition in Göteborg of some γ-emitting radionuclides from Chernobyl

Radionuclide	*Activity per unit area, Bq/m²*	
	1986-05-07-22.00	1986-05-10-24.00
Zr-95	20-25	110
Ru-103	27	6 400
Ru-106	10-15	2 300
I-131	130	7 000
Cs-134	6,1	1 020
Cs-137	13	2 030
Ba-140	35	640
Ce-141	38	120

Mattsson and Vesanen, 1988

Sewage sludge

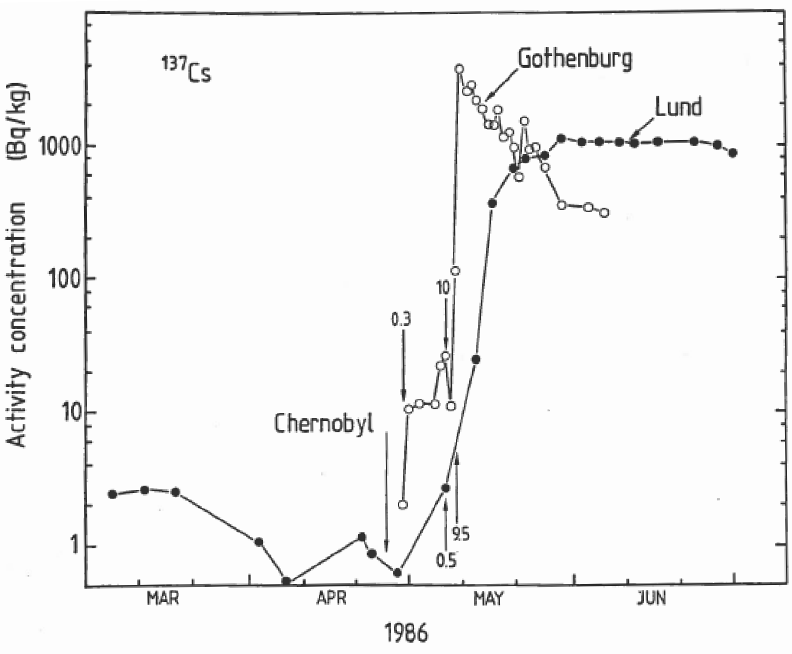


Fig. 2 Activity concentration of ^{137}Cs in dried sewage sludge at Lund and Gothenburg. The first occasions of precipitations and the amount is marked with arrows.

Erlandsson et al., 1991

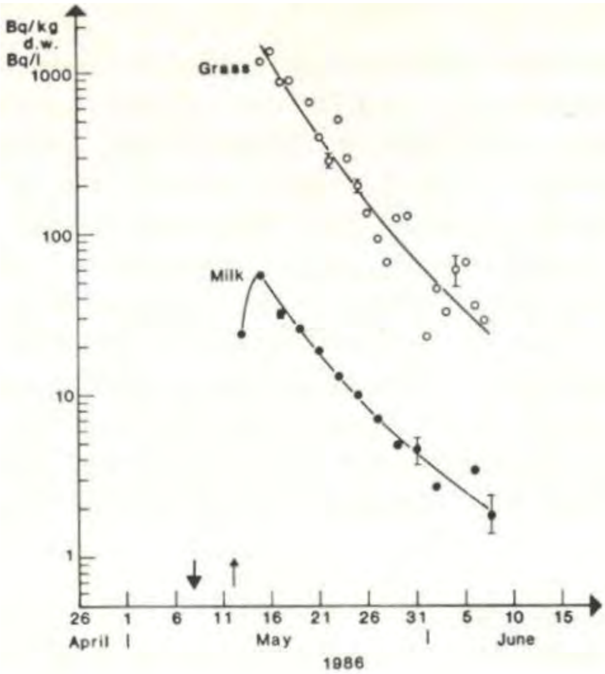
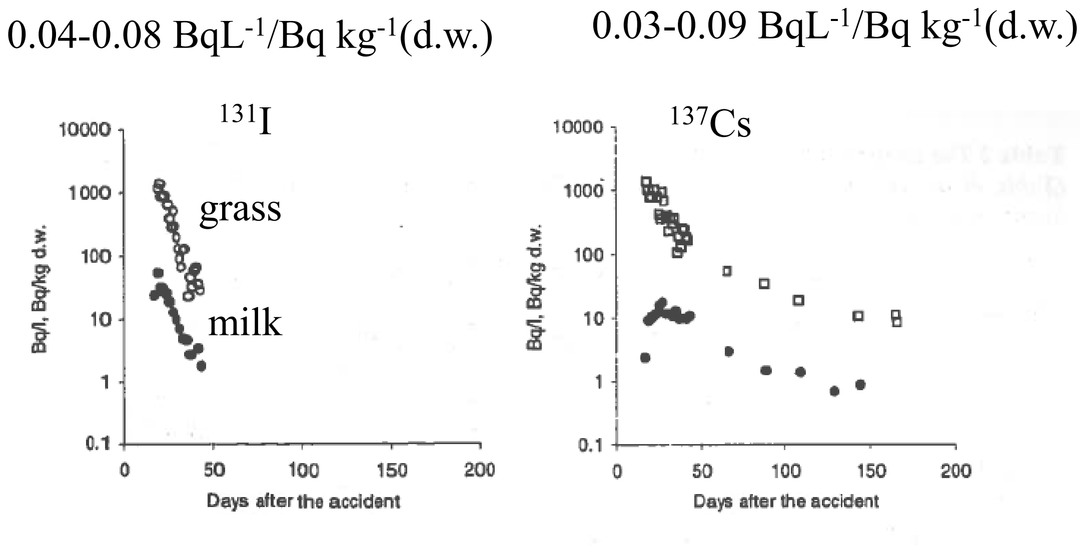


Fig. 2. Activity concentration of I–131 in milk and grass at farm A.

Wallström et al., 1991



a) b)

Figure 5 *Activity concentration of ^{131}I (a) and ^{137}Cs (b) in grass and cow's milk from May to September 1986 at farms A. Open symbols refer to grass (Bq kg^{-1} d.w.), filled to milk (Bq L^{-1})*

Wallström et al., 1991

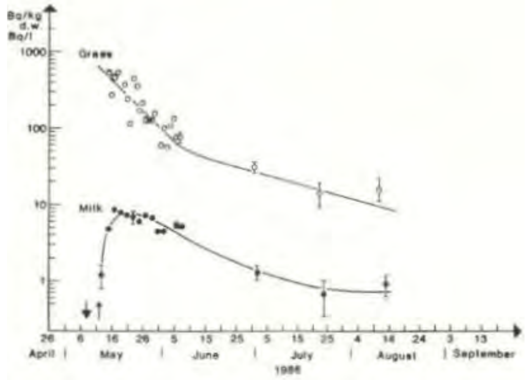


Fig. 3. Activity concentration of Cs–134 in milk and grass at fram A.

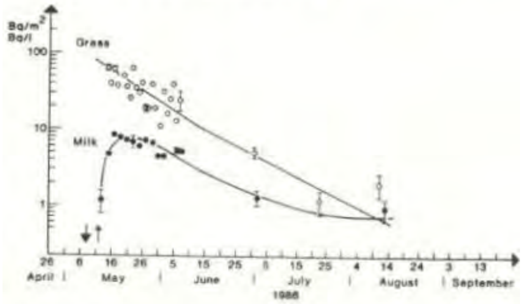
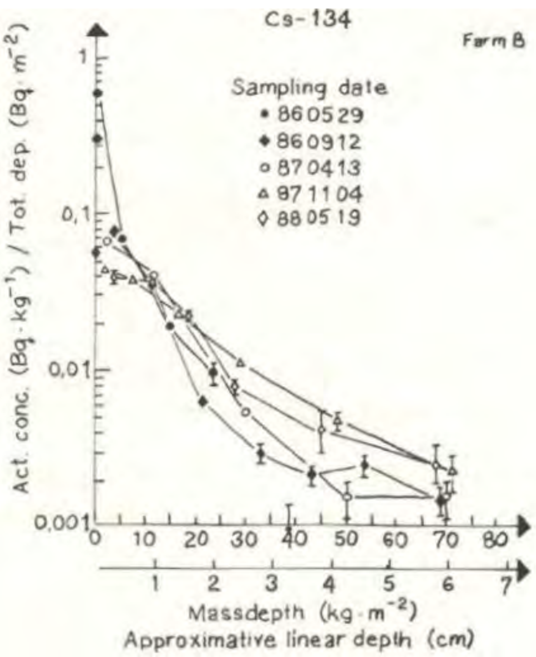


Fig. 4. Activity content of Cs–134 in milk and grass at farm A.

Wallström et al., 1991



Activity concentration of Cs–134 in soil (normalized), 1986–1988.

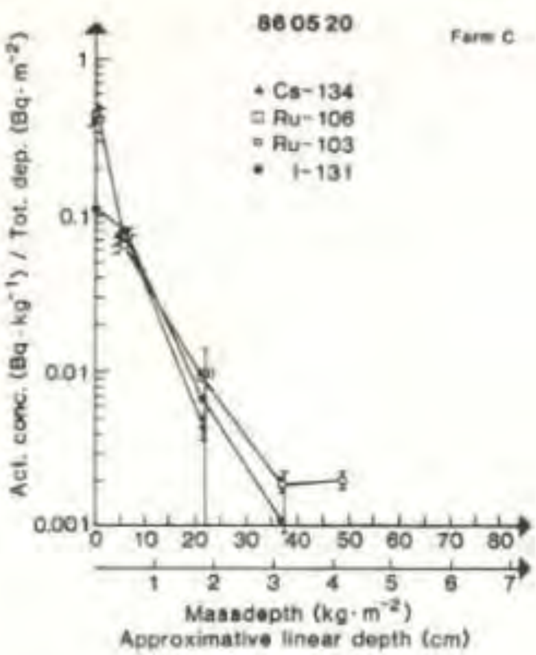


Fig. 6. Activity concentration (normalized) in soil for a number of radionuclides, May 20th 1986.

Wallström et al., 1991

Whole-body countings

Table 1. I-131 content (Bq) (±1 SE) in the thyroid gland of persons of various ages in the Göteborg and Malmö area. (n = number of persons, ND = non detectable)

Time period Age, year Area	7/5	8-11/5	12-18/5	19-25/5	26/5-1/6	2-10/6
0-1 Göteborg	-	-	ND n=4	2.5 n=1	-	-
1-7 Göteborg	-	13.7±3.4 n=4	6.9±1.2 n=5	3.5±0.4 n=2	-	ND n=3
7-16 Göteborg	8.3 n=1	9.5±1.3 n=4	5.7±1.4 n=6	-	-	4.9 n=1
7-16 Malmö	34 n=1	-	15.5±4.0 n=7	4.9±3.0 n=5	7.0±2.8 n=4	3.0±3.5 n=7
16- Göteborg	5.5±1.4 n=6	6.8±1.1 n=7	6.9±0.7 n=27	4.7±0.9 n=5	3.9±1.1 n=6	2.2±1.0 n=8
16- Malmö	-	3.4 n=1	11.5±1.2 n=17	7.8±2.2 n=14	3.7±1.6 n=9	ND n=17
16- Malmö, outdoor workers	-	-	18.5±4.0 n=5	9.3±3.1 n=2	8.8±1.9 n=3	ND n=5

Mattsson et al., 1989

Whole-body countings

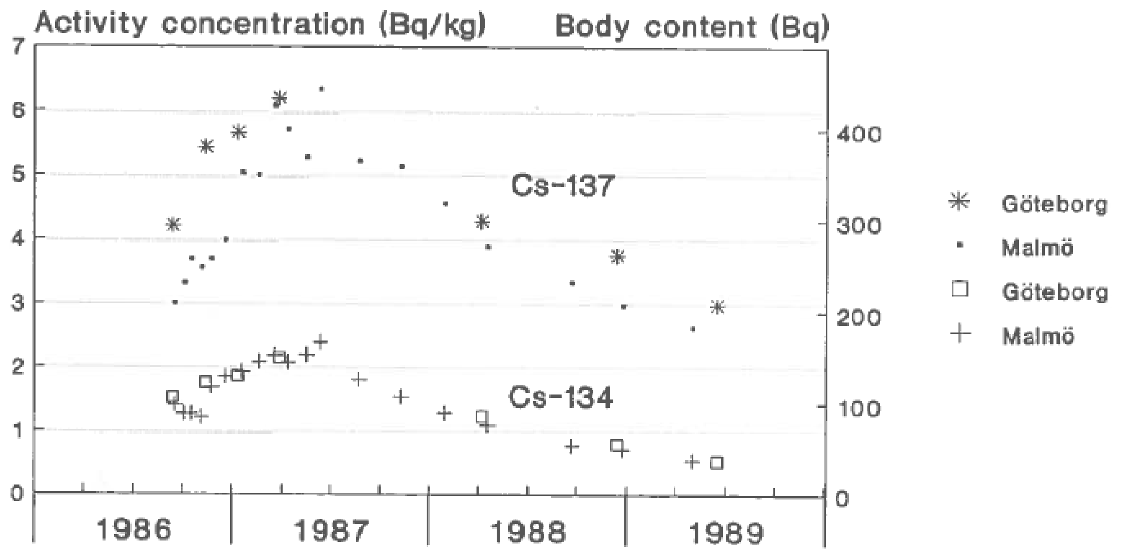


Figure 1. The mean activity concentration (and the total activity in a 70 kg person) of Cs-137 and Cs-134 in the reference groups from the Göteborg (8 men and 10 women) and Malmö areas (6 men and 6 women).

Mattsson et al., 1989

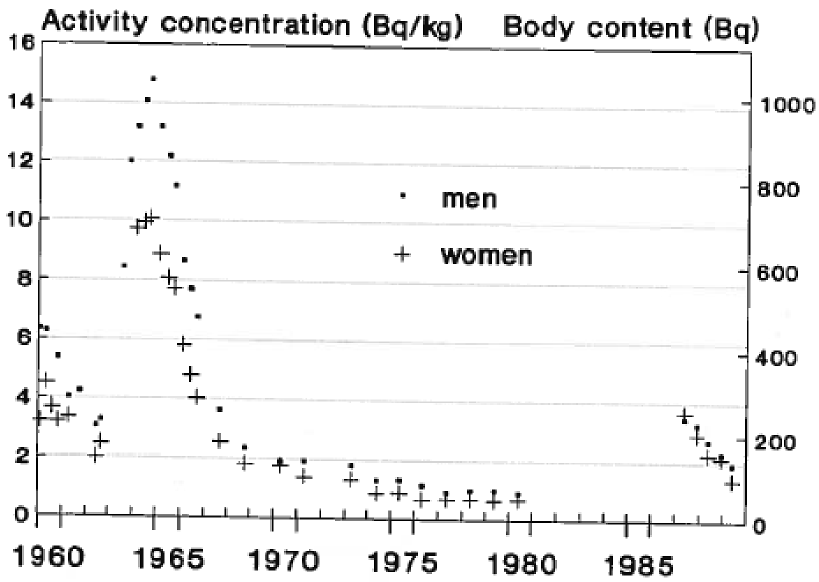


Figure 2. The mean activity concentration (and the total content in a 70 kg person) of Cs-137 in the reference group from Lund during the time period 1960 to 1989. No measurements were carried out in the period 1981 to 1986. The mean age of the group was 39 (20-54) years in 1964 and 56 (28-77) years in 1987.

Mattsson et al., 1989

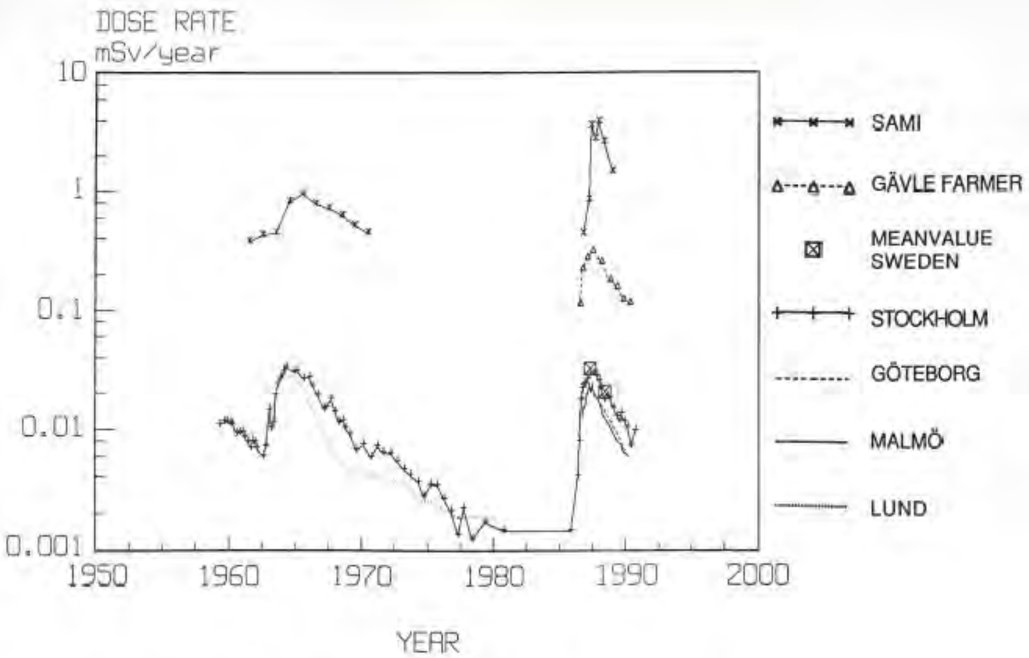
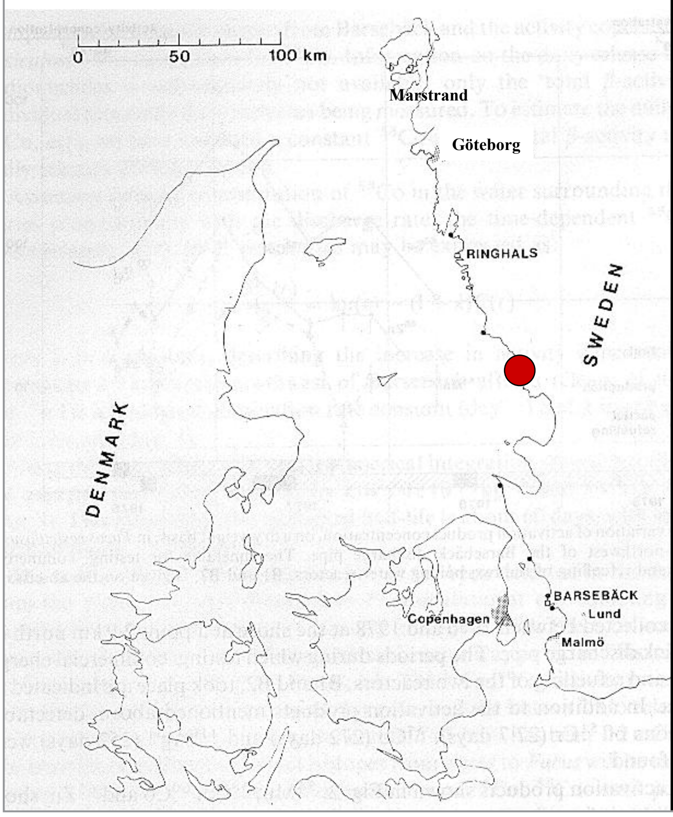


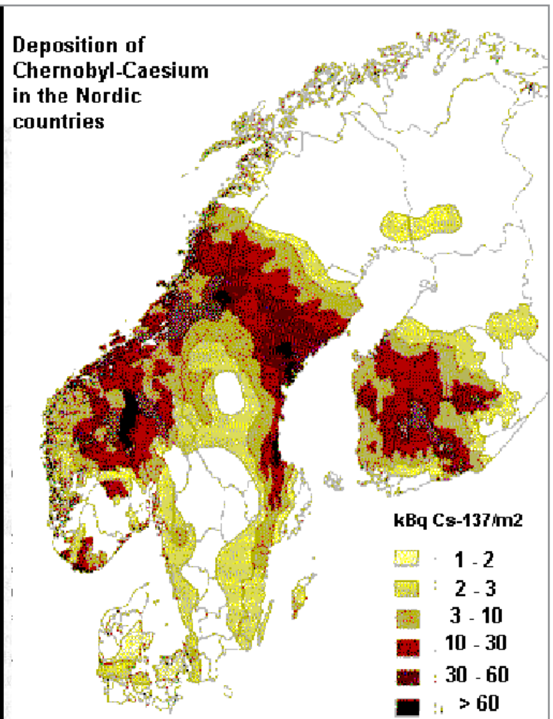
Figure 2. The effective dose equivalent rate (mSv/year) from cesium (Cs-134 and Cs-137) as calculated from whole-body measurements (Falk et al, this volume; Mattsson et al, 1989, Hemdal, 1991, Wallström, 1991).

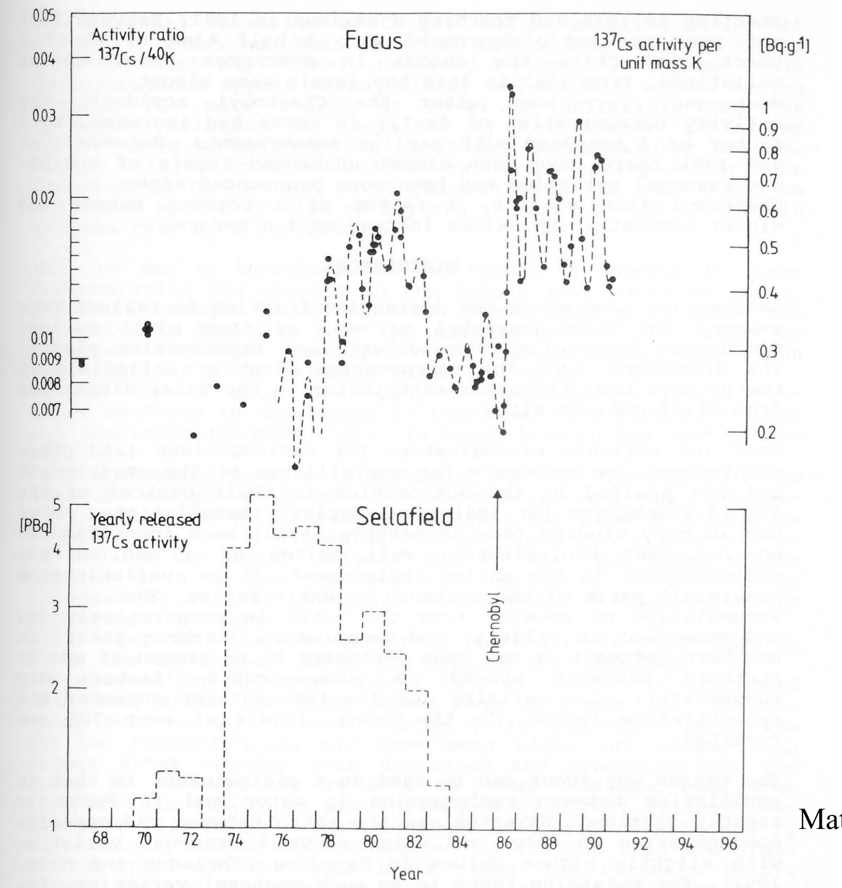
Mattsson and Moberg, 1991

Fucus serratus
Sågtång

Fucus vesiculosus
Blåstång



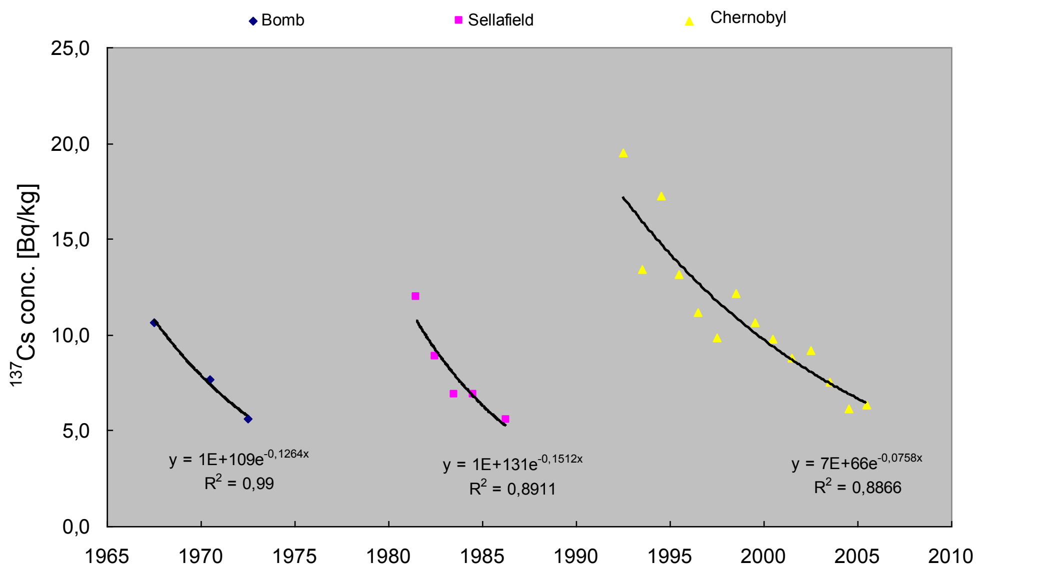




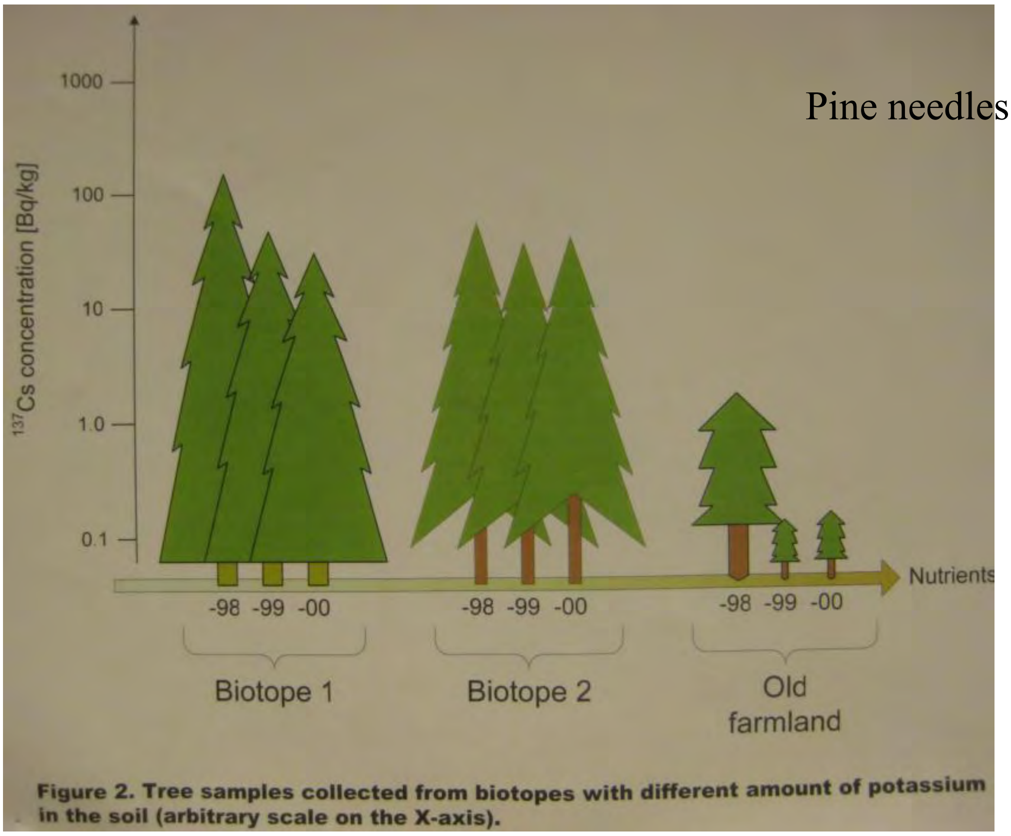
Mattsson and Erlandsson, 1991

Effective decrease rate related to different input sources

Atmospheric nuclar weapons tests	13 % per year - $T_{\frac{1}{2}}$ = 5.5 yr
Sellafield	15 % per year - $T_{\frac{1}{2}}$ = 4.6 yr
Chernobyl	8 % per year - $T_{\frac{1}{2}}$ = 9.1 yr



Mattsson et al., 2006



Bernhardsson et al., 2006

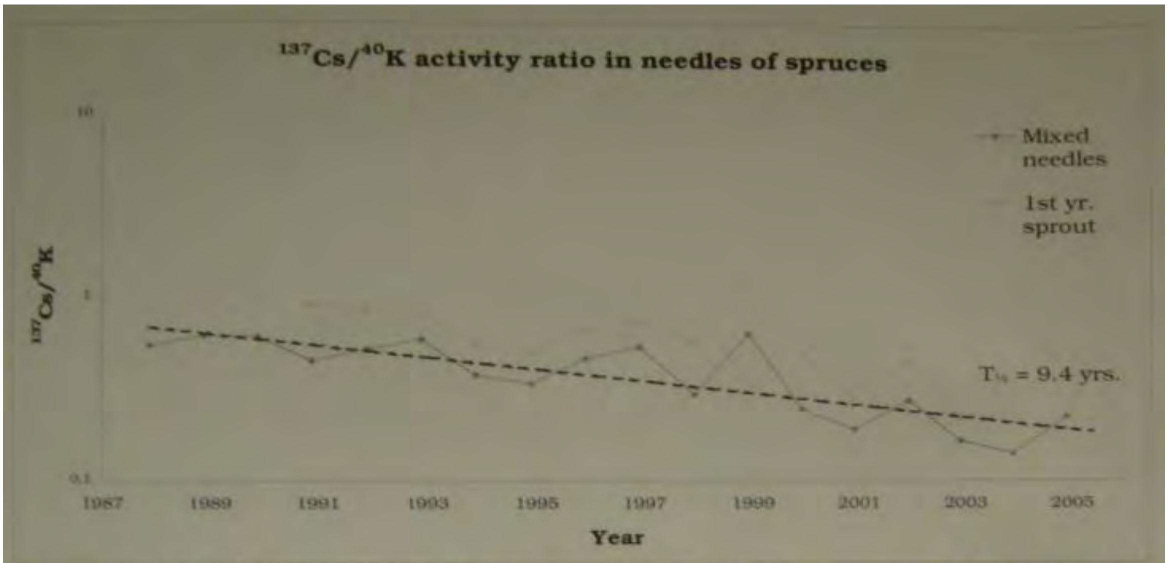


Figure 1. The ^{137}Cs/^{40}K ratio in the youngest needles compared to the older needles (mix). Each tree comes from biotope 1, where there is a smaller amount of potassium in the soil. The years on the X-axis indicate January that year.

Bernhardsson et al., 2006

Necessary conditions to carry out such studies

- Suitable detectors in use for other projects
- Staff with experiences of sampling and measurements in the environment
- Interest for such measurements

Desirable conditions

- Possibilities for very early measurements
- Existing background values
- Fast measurement methods
- National or regional coordination
- National and international networks

Thank you for listening!

soren-mattsson@med.lu.se

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(continued)

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3.3 Analysis of the radiocaesium fixation process in soil using radioactivity monitoring data on spinach from Fukushima

Nobuko Mitsuoka†, [1], Naoto Nihei[1], Sho Shiozawa[1], Shuichiro Yoshida[1], Kazuhiro Nishida[1]

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Radiocaesium (^{137}Cs) emitted by the Fukushima Daiichi nuclear power plant accident contaminated the soil and agricultural products in the Fukushima area. Although ^{137}Cs has a long half-life of 30.1 years, and should remain in the soil surface for a relatively long time, the radiocaesium concentration in most agricultural products decreased rapidly and reached non-detectible levels within a few months. One reason for this is thought to be the aging process, in which the binding of radiocaesium to soil particles shifted from exchangeable weak binding to non-exchangeable strong fixation, which happened within a few months of the accident. To determine the rate at which strong fixation occurred in Fukushima, we calculated the duration of the transfer factor (TF) using spinach produced in the Fukushima area that had been monitored for radioactivity levels. The TF is calculated as the ratio of the radiocaesium concentration of the plant (Bq/kg) to that of the soil (Bq/kg). Since plants can only absorb the exchangeable fraction, TF represents the amount of exchangeable fraction. We obtained the radiocaesium concentrations of spinach from a published database of monitored radioactivity for agricultural products in Fukushima, in which radiocaesium concentration, date of measurement, and city name were recorded, and the radiocaesium concentrations of the corresponding soil were estimated from the city name in another published data set of soil radiocaesium concentrations. We found that the TF of the spinach decreased exponentially with a half-life of around 15 days, and reached non-detectible levels within around 100 days. The decrease in exchangeable radiocaesium due to strong fixation to soil particles should proceed similarly.

Keywords: Exchangeable radiocaesium, behaviour in soil, transfer factor; spinach, Fukushima Daiichi nuclear power plant accident

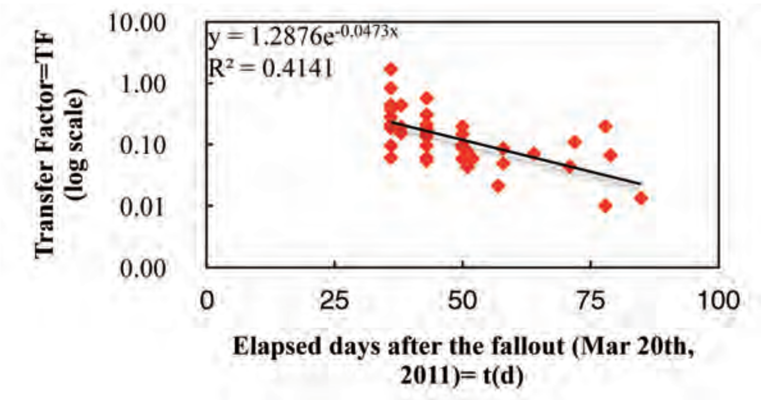


Fig. 1 Relationship between number of elapsed days after nuclear fallout (Mar 20, 2011) and transfer factor

Initial Fixation Rate of Radiocesium to Soil Estimated with Municipal Monitoring Data of Radioactivity of Spinach in Fukushima

The University of Tokyo
〇Nobuko Mitsuoka、
Naoto Nihei、Sho Shiozawa、
Shuichiro Yoshida,
Kazuhiro Nishida

1

Background and Objective

2

Fukushima Daiichi NPP Accident

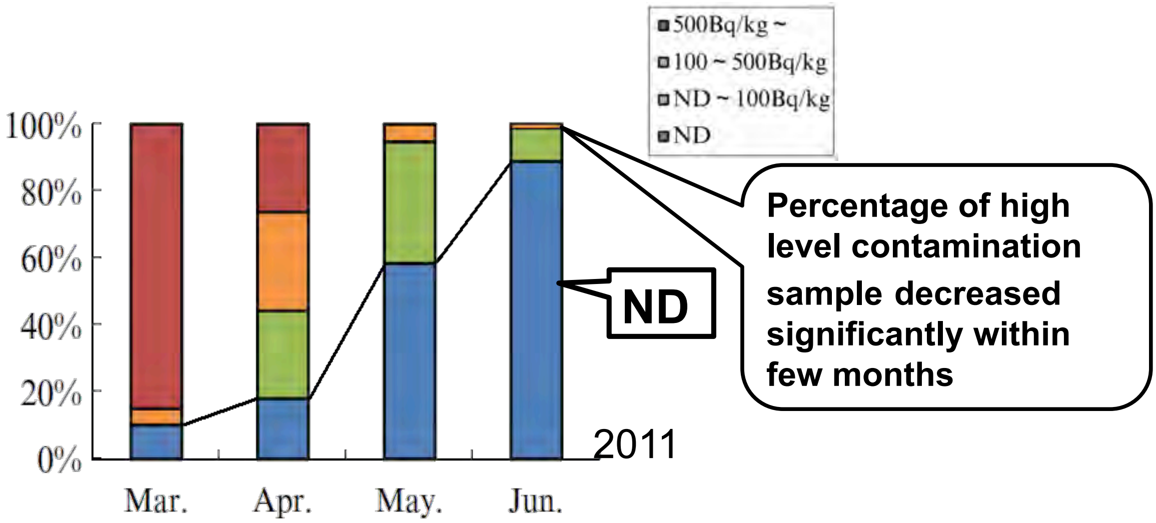
As a result of Fukushima Daiichi Nuclear Power Plant accident (Mar 2011),

Radioactive cesium fell out and contaminated soil and agricultural product around Fukushima area.

Radioactivity map of area with in 80km from Fukushima Daiichi Nuclear Power Plant→

3

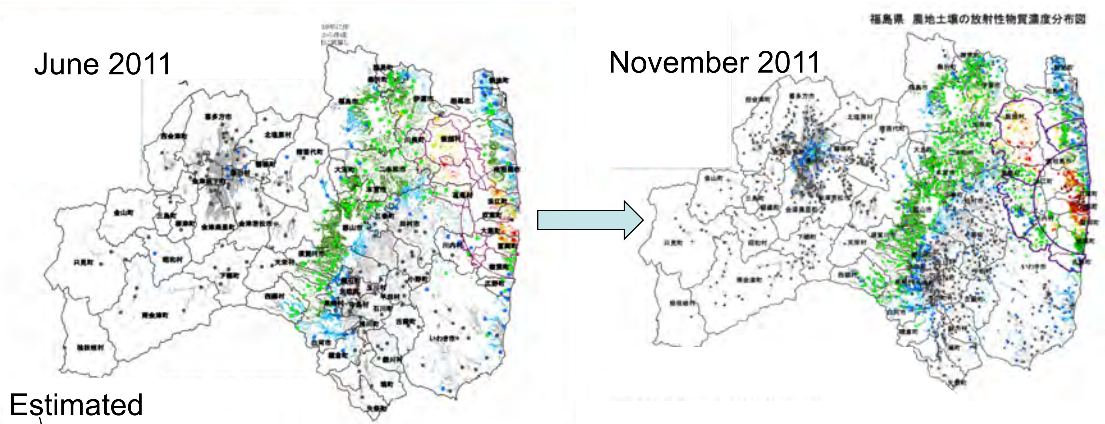
Temporal change of vegetable Cs concentration after fallout



Radiocesium concentration in spinach after the accident (2011、Fukushima、Nihei 2013 modified）

4

Cs concentration in soil



Estimated
Measured

- 0–500
- 500–1000
- 1000–5000
- 5000–10000
- 10000–25000
- 25000–50000
- 50000以上

- Half-life of Cs-137=30.2 years
- Cs concentration in soil had not decreased within few months・・・・・

(Average value of surface soil (~15cm))

5

What happened within this few months after the fallout??

- Cs in vegetable decreased significantly
- Soil Cs concentration has not changed as much???

● *Existence form of Cs in the soil*

bioavailable form → non-bioavailable

weak bonding → strong fixation

6

Objective of Research

<u>To estimate velocity of Cs strong fixation to soil particle</u>

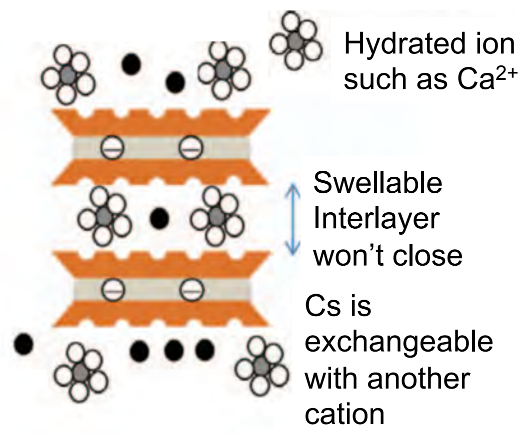
by determining temporal change of municipal level transfer factor of spinach

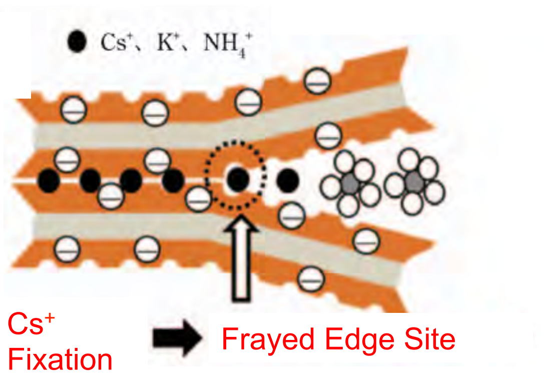
7

What does Cs Strong Fixation mean?

Weak bonding → Strong fixation

- Ionic bond of cation by electric charge
- Specific absorption to clay particle (ex. FES)





(National Institute for Agro-Environmental Sciences, Report No.31,modified)

8

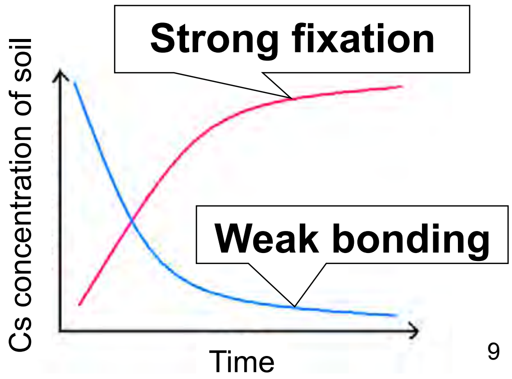
What does Cs Strong Fixation mean?

Weak bonding → Strong fixation

- Move along with soil water
- Plants can easily absorb

- Hardly move with soil water
- Hard to absorb for plants

Shift from weak bonding to strong fixation with time



9

Previous Research showing the evidence of strong fixation

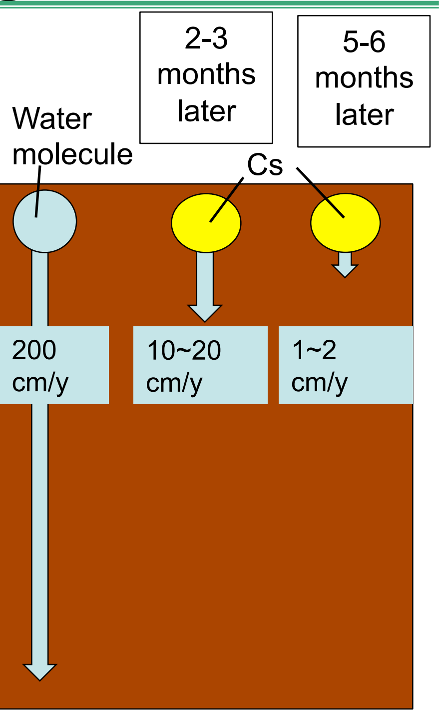
- **2-3 months after fallout**

1/10-1/20 of water molecule

- **5-6 months after fallout**

1/100-1/200 of water molecule

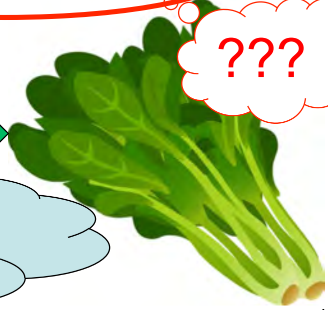
Transfer from weak bonding to strong fixation might have proceeded during this few months?? (Shiozawa 2013)



Objective of Research

To estimate velocity of Cs strong fixation to soil particle
by determining temporal change of municipal level transfer factor of spinach

Change of Transfer Factor??



???

11

What is transfer factor (TF)??

Transfer Factor(TF) = RCs concentration in Plant (Bq/kg wet weight) / RCs concentration in Soil(Bq/kg dry soil)

- Shows absorbability of Cs by plant
- Transfer factor of same plants indicates level of fixation of Cs to soil

Objective:how fast strong fixation of Cs to soil particle proceeded after the fallout

⇩

Estimate fixation rate through determining decrease rate of transfer factor

Objective of Research

<u>To estimate velocity of Cs strong fixation to soil particle</u>

by determining temporal change of municipal level transfer factor of spinach

Change of Transfer Factor??

13

Methods

14

Crop used for analysis：field-grown spinach

Why Spinach？？

- **Leaf vegetables are cultivated at their peak of nutrient absorption**

→Directly reflect soil condition when It cultivated

- **Seedling from harvest is relatively short (1-1.5months)**

→include samples which grown within period when strong fixation have not proceeded yet.

- **Many samples are available**

→We need many samples to determine time variance of transfer factor. More than 300 data available for spinach just in 2011.

15

Calculation of Transfer Factor

Transfer Factor(TF) = **RCs concentration in Plant (Bq/kg wet weight)** / **RCs concentration in Soil(Bq/kg dry soil)**

Monitoring Data of Agricultural Product from Fukushima

→326 Samples of Spinach (2011)

- Cs Concentration
- Place of production (municipal level)
- Date of sampling

16

Data①：
Spinach Cs Concentration

- Monitoring data of spinach's Cs concentration published on Website "Toward a new future of Fukushima" which is operated by Fukushima prefecture

Category	Producer Municipality	Detected Nuclide（Bq/kg）			Sample harvested date	Date of results publication
		I-131	Cs-134	Cs-137		
Spinach	Kawamata Town	15	94	65	2011-05-09	2011-05-11
Spinach	Izumizaki Village	9.2	28	31	2011-05-09	2011-05-11
Spinach	Nakajima Village	ND	21	22	2011-05-09	2011-05-11
Spinach	AizuWakamatsu City	ND	34	44	2011-05-02	2011-05-04
Spinach	Iwaki City	130	60	59	2011-05-02	2011-05-04
Spinach	Iwaki City	110	110	110	2011-05-02	2011-05-04

Example of data on "Toward a new future of Fukushima"
<http://www.new-fukushima.jp/monitoring/ >visited July 8th .2015

17

Calculation of Transfer Factor

$$\text{Transfer Factor(TF)} = \frac{\text{RCs concentration in Plant (Bq/kg wet weight)}}{\text{RCs concentration in Soil(Bq/kg dry soil)}}$$

Monitoring Data of Farmland by Agriculture,Forestry and Fisheries Research Council (AFFRC)

➢Cs concentration of plow layer from2247 places

↓

➢Calculate soil Cs concentration of 59 municipalities

18

Data②：Cs concentration of Farmland

Data acquired from a report, "Radiocesium concentration analysis" of Farmland soil

Municipalities and section

Common upland, land under perennial land, paddy field, grassland, and converted field

Cs-134,Cs-137 and sum of Cs

Modified data setting Nov. 5th 2011 as base date (Bq/kg)

福島県　農地土壌中の放射性セシウムの分析値

No	Place of Sampling			Date of Sampling			Classification of land	RCs concentration（Bq/kg）			Modified data setting Nov. 5th 2011 as base date			備考
	地図No	市町村名	大字等	年	月	日		Cs-134	Cs-137	Cs合計				
1	1	福島市	瀬上町	2012	1	18	普通畑	1050	1430	2480	1120	1440	2560	
2	2	福島市	瀬上町	2011	12	21	樹園地	200	270	470	210	270	480	
3	3	福島市	瀬上町	2012	1	18	樹園地	1050	1430	2480	1120	1440	2560	
4	4	福島市	瀬上町	2012	1	18	樹園地	580	820	1400	620	820	1440	
5	5	福島市	鎌田	2012	1	18	樹園地	2030	2750	4780	2170	2760	4940	
6	6	福島市	本内	2012	1	20	普通畑	930	1280	2210	1000	1290	2280	
7	7	福島市	南沢又	2012	1	18	樹園地	1040	1410	2450	1110	1420	2530	
8	8	福島市	八島町	2012	1	20	普通畑	1740	2260	4000	1870	2270	4140	
9	9	福島市	山口	2011	12	21	普通畑	1230	1590	2820	1280	1600	2880	
10	10	福島市	山口	2011	12	20	水田	1400	1770	3170	1460	1780	3230	
11	11	福島市	山口	2012	1	19	普通畑	1570	2110	3680	1680	2120	3800	
12	12	福島市	渡利	2012	1	19	普通畑	2290	2900	5190	2450	2910	5370	
13	13	福島市	小倉寺	2012	1	20	普通畑	1580	2180	3760	1690	2190	3880	

Example of "Radiocesium concentration analysis"

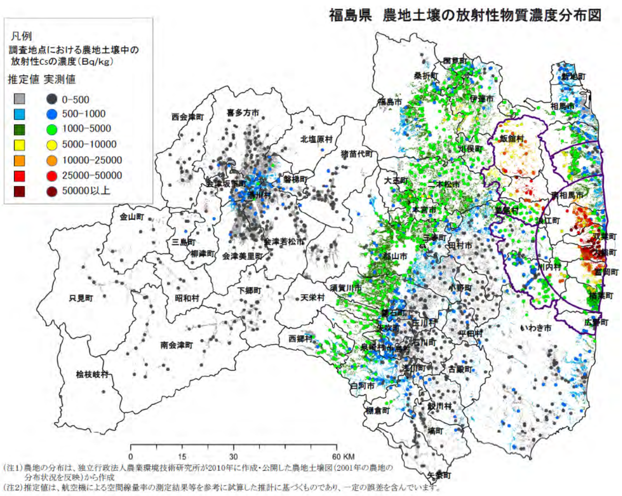
(Press released on Mar. 23rd ,2012 by AFFRC)

＜http://www.s.affrc.go.jp/docs/press/120323.htm ＞visited July 8th .2015

19

Data②：Cs concentration of Farmland

Distribution map of RCs concentration of Farmland soil (Fukushima Prefecture)



- Data from 2247 spots are plotted on the map

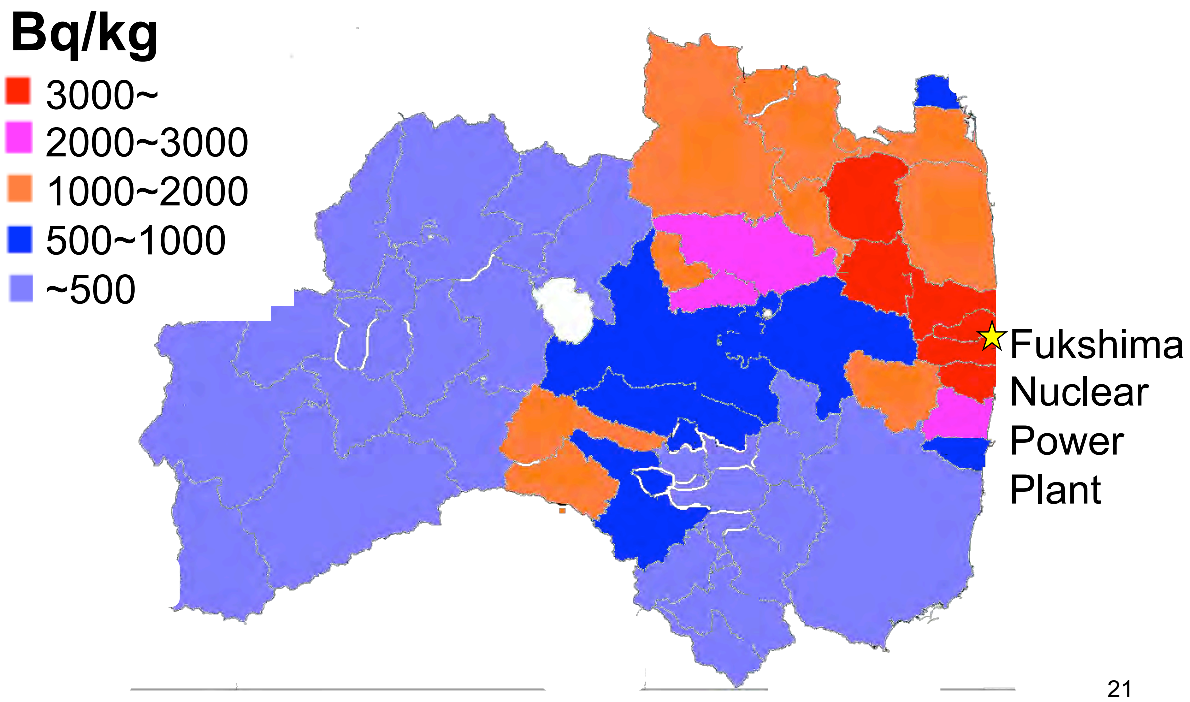
↓

- Calculate a geometric mean of RCs concentration of each municipality

＜http://www.s.affrc.go.jp/docs/press/120323.htm ＞visited July 8th ,2015

20

Distribution map of RCs concentration of farmland soil in municipal level



21

Calculation of Transfer Factor

$$\text{Transfer Factor(TF)} = \frac{\text{RCs concentration in Plant (Bq/kg wet weight)}}{\text{RCs concentration in Soil(Bq/kg dry soil)}}$$

Monitoring Data of Agricultural Product from Fukushima

→326 Samples of Spinach (2011)

- Cs Concentration
- Place of production (municipal level)
- Date of sampling

Monitoring Data of Farmland by Agriculture,Forestry and Fisheries Research Council (AFFRC)

- Cs concentration of plow layer from2247 places

↓

- Calculate soil Cs concentration 59 municipalities

22

Results & Conclusion

23

Conclusion

- Estimated temporal variation of TF for the period 1.5-4 months after the fallout using monitoring data of RCs concentration of Spinach and farmland soil
- As a result, half-life of TF is estimated as 15days→TF becomes 1/100-1/200 with in around 3.5 months after the fallout
- Strong fixation to soil particle proceeded within around 3 months after the accident which is in consistant with previous research of Cs migration rate in soil by Shiozawa et al

24

New Research project undergoing・・・

- This research focused on estimating overall temporal change of TF in broad area of Fukushima prefecture using publicized data.
- It does not consider the difference depending on soil characteristics and growing environment
- Experiment
  - Measuring temporal change of weakly bonded radiocesium using different kind of soils from Fukushima under different environment
  - Cultivating spinach with different soils from Fukushima

25

Thank you very much!
Tack så mycket

26

3.4 Temporal change in radiocesium concentration of peaches cultivated in Fukushima Prefecture

Kyoko Ichikawa†[1], Daisuke Takata[1], Mamoru Sato[2], Eriko Yasunaga[1]

† Presenter: 4170475201@mail.ecc.u-tokyo.ac.jp

1 Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1, Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan

2 Fruit Tree Research Center, Fukushima Agricultural Technology Center, hirano, iizaka, Fukushima 960-0231, Japan

Fukushima Prefecture in Japan is well known for the production of fruits and vegetables, especially peaches (Prunus persica L.). Fruit trees are perennial plants, and most were without leaves or fruit at the time of the Fukushima Daiichi Nuclear Power Plant accident in 2011. Over the past few years, there has been growing concern about radiocesium contamination of peaches. Since 2012, we have measured radiocesium concentrations in peaches produced near the city of Date in Fukushima Prefecture. Although Date was exposed to high levels of radiation, farmers have been able to produce fruits with levels of radiocesium below the minimum acceptable. The radiocesium concentration of peaches was highest 15 days after full bloom (DAF15, DAF0 in late April). The concentration rapidly decreased until DAF60, and then slowly decreased through harvest (DAF103 in late July). This trend was consistent from 2012 to 2014.

The radiocesium concentration of peaches harvested in 2013 decreased about half to that of fruit harvested in 2012, but the concentration in 2014 was similar to the level recorded in 2013. It seems that the transfer of radiocesium from the trees to mature fruits was greatest in peaches produced in the first year after the accident, and declined in subsequent years.

Keywords: Peach fruit, radiocesium, Fukushima Daiichi nuclear power plant accident

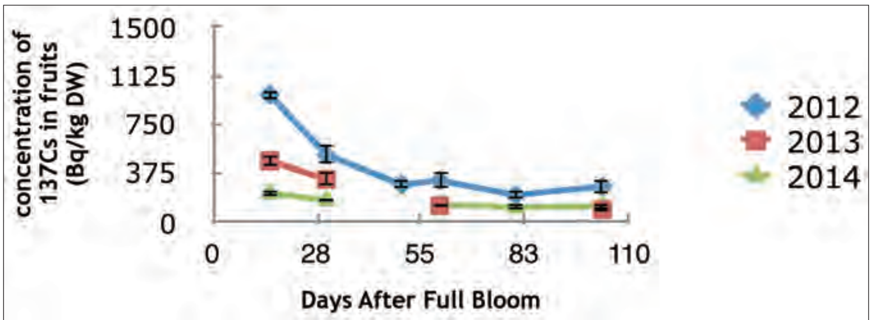
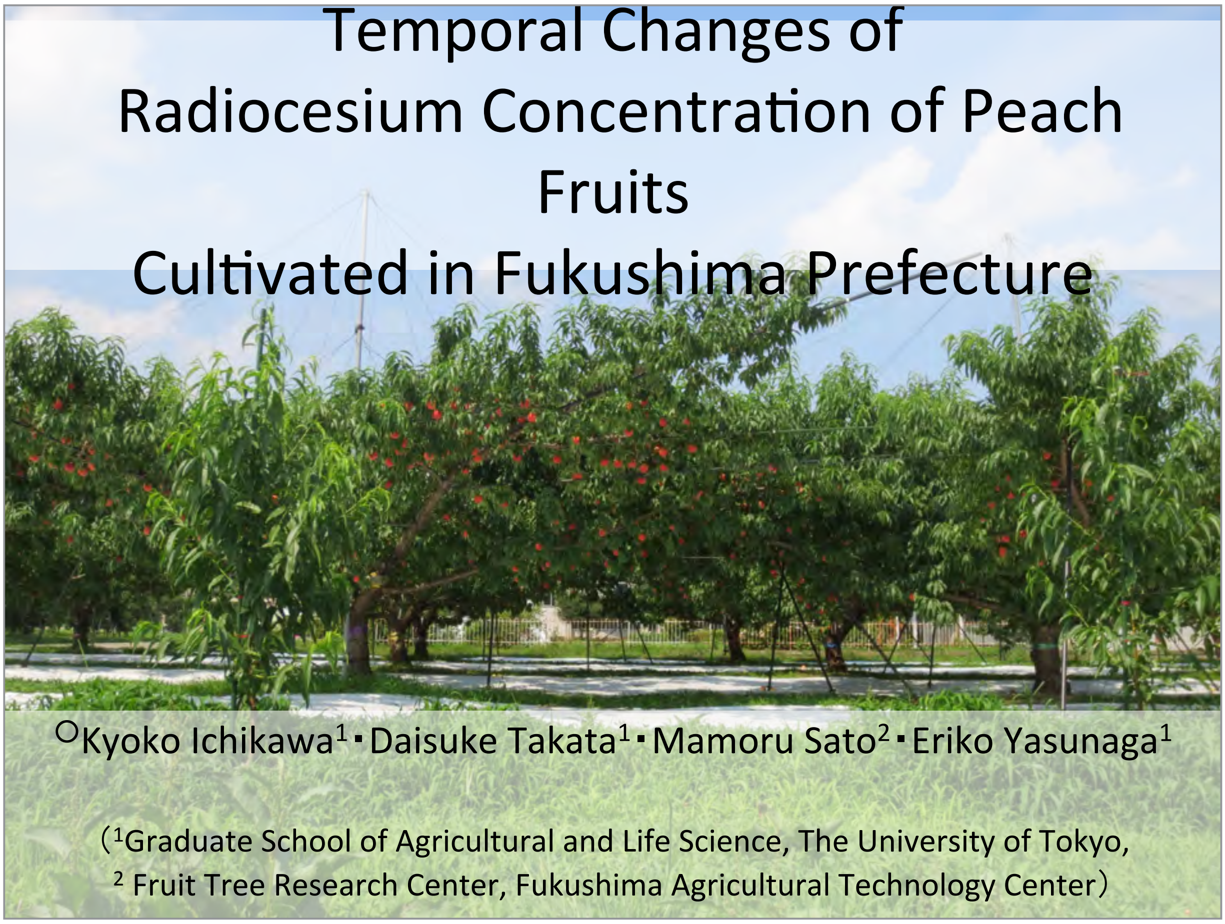
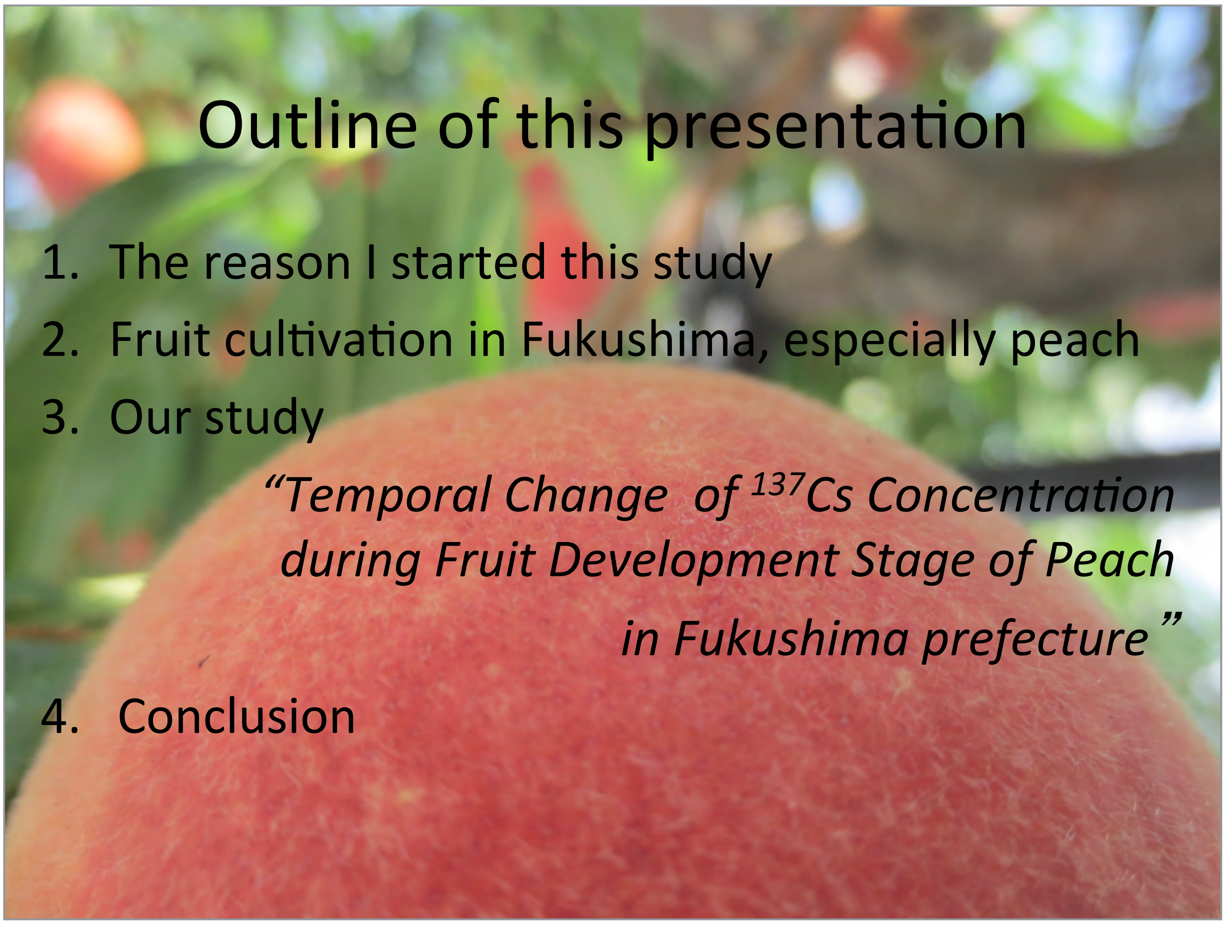


Fig. 1 Comparison of radiocesium concentrations during fruit development stages, from 2012 to 2014. The bars represent SE (n = 3).
(Ichikawa et al., 2015, HORT. RES. (JAPAN) 14 (SUPPL.)


Temporal Changes of
Radiocesium Concentration of Peach Fruits
Cultivated in Fukushima Prefecture
○Kyoko Ichikawa[1]・Daisuke Takata[1]・Mamoru Sato[2]・Eriko Yasunaga[1]
([1]Graduate School of Agricultural and Life Science, The University of Tokyo,
[2] Fruit Tree Research Center, Fukushima Agricultural Technology Center)


Outline of this presentation
1. The reason I started this study
2. Fruit cultivation in Fukushima, especially peach
3. Our study
"Temporal Change of ^{137}Cs Concentration during Fruit Development Stage of Peach in Fukushima prefecture"
4. Conclusion

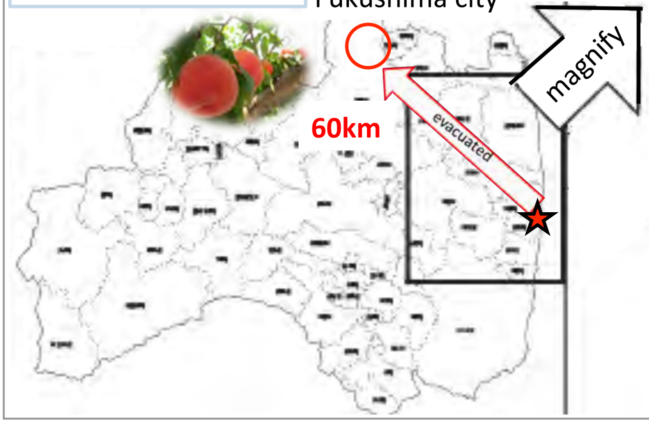
The reason I started this study

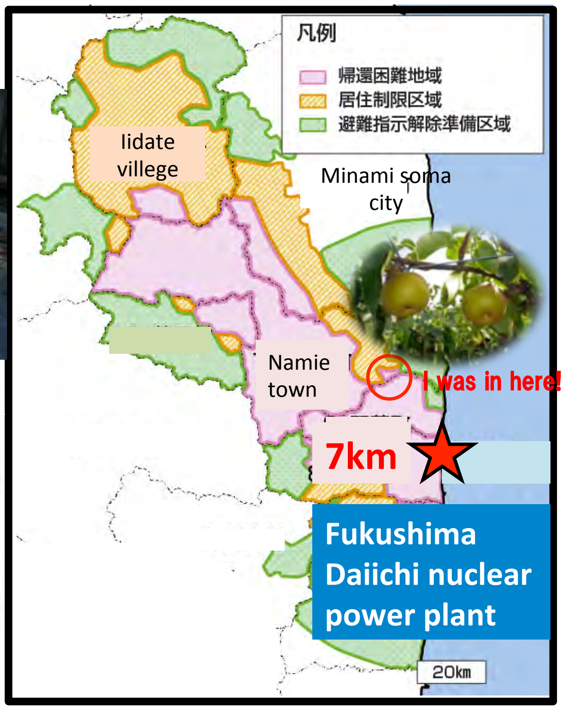
Japanese traditional festival
1 week ago before the earthquake

2011.Mar.11

Fukushima prefecture

Fukushima city





Fruit cultivation in Fukushima

Fukushima prefecture is one of
the most famous places for agriculture in Japan.

Peach production in Japan

	prefecture	Amount of production of peach (t)	Ratio to total (%)
1	Yamanashi	39100	34.1
2	Fukushima	29300	25.5
3	Nagano	15400	13.4
total	Japan	124700	100

(the Ministry of Agriculture, Forestry and Fisheries)
(2014)

Peaches' stock volume, market share and whole price from 2009 to 2013 in Fukushima

Year	Stock volume (t)	Market share (%)	Whole price (Yen/kg)
2009	3294	47.5	389
2010	3309	42.2	450
2011	5433	50.9	211
2012	3881	46.3	350
2013	4574	56.0	353

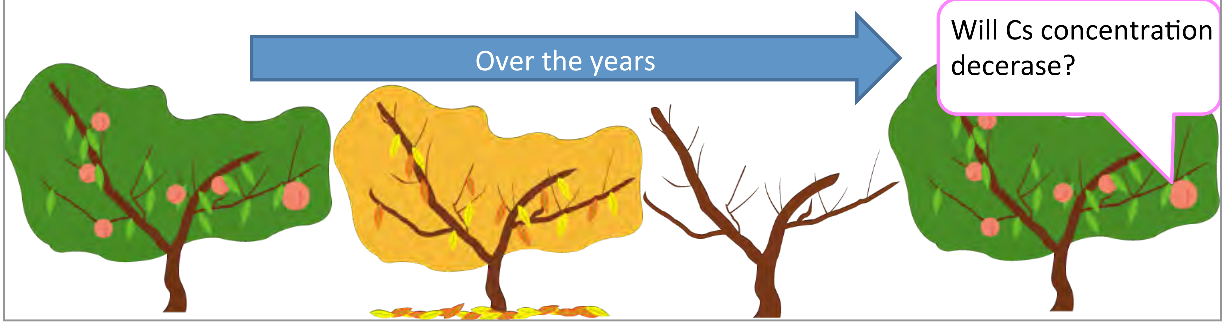
(Tokyo metropolitan central market)
(2013)

Our study

Temporal Change of ^{137}Cs Concentration during Fruit Development Stages of Peach fruits in Fukushima Prefecture.

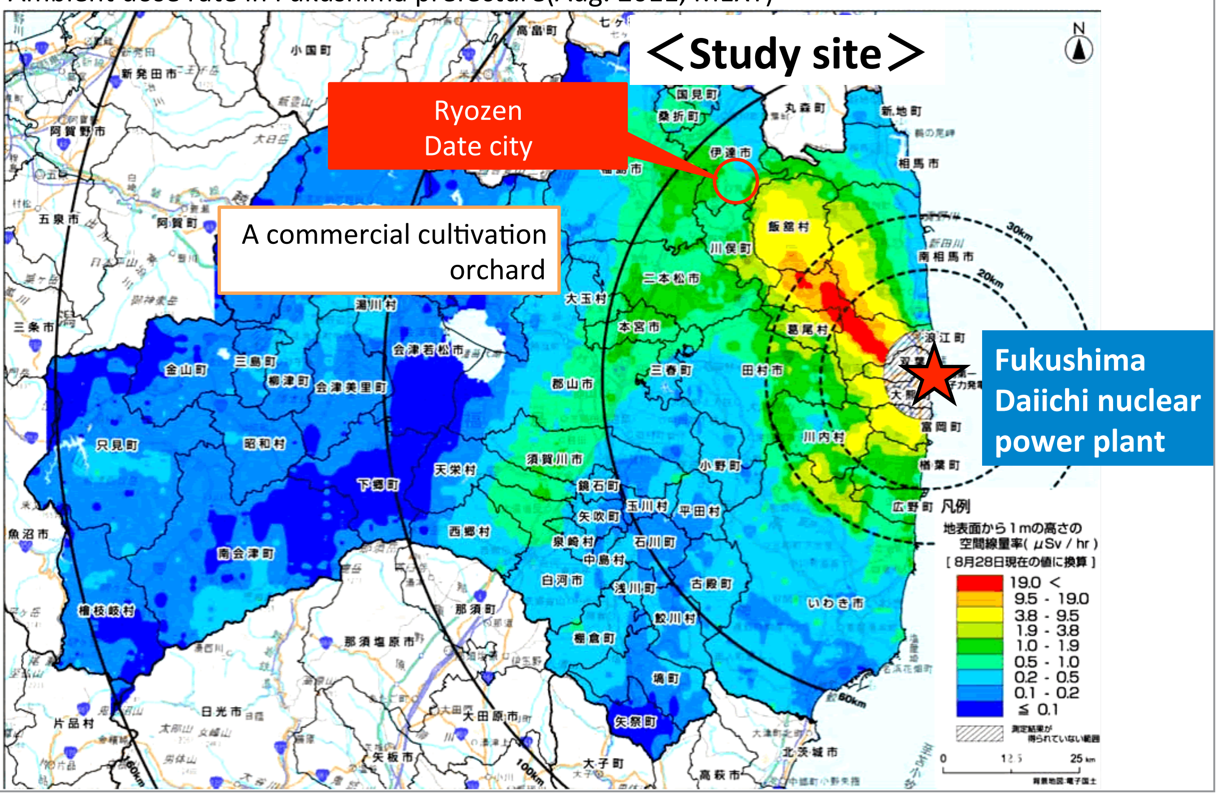
GOAL

"to know the changing trend of radiocesium concentrations of peach fruits"



Materials and Methods

Ambient dose rate in Fukushima prefecture(Aug. 2011, MEXT)



Materials and Methods

Peach(*Prunus persica* L. 'Akatsuki') 3 trees.

which can harvest about 100 days after full bloom

Annual growth in Fukushima

Jan. Feb. Mar. Apr. May. Jun. Jul. Aug. Sep. Oct. Nov. Dec.

bloom

harvest

Dormancy period

March 11, 2011
Fukushima Daiichi
nuclear plant Accident

Materials and Methods

< Sampling date>

	Full bloom DAF 0	DAF15	DAF30	DAF60	DAF80	Harvest DAF99-105
2012	Apr. 29	May. 14	May. 29	Jun.28	Jul. 17	Aug. 6
2013	Apr. 18	May. 2	May.20	Jun. 17	n.a.	Aug. 8
2014	Apr. 19	May. 7	May. 19	Jul. 18	Jul. 8	Jul. 29
2015	Apr. 17	Apr. 30	May. 15	Jun. 15	Jul. 3	Jul. 22

The fruits at DAF60

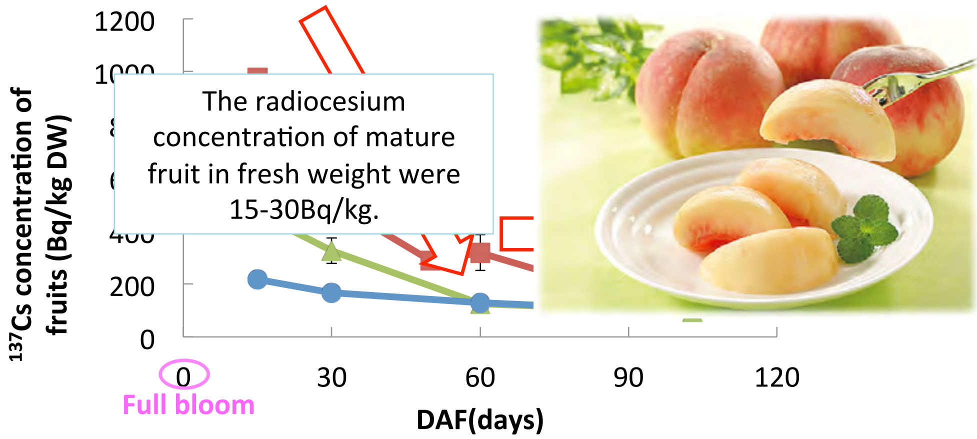
dried

At harvest

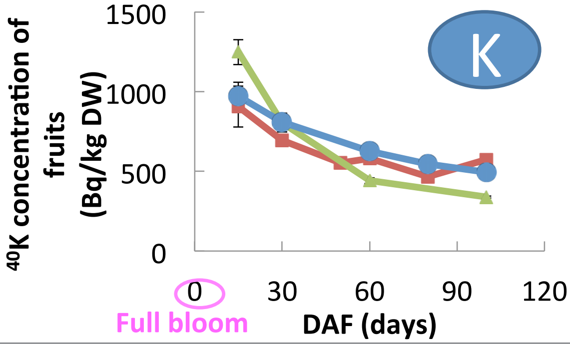
Determined ^{137}Cs and ^{40}K by germanium semiconductor detector.

RESULT AND DISCUSSION

The Cs changes during fruits development stage

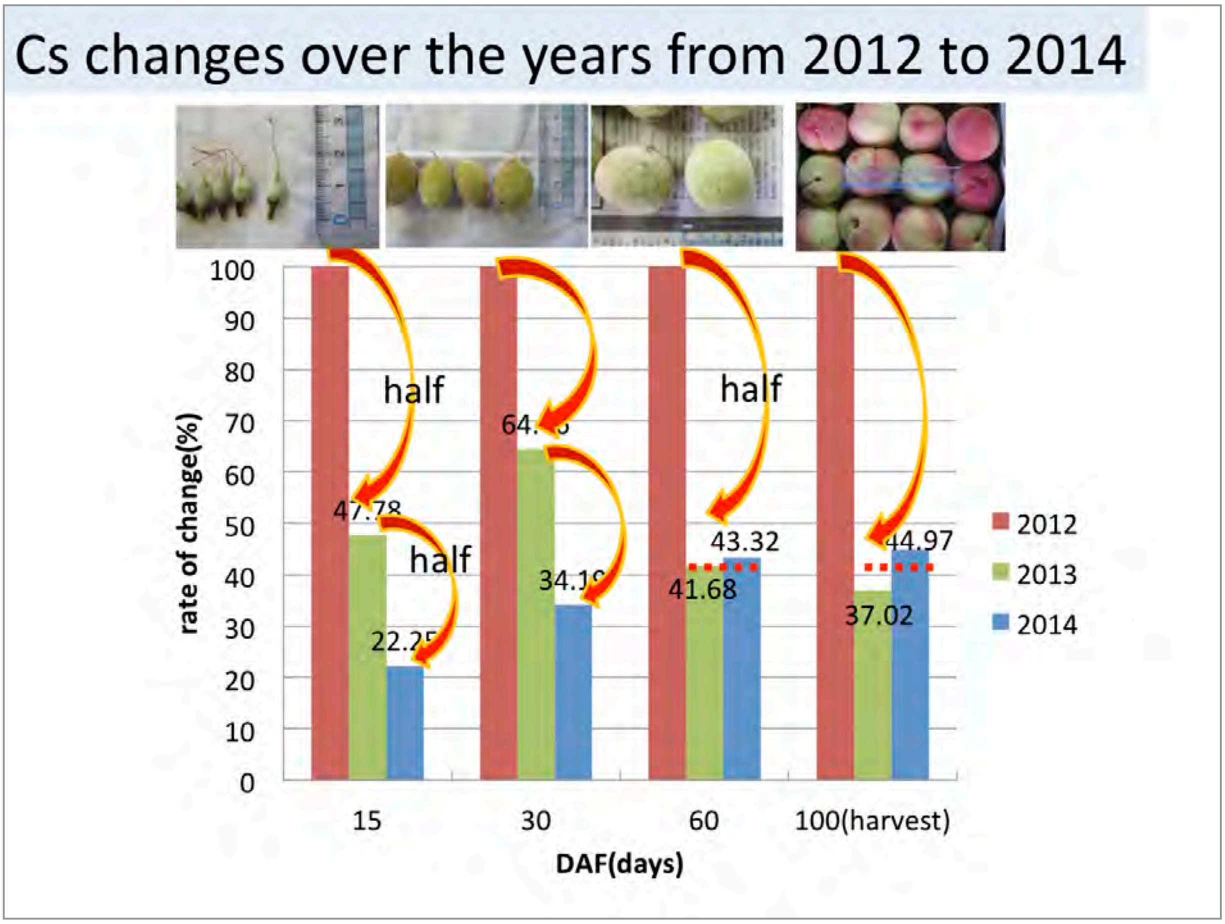


The Aging changes of radiocesium concentration and contents of fruit
The bar is SE, n=3



The Aging changes of ^{40}K concentration of fruit

The bar is SE, n=3


Cs changes over the years from 2012 to 2014
100
90
80
70
60
50
40
30
20
10
0
rate of change(%)
half
half
half
47.78
22.25
64.
34.1
43.32
41.68
44.97
37.02
15
30
60
100(harvest)
DAF(days)
2012
2013
2014


CONCLUSION

“whether the radiocesium levels of peach will decrease over the years”

1. the radiocesium concentration of peach fruits in one year remarkably declined by DAF60 and these values continue until harvest.
2. The decrease of radiocesium in peach fruits through years might move into a steady state after 3 or 4 years from the nuclear power plant accident. We would check the result in this year sooner.

3.5 Monitoring inspection for radiocaesium in agricultural, livestock, forest and fishery products in Fukushima Prefecture

Naoto Nihei†, [1], Keitaro Tanoi[1], Tomoko M. Nakanishi[1]

† Presenter: anaoto@mail.ecc.u-tokyo.ac.jp

1 Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1, Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan

We selected and re-categorized the 90,000 items of monitoring data obtained in the 3 years following the nuclear accident from Fukushima Prefecture focusing on the radiocaesium concentration in the following four categories of agricultural products: (A) cereals, vegetables, and fruits; (B) meats, milk, and eggs; (C) mushrooms and wild vegetables; and (D) fish in seawater and freshwater. In the case of plants grown in the field, radioactivity was high during the first 3 months after the accident because of direct fallout. The radioactivity of foods decreased rapidly thereafter, and the radiocaesium therein seemed to be derived from indirect contamination. However, some forestry or fish products harboured a radioactivity level greater than that permitted by the regulations, 100 Bq kg^{-1}. Further selection of data from Fukushima Prefecture was performed for rice, vegetables, fruits, meats, milk, forest products, and fish, especially those produced in Sousou district where the highest level of contamination of rice was detected in 2011. Based on the second selected dataset, the internal exposure level of the population of the Sousou area during the first 3 months after the accident was calculated (taking into consideration the average uptake amount of each food type) to be 0.75 mSv year-1.

Keywords: Monitoring inspection, Fukushima Daiichi nuclear power plant, radiocaesium, internal exposure

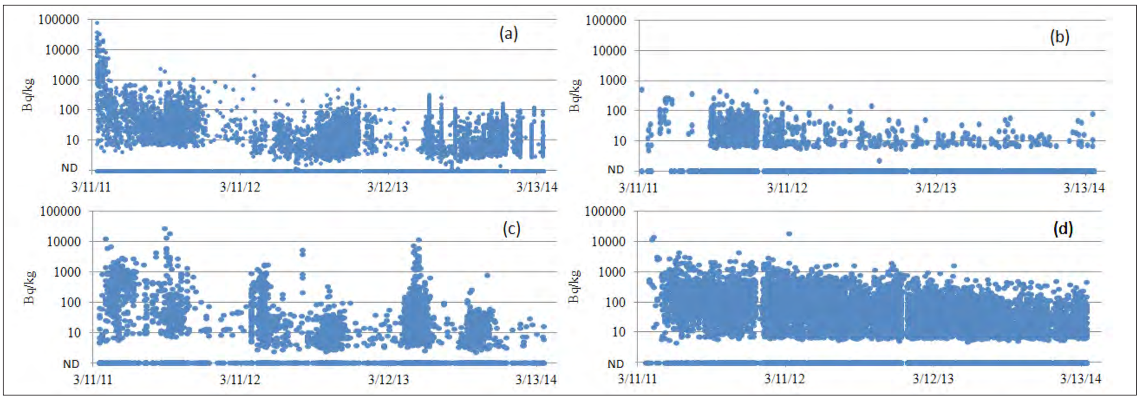


Fig.1 Measurement of radiocaesium concentration in each food item after the Fukushima DNPP accident.

(a) Category A, (b) category B, (c) category C, and (d) category D; ND: not detected. Horizontal axis indicates days after the accident. Vertical axis indicates the radiocaesium concentration (Bq per kg) on a logarithmic scale.

Sep.2, 2015

ふくしまから はじめよう。
Future From Fukushima.

Monitoring Inspection for Radiocesium in Agricultural, Livestock, Forest and Fishery Products in Fukushima Prefecture

Naoto Nihei, Keitarou Tanoi, Tomoko M. Nakanishi
(The Univ. of Tokyo)

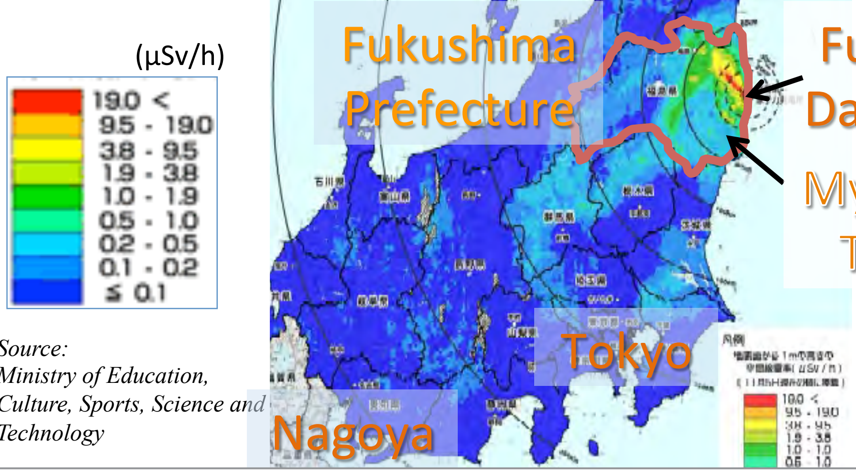
Background

The Great East Japan Earthquake (March 11, 2011)

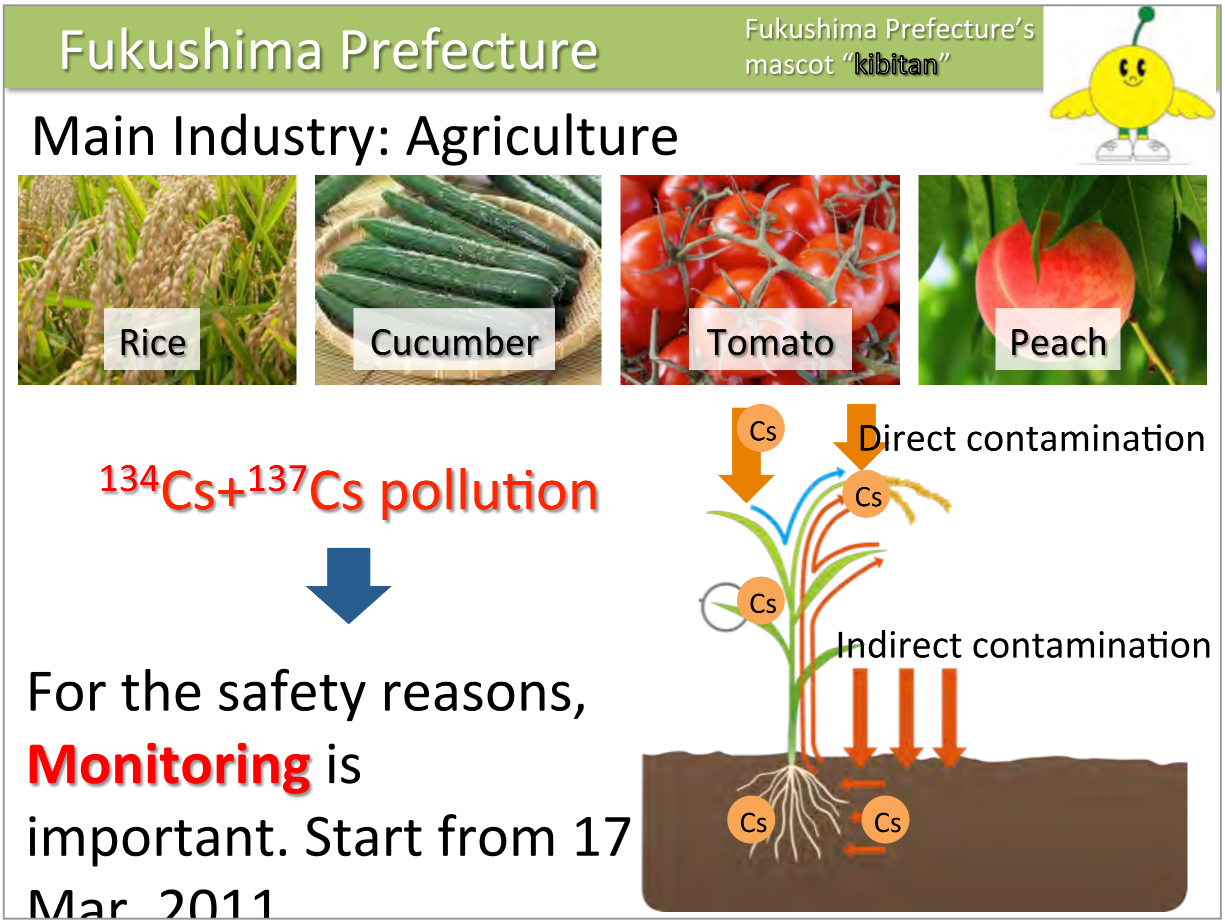
The accident at the Fukushima Dai-ichi NPP

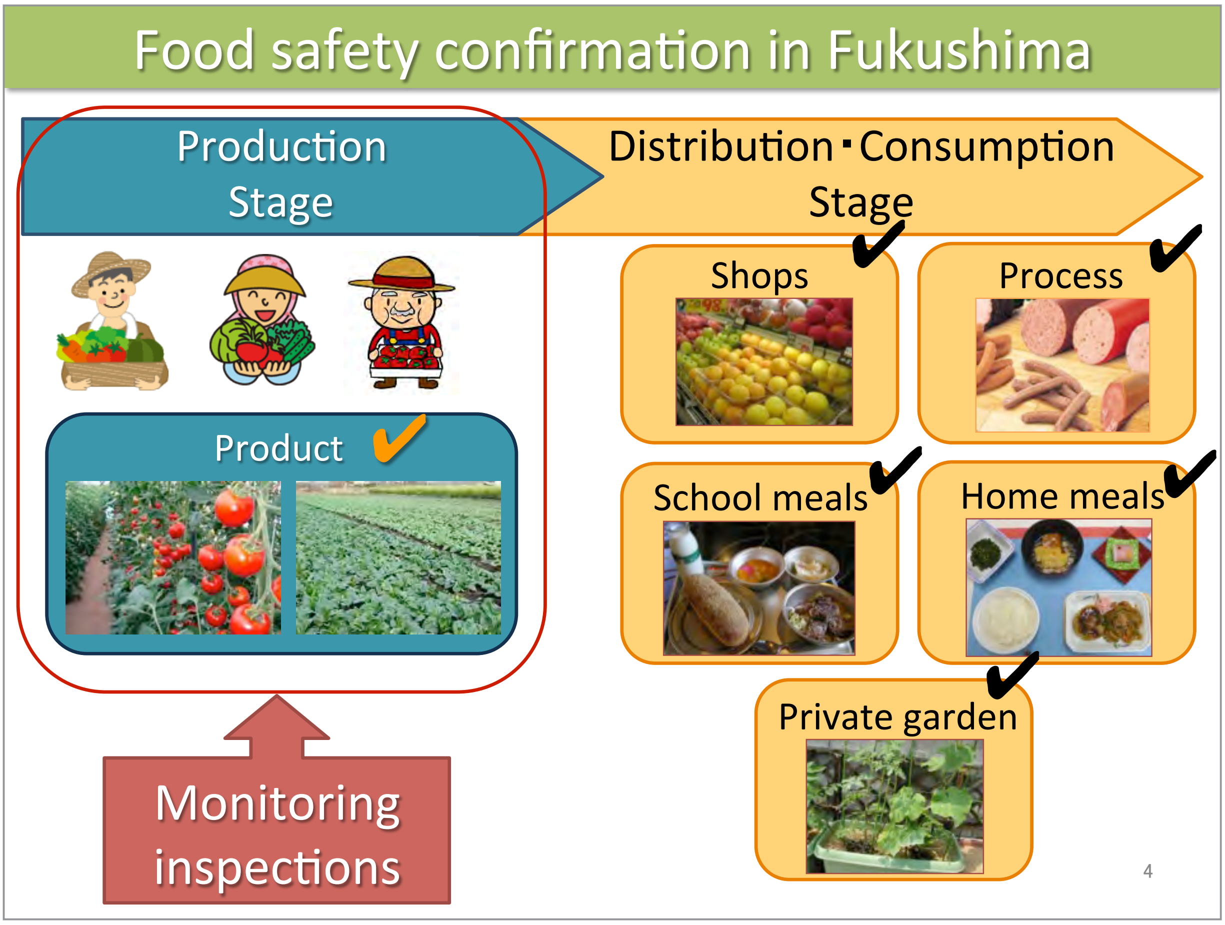
Radioactive nuclides (mainly cesium)

Evacuees: about 100,000 persons (2015)

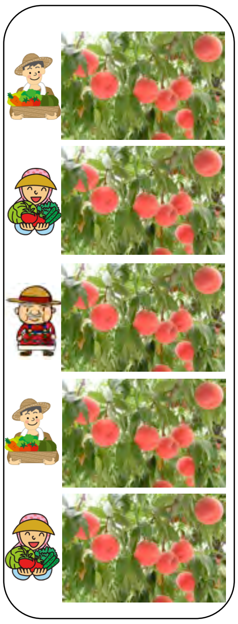


Source: Ministry of Education, Culture, Sports, Science and Technology


Fukushima Prefecture
Fukushima Prefecture's mascot "kibitan"
Main Industry: Agriculture
Rice
Cucumber
Tomato
Peach
134Cs+137Cs pollution
For the safety reasons, Monitoring is important. Start from 17 Mar. 2011
Direct contamination
Indirect contamination
Cs


Food safety confirmation in Fukushima
Production Stage
Distribution･Consumption Stage
Product
Shops
Process
School meals
Home meals
Private garden
Monitoring inspections
4

Monitoring inspections



- Production by Farmer

- >3 samples are selected

- Cut a sample to pieces

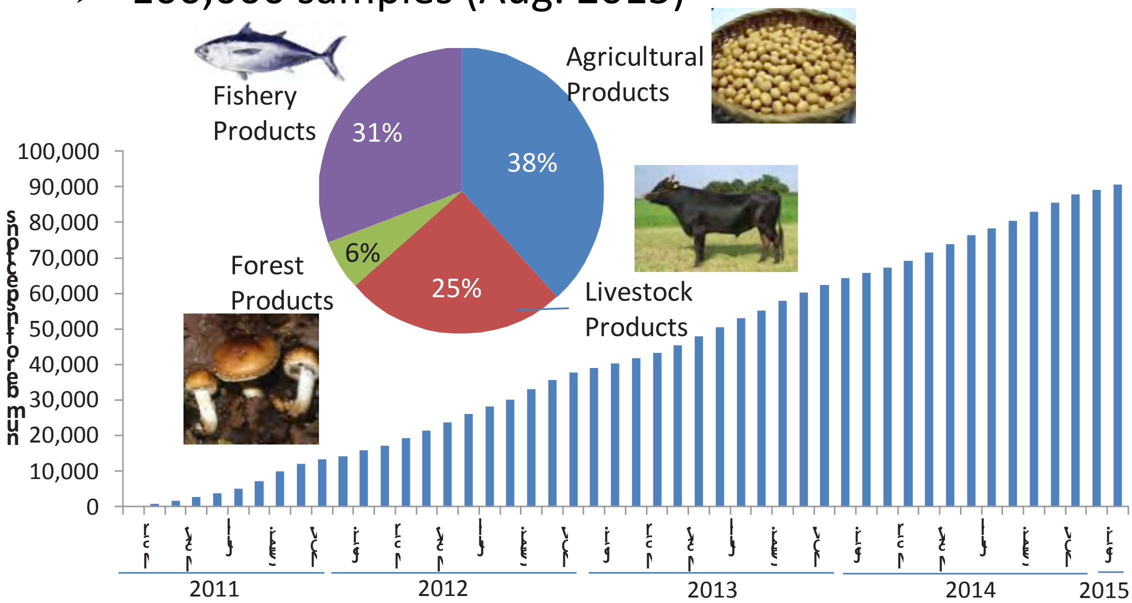
- Fill the sample to a vessel

- 10 Ge detectors
- 30 minutes
- 200 samples/d

Number of Monitoring inspections

○ Target of monitoring inspections

- Before the shipment and distribution
  - ➢ 500 items
  - ➢ 100,000 samples (Aug. 2015)



Regulation Level of Radiocesium

Mar. 2011～Mar. 2012 → One years ago → **Apr. 2012～**

Item	Bq/kg
Vegetable, Cereal, Meat, Egg, Fish, et al.	500
Milk, Dairy Product	200
Water	200

Item	Bq/kg
General food	100
Infant food	50
Milk	50
Water	10

1250Bq/kg in Sweden

When the radioactivity of the sample was higher than the regulation level,
the shipments of the sampling item are stopped.

7

Results of the monitoring

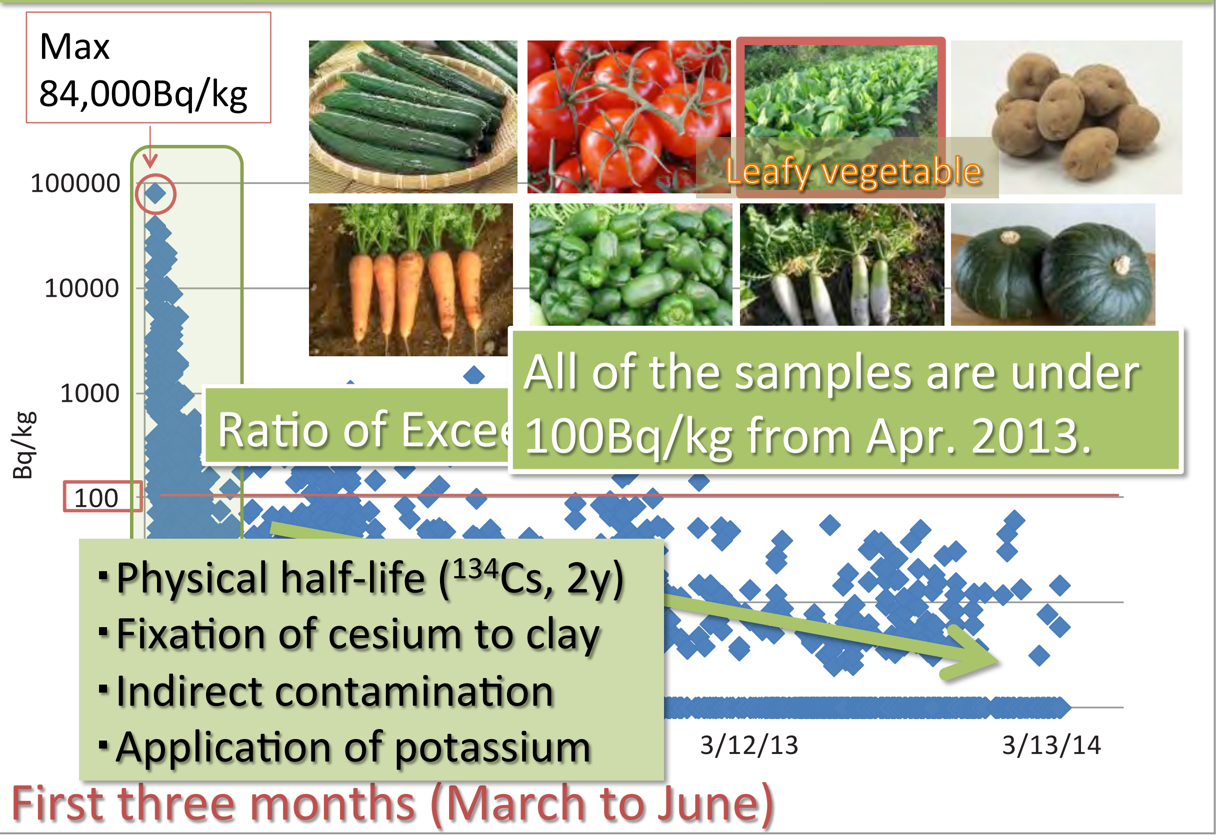
We can check the latest monitoring results.

"http://www.new-fukushima.jp/monitoring/en/"

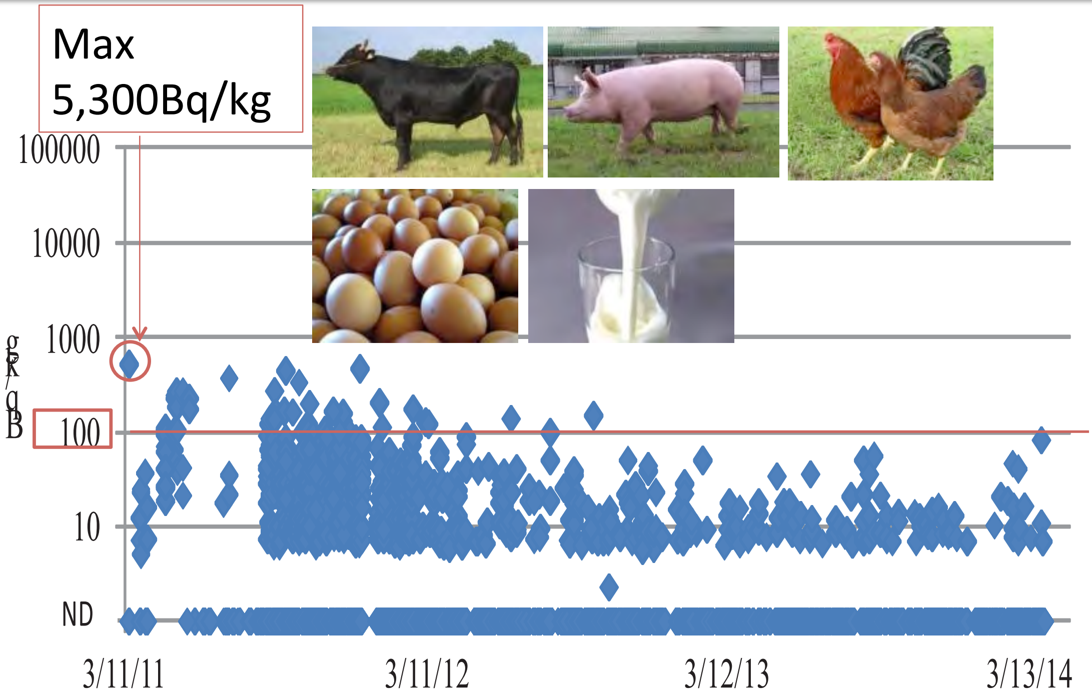
Results of the monitoring

- Agricultural Products
- Livestock Products
- Forestry Products
- Fishery Products
- Rice

Agricultural Products (Vegetable)

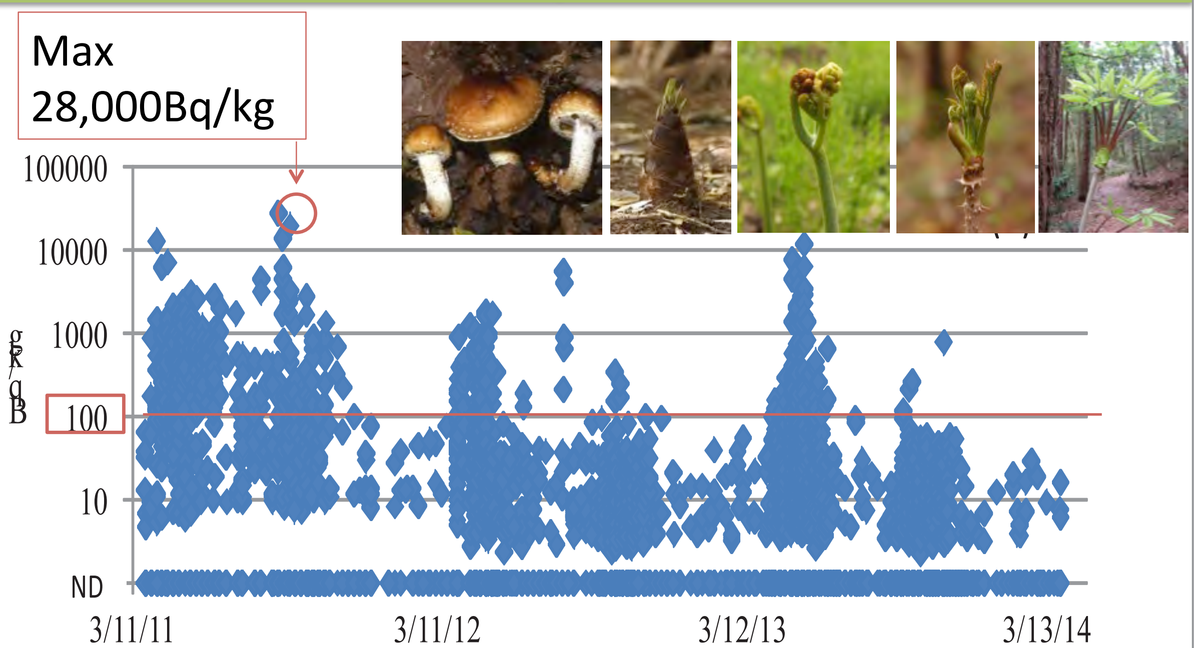


Livestock Products



All of the samples have been under 100Bq/kg since Apr. 2013.

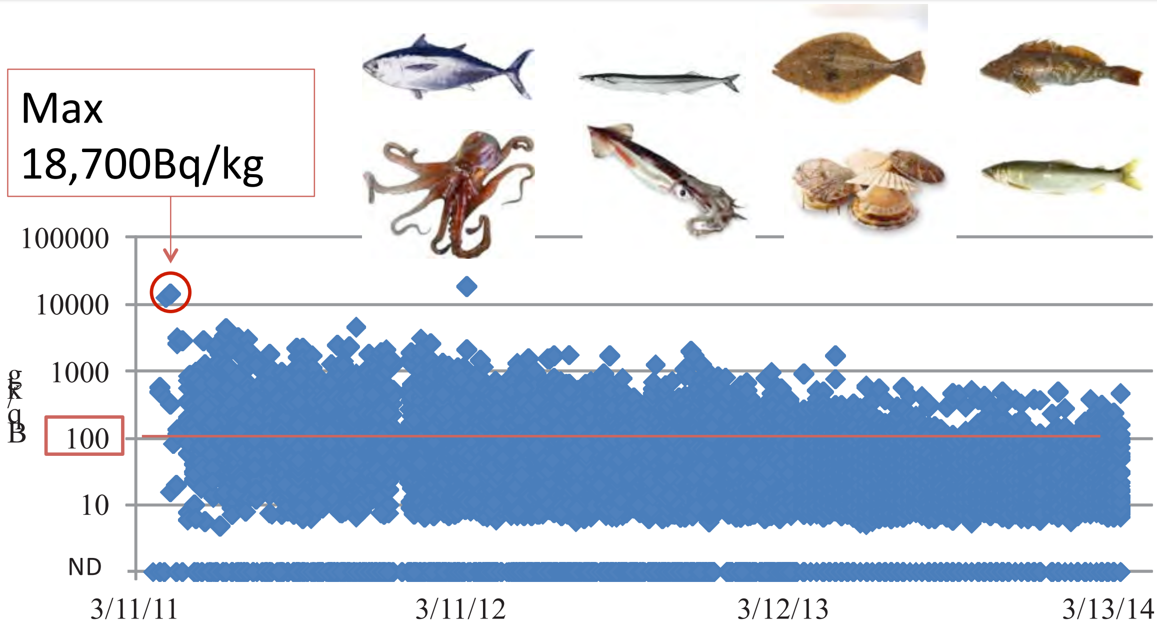
Forestry Products



Although the contamination level has gradually decreased, samples exceeding 100 Bq/kg still remain.

12

Fishery Products



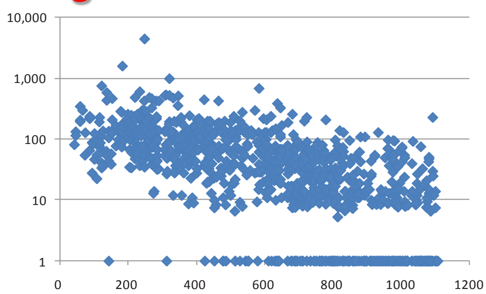
Although the contamination level is gradually decreasing, samples exceeding 100Bq/kg still remain.

13

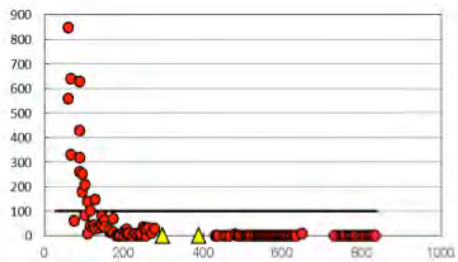
Fishery Products

High Cs concentration

Mr.Fujita(Fukushima Pref.)



Low Cs concentration



Results of the monitoring

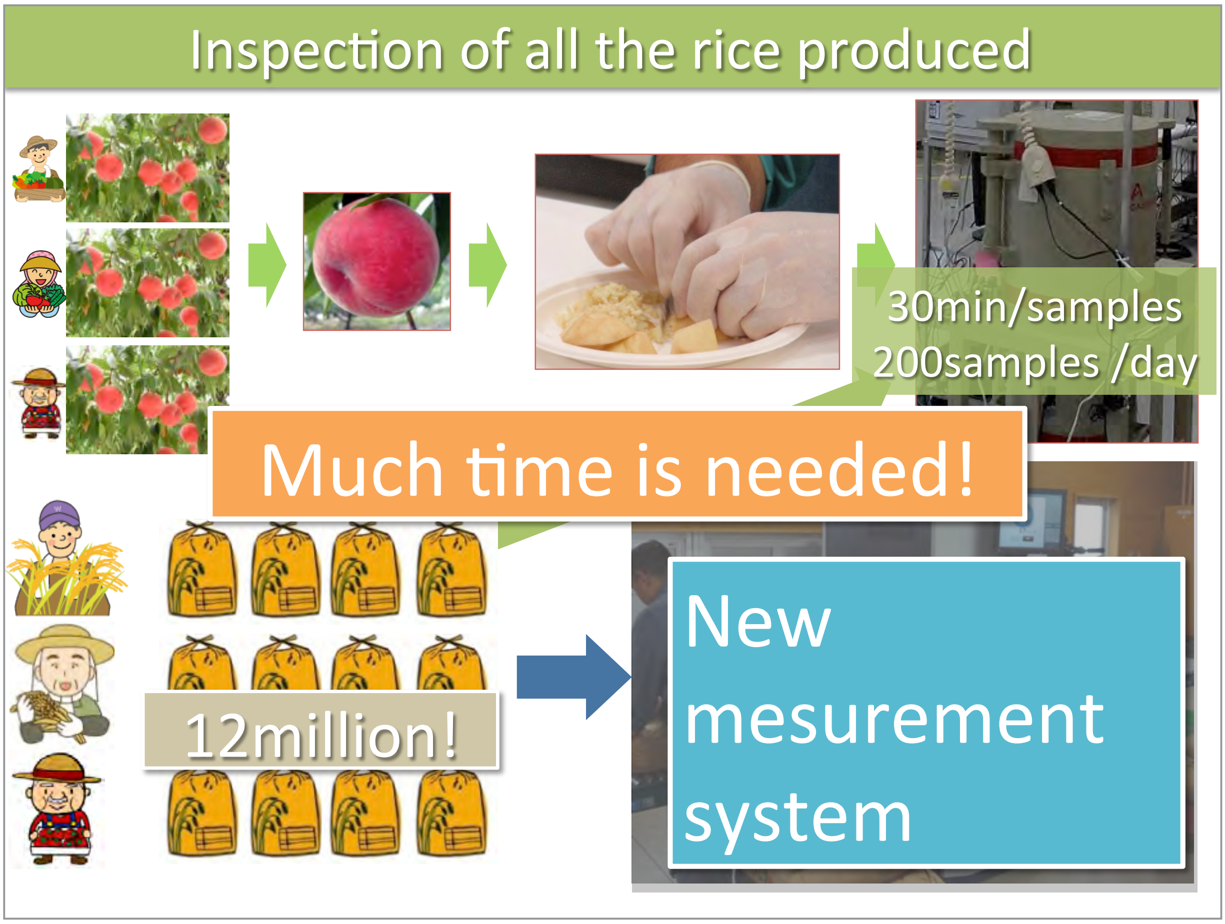
- Agricultural Products
- Livestock Products
- Forestry Products
- Fishery Products
- Rice

Rice

✔ Most important food in Japan!

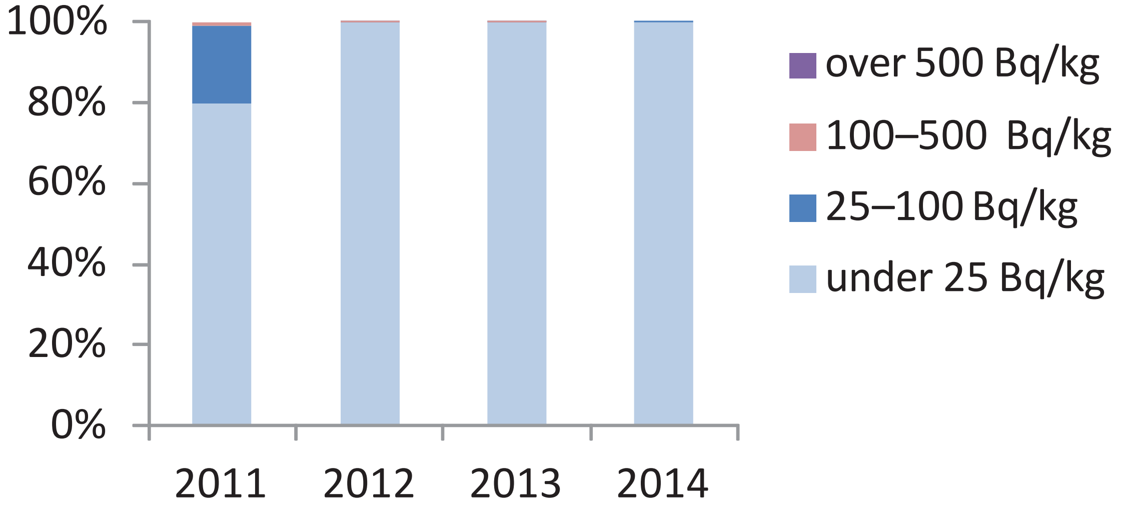
✔ Production in Fukushima Prefecture
About 360,000 tons/year

<u>All (12,000,000) rice bags</u>
must be checked from 2012.


Inspection of all the rice produced
30min/samples
200samples /day
Much time is needed!
12million!
New
mesurement
system


New measurement system (Belt conveyor tester)
✔ Fast measurement: Three rice bags per minute
✔ High sensitivity: Detect less than 100 Bq/kg
FOODS EYE

Rice



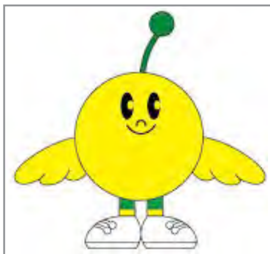
More than 100Bq/kg : 2012 71bags/10,335,000bags
2013 28bags/
10,809,000bags

Summary

1. To verify the safety, monitoring inspections have been conducted. In the case of rice, all the products were measured by a newly developed monitoring system.

2. Contamination has been significantly reduced compared to the observed levels immediately after the incident, with the exception of some of the forestry and fishery products.

3. The monitoring system must be used in order to continue producing safe agricultural products.



Thank you for your attention.

ふくしまから
はじめよう。

Future From Fukushima.

3.6 Penetration of cesium, silver and other metals in soils with examples from the Fukushima accident

Gunnar Bengtsson
Presenter: gunnarbengt@telia.com
Former Director General of SSI (Swedish Radiation Protection Institute)

Penetration of cesium, silver and other metals in soils with examples from the Fukushima accident

Gunnar Bengtsson, PhD

Presentation at

Joint Japan Sweden Radioecology Workshop

University of Gothenburg Department of Radiation Physics

September 1-2, 2015

Metals pass through agricultural soil

About 3 mm/year

- Same speed for many metals
- Same speed in control soils and for organic matter
- Enhanced speed at large organic amendment
- Enhanced speed below the topsoil
- Risk for groundwater contamination
- Same speed equation applied also to Fukushima cesium and silver

Do metals stay in the topsoil?

Studies on metals from organic amendments in agriculture, e g manure, sludge

- No penetration to subsoil
- No metals found in subsoil
- Assumptions that supplied metals accumulate, e.g. Swedish EPA over 500 years

But yes, they do penetrate topsoil!

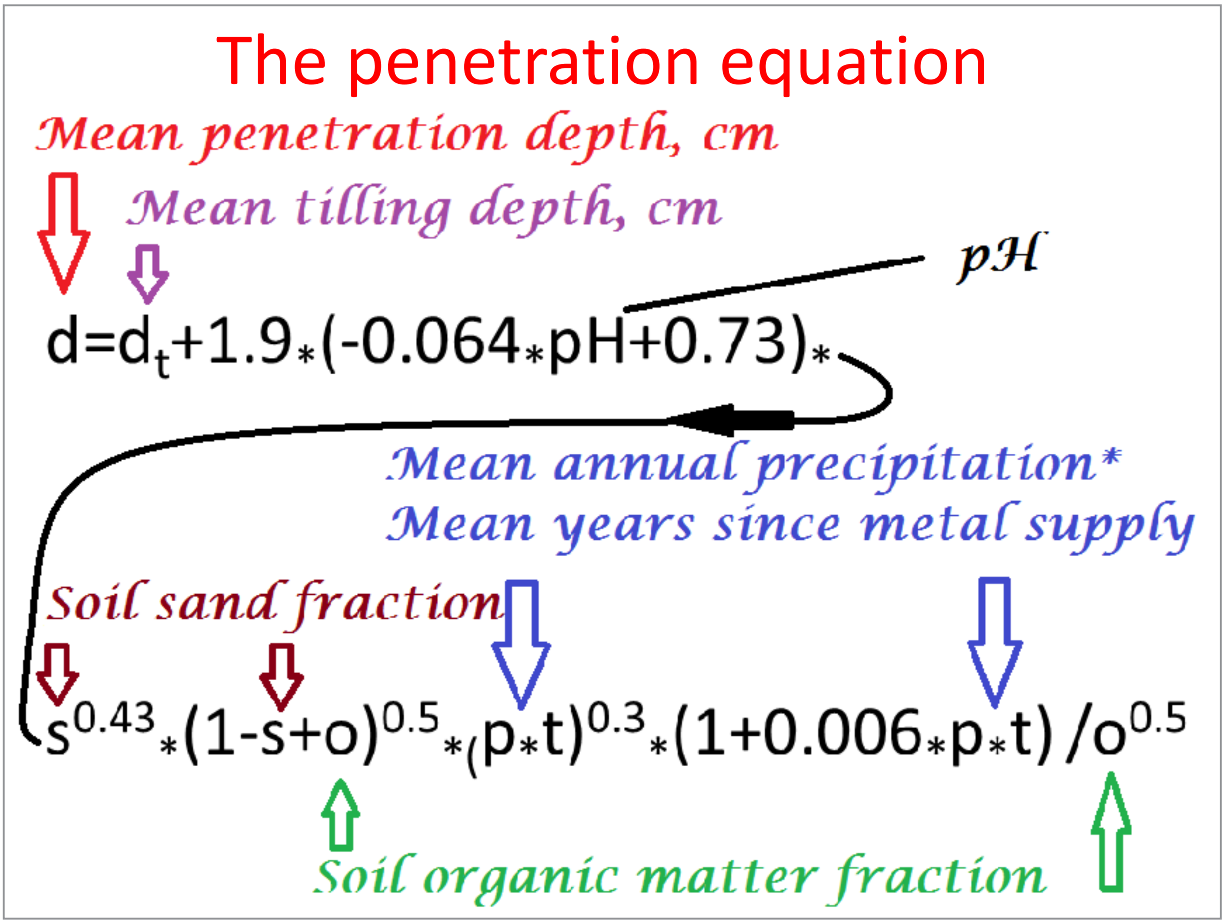
Evidence for penetration

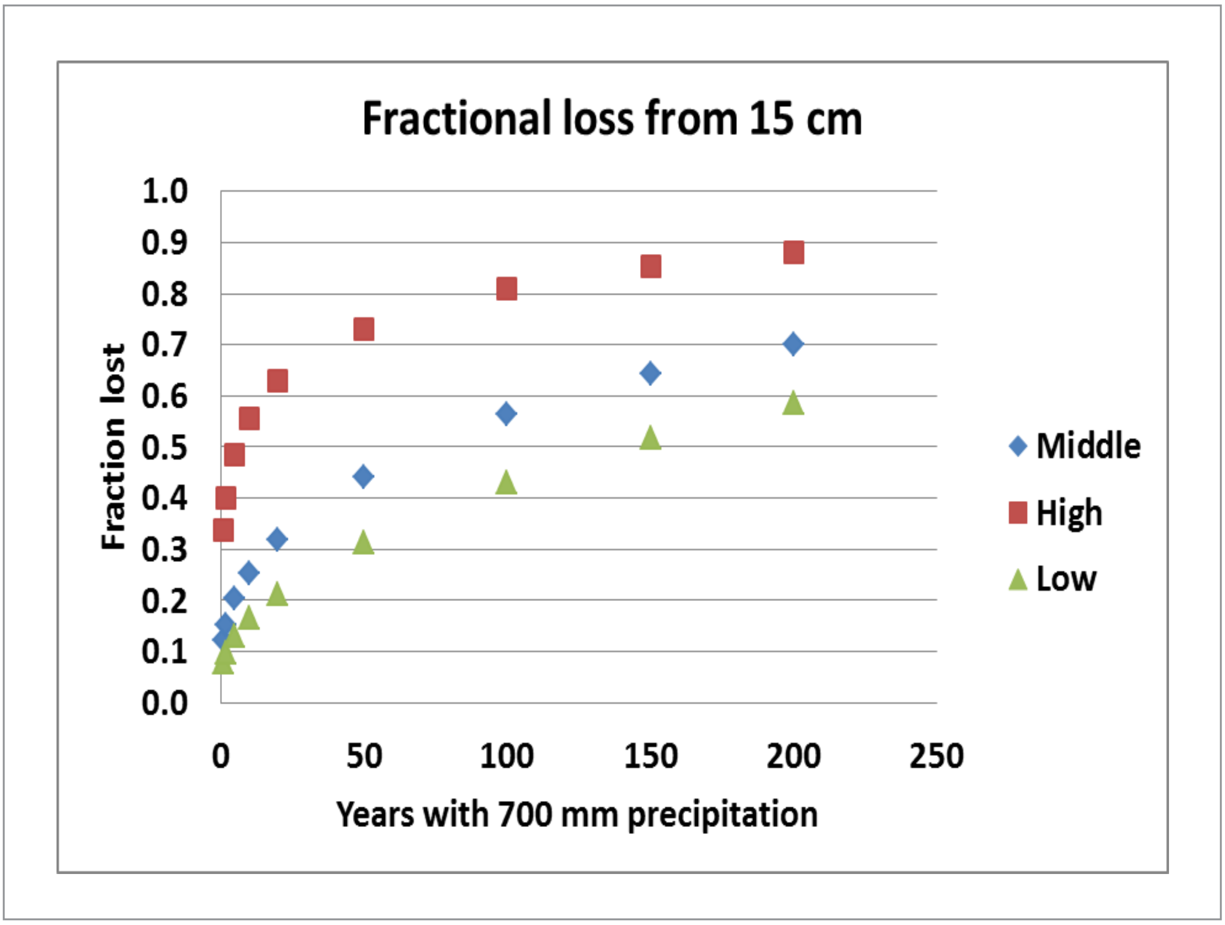
Review of long term studies in agriculture

- Only few studies eligible, e g with respect to existing background levels
- Penetration in topsoil standardisation with respect to 11 parameters, e g precipitation and bulk density, total metal, only copper and silver
- 11 eligible studies result in a penetration equation

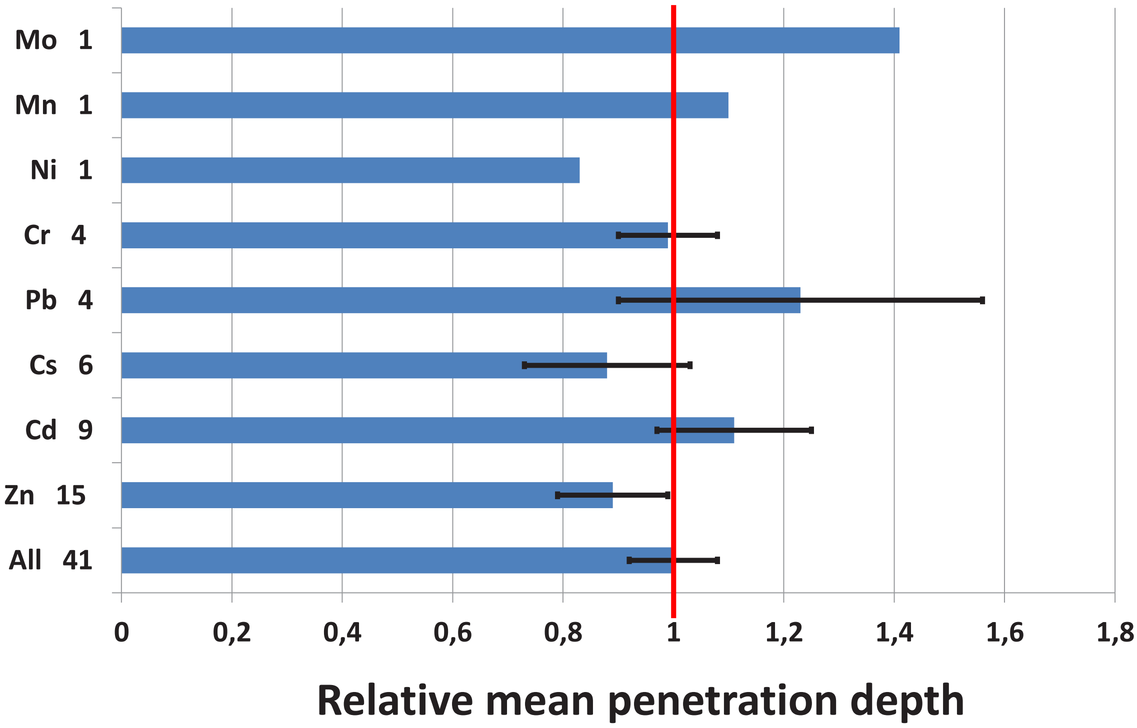
$$d=d_t+1.9*(-0.064*pH+0.73)*s^{0.43}*(1-s+o)^{0.5}*(p*t)^{0.3}*(1+0.006*p*t)/o^{0.5}$$

- Describing mean penetration for copper and silver in the eligible studies with standard deviation 11 %

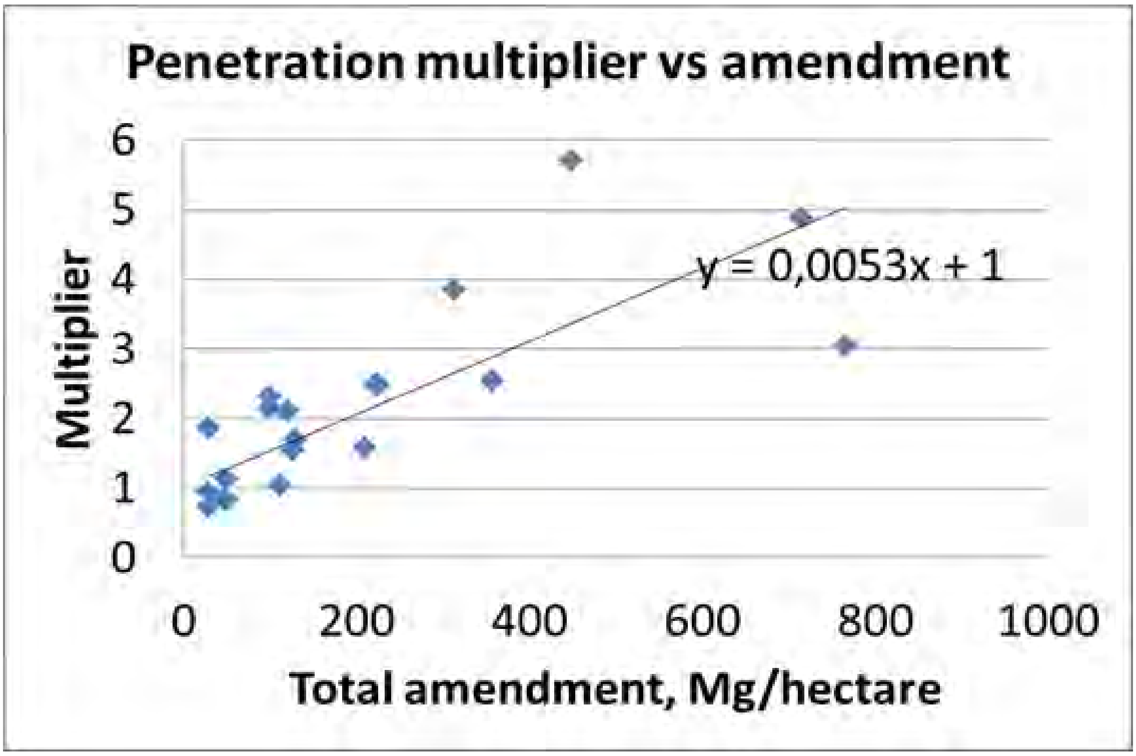

The penetration equation
Mean penetration depth, cm
Mean tilling depth, cm
pH
d=dt+1.9*(-0.064*pH+0.73)*
Mean annual precipitation*
Mean years since metal supply
Soil sand fraction
s0.43*(1-s+o)0.5*(p*t)0.3*(1+0.006*p*t) /o0.5
Soil organic matter fraction


Fractional loss from 15 cm
Fraction lost
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
50
100
150
200
250
Years with 700 mm precipitation
Middle
High
Low

Other metals than copper and silver



Very large organic amendment



Other findings

- Organic matter and control soil metals lost at similar rates as penetration equation metal loss
- Hypothesis: If the organic matter content increases with time, the rate of penetration decreases, and vice versa
- Of 13 cases reporting metal levels at 100-200 cm depth, only 1 case exhibited significant accumulation. Thus the normal case is rapid loss of metals below 100 cm; few sinks except peat

Significance of the penetration

Concern moves from organisms affected by soil to organisms affected by groundwater

Equilibrium metal levels in groundwater after long-term sludge amendment may reach > 200 times natural levels even with stringent restrictions. Whether this is acceptble requires careful assessment.

Fukushima relevance

- Chernobyl cesium measured depth 1-10 years, 3 locations (Rosén et al 1999) 0.89 of predicted
- Fukushima cesium (Lepage et al 2014) not eligible because of extremely low bulk density still measured depth = 0.7 of predicted
- Fukushima cesium measured depth 1 year 1 location (Lepage et al 2014) 0.81 of measured silver
- Fukushima silver and cesium similar in soil and sediment (Lepage et al 2014)

Summary: Metals pass through agricultural soil

About 3 mm/year or 30 cm in a century

- Same speed for many metals, hitchhiking with organic matter
- Same speed in control soils and for organic matter
- Enhanced speed at large organic amendment
- Enhanced speed below the topsoil
- Risk for groundwater contamination
- Applied also to Fukushima cesium and silver

Thank you!

Manuscript in advanced preparation to be submitted for open access to Journal of Agricultural Science

Gunnar Bengtsson:
“Metals leak from tilled soil in a century – A review”

3.7 Spatial and vertical distribution of fall-out ^{137}Cs in Sweden

Mats Isaksson†, [1]
† Presenter: mats.isaksson@radfys.gu.se
1 Dept of Radiation Physics, Institute of Clinical Sciences,
Sahlgrenska Academy at University of Gothenburg, Sweden

Some methods used for estimating deposition density and vertical distribution of radionuclides are presented. Deposition density from nuclear weapons fallout and fallout from the Chernobyl accident has been modelled for an area of about 100 x 100 km^2.

Using a slightly more elaborate model, the deposition density from nuclear weapons fallout has been modelled for the whole Swedish territory as well. The estimations are based on precipitation measurements and measurements of the activity concentration in precipitation at some reference sites.

The results from model validation indicate that the assumptions made in the model are reasonable. Furthermore, results from analysis of soil samples and field gamma spectrometry from a network of about 30 sites in Western Sweden are presented, and results from the two measurements methods are compared. The vertical distribution is modelled by various methods, which will be discussed.

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Spatial and vertical distribution of fall-out ^{137}Cs in Sweden

Joint Japan Sweden Radioecology Workshop 2 Sept. 2015, Gothenburg

Mats Isakson, prof.

Dep. of Radiation Physics

The Sahlgrenska Academy

STUDIES OF SPATIAL VARIATION

The Sahlgrenska Academy

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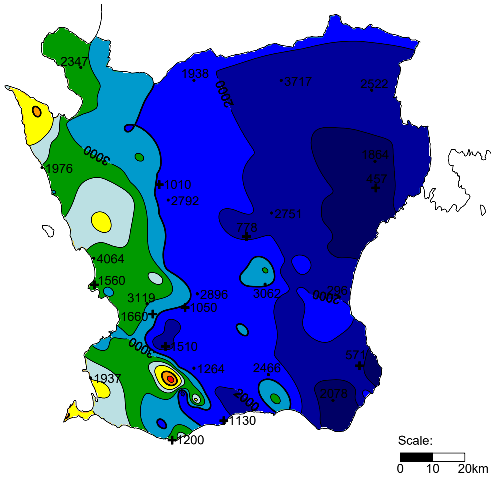
Deposition density southern Sweden

Deposition density
^{137}Cs 1962-1994



M. Isaksson, B. Erlandsson & M-L. Linderson, *Calculation of the deposition of 137Cs from nuclear bomb tests and from the Chernobyl accident over the province of Skåne in the southern part of Sweden based on the precipitation.* Journal of Environmental Radioactivity, 49, 2000

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Method

- Dense network of precipitation measurements (>100)
- Quarterly measurements of activity concentration in precipitation (1 site)
- Homogeneous activity concentration in air assumed
- Kriging interpolation

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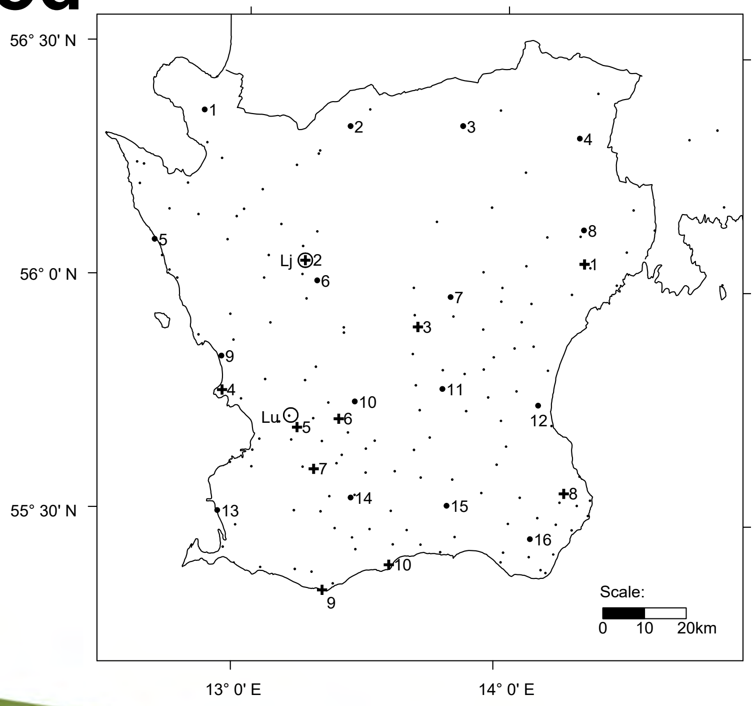
Method



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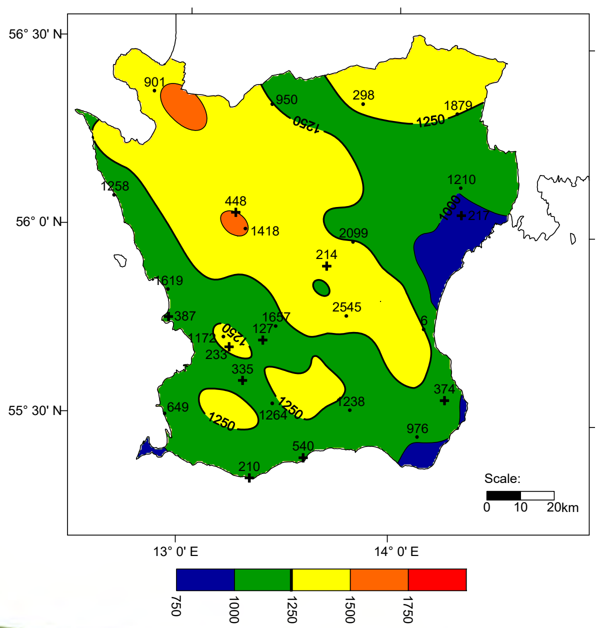
Deposition 1962-1977



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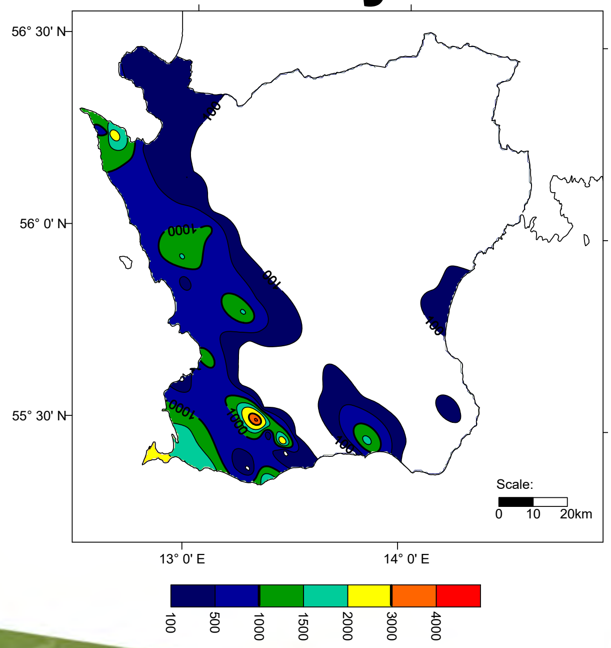
Deposition 06.00 GMT May 7th until 06.00 GMT May 8th 1986



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Validation

Modelled deposition compared to

- soil samples
- field gamma spectrometry
- AGS

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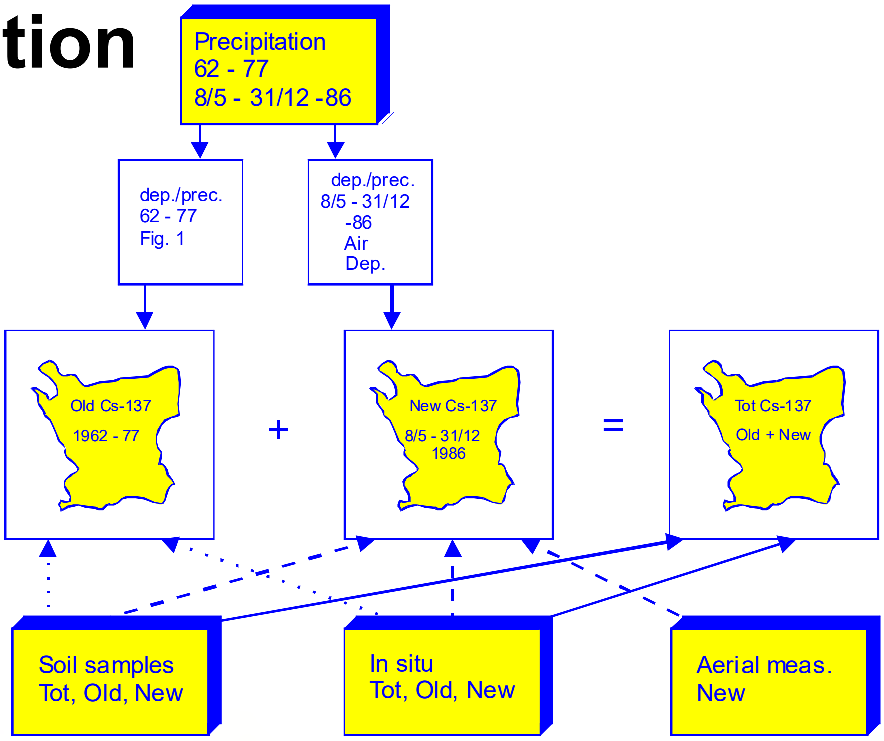
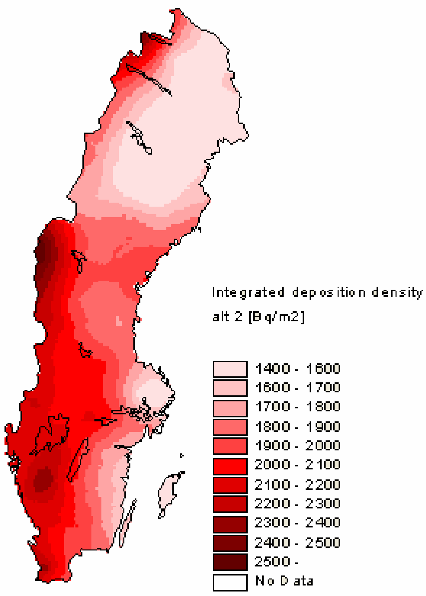
Validation

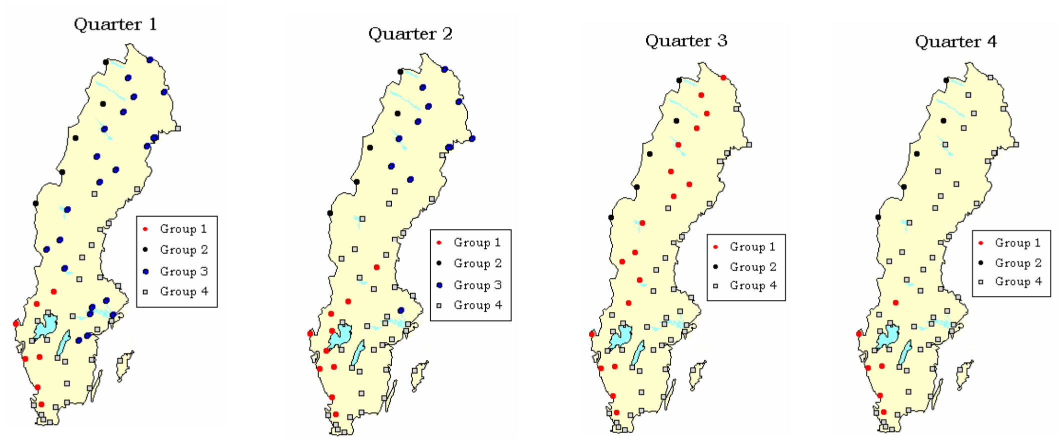


Nuclear weapons fallout

S Almgren, E Nilsson, B Erlandsson & M Isaksson. *GIS supported calculations of ^{137}Cs deposition in Sweden based on precipitation data*. Science of the Total Environment, Vol. 368, Iss. 2-3, pp. 804-813, 2006



Method – 4 reference sites



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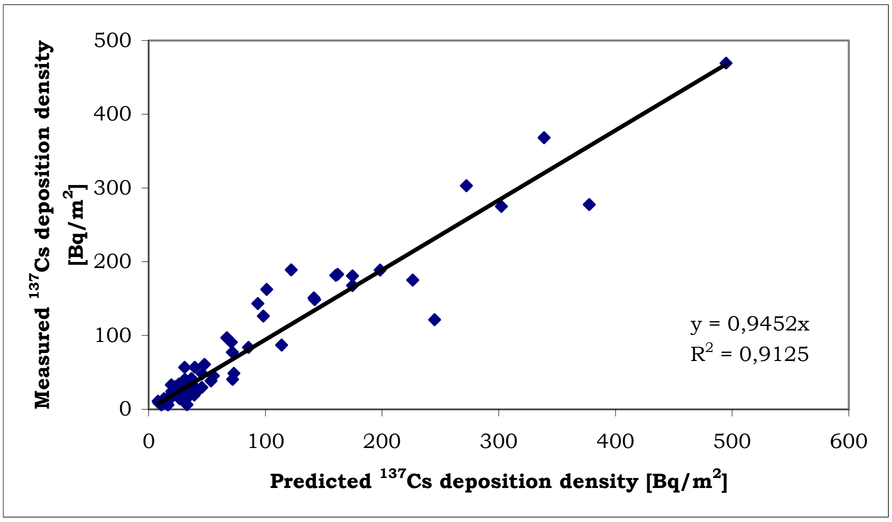
Validation



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Global fallout

S.E. Pálsson, B.J. Howard, T.D. Bergan, J. Paatero, M. Isaksson and S.P. Nielsen. A simple model to estimate deposition based on a statistical reassessment of global fallout data. Journal of Environmental Radioactivity, 121, pp. 75-86, 2013

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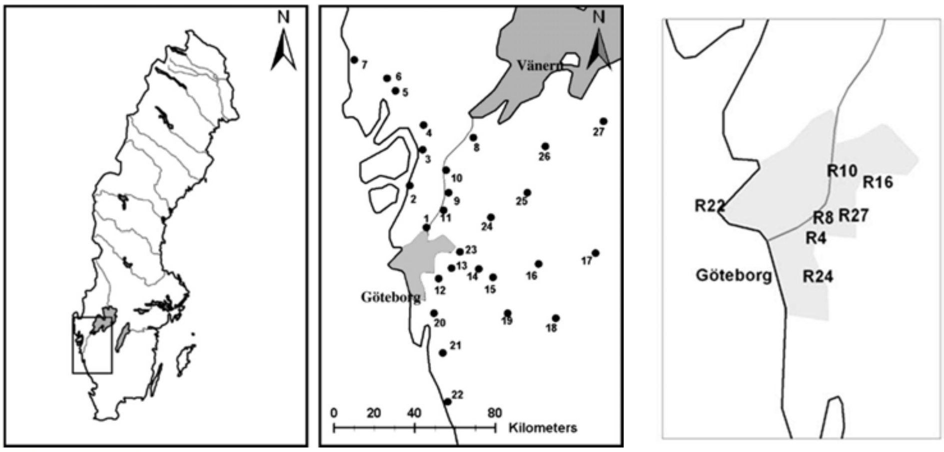
Reference sites in Western Sweden



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Metod

- Soil sampling: 0-15 cm depth
- Field gamma spectrometry
- Measurements with dose rate meter

S. Almgren & M. Isaksson. Long-term investigation of anthropogenic and naturally occurring radionuclides at reference sites in western Sweden. Journal of Environmental Radioactivity, 100, pp. 599-604, 2009

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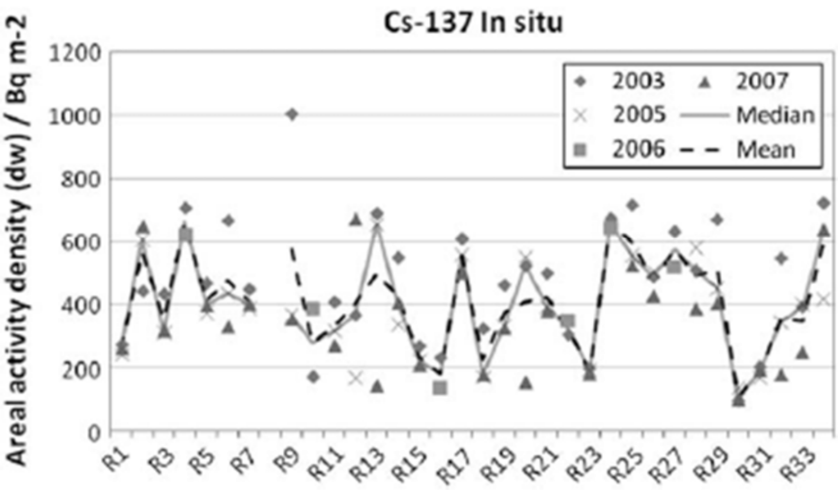
Results

Equivalent surface activity



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Results

Accuracy of in situ calibration

Site	Activity ratio soil/in situ								
	Bi-214			K-40			Cs-137		
	2003	2005	2006	2003	2005	2006	2003	2005	2006
R1	1.42	1.04		1.17	1.43		6.91	5.32	
R2	1.11	0.78		0.91	0.86		8.75	5.86	
R3	0.95	0.53		0.89	0.71		7.35	4.14	
R4	2.26		1.06	1.08		0.97	6.76		6.66
R5	0.54	0.47		1.01	2.10		5.63	6.55	
R6	0.71	0.85		0.95	1.22		4.90	5.03	
R7	1.42	1.40		1.04	1.64		6.66	7.72	
R8									
R9	1.06	0.73		0.93	1.33		5.33	8.56	
R10	1.07		1.61	1.01		1.13	3.75		6.11
R11	1.21	1.30		1.01	1.29		7.16	7.34	
R12	1.34			1.04	1.71		10.73	11.70	
R13	1.02	1.17		1.02	1.19		6.56	7.91	
R14	1.11	0.66		[illegible]	[illegible]		[illegible]	[illegible]	

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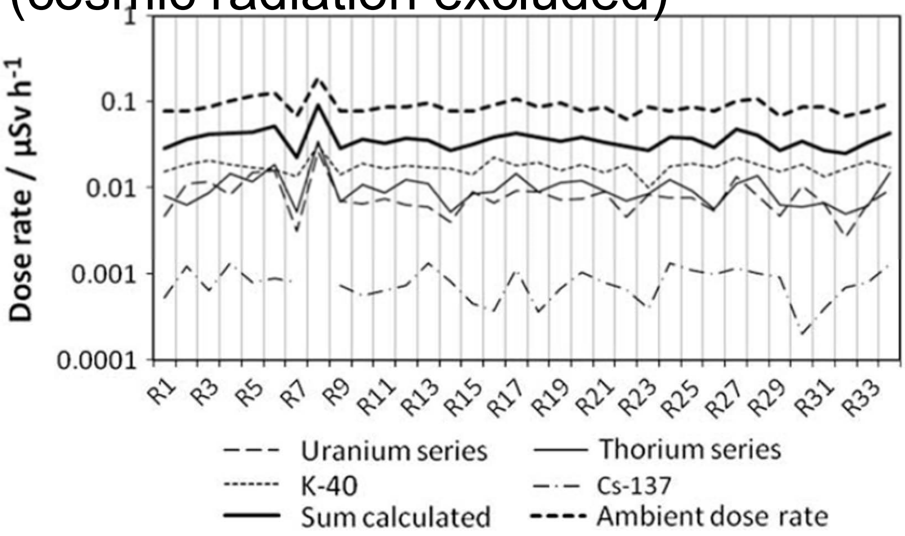
Results

Overestimation by dose rate meter (cosmic radiation excluded)



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VERTICAL MIGRATION

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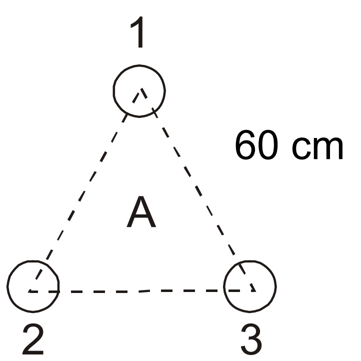
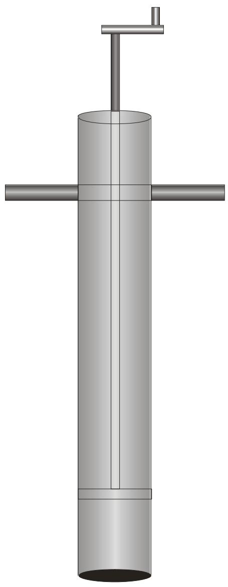
Method

Soil sampling with corer





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Models of vertical distribution

Convection-diffusion equation (CDE)

$$C(x,t) = J_0\,\mathrm{e}^{-\lambda t}\left(\frac{1}{\sqrt{\pi D t}}\,\mathrm{e}^{-(x-vt)^2/(4Dt)} - \frac{v}{2D}\,\mathrm{e}^{vx/D}\,\mathrm{erfc}\left(\frac{v}{2}\sqrt{\frac{t}{D}} + \frac{x}{2\sqrt{Dt}}\right)\right)$$

Relaxation depth

$$c(z) = \alpha e^{-\beta z^{p}}$$

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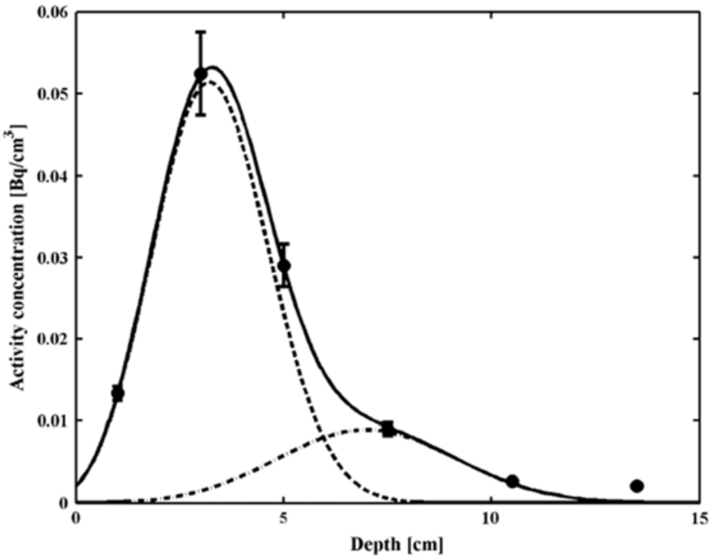
Chernobyl + NWF (ADE-based)



S Almgren & M Isaksson. Vertical migration studies of 137Cs from nuclear weapons fallout and the Chernobyl accident. Journal of Environmental Radioactivity, 91 (1-2), pp. 90-102, 2006.

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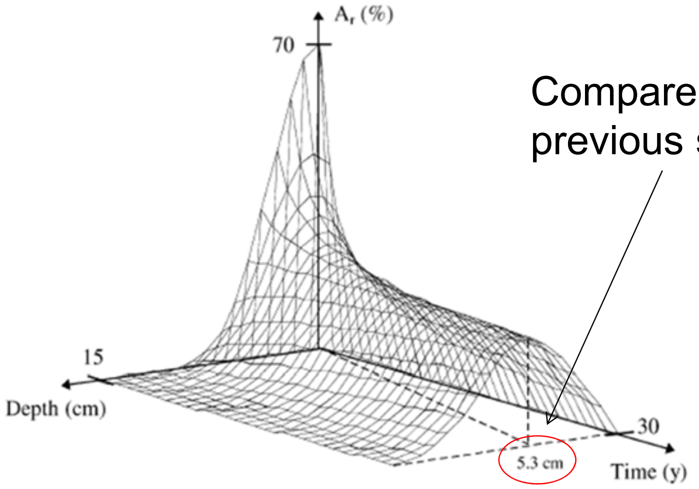
Results

Slow vertical transport, average depth of max activity for Cs-137: 5.4 cm

D & v consistent with other studies

In situ calibration corrected by CDE fit with good results

Vertical migration – non-ADE



Compare previous slide

Mats Isaksson & Bengt Erlandsson. Models for the vertical migration of 137 Cs in the ground - a field study. Journal of Environmental Radioactivity, 41, 1998.


Thank you!
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3.8 Caesium contamination in the Swedish town Gävle eleven years after the Chernobyl accident and some unexpected findings

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The radioactive cloud from the Chernobyl accident reached the southeast part of Sweden in the morning of April 27, 1986 and continued spreading northwards. During the night between April 28 and 29 rainfalls caused increased deposition of radionuclides on the ground mainly along the Swedish coastline from the town Gävle and northwards. The heaviest deposition occurred just north-east of Gävle, resulting in a deposition density of about 100 kBq/m^2 over more than 300 square kilometres with a maximum value of up to 200 kBq/m2 over about 2 square kilometres. No specific large-scale decontamination activities of streets or land areas were performed, other than the usual street-sweeping of non-slip sand that was spread out on streets during winter-time and swept-up in the beginning of May. In 1997 the Swedish Radiation Protection Authority (SSI) performed mobile gamma spectrometry in the whole city of Gävle and parts of the surroundings. Hardened areas, such as asphalt covered streets in the centre of the city were found to be almost clean from caesium deposition, but areas with one-family houses with gardens were still contaminated, although the caesium had penetrated somewhat into the ground. Dose rates from radiocaesium in the streets in areas with one-family houses were typically in the order of 0.02 – 0.04 μSv/h and double this value above grass covered garden areas. The normal background in Gävle is in the order of 0.1 μSv/h, so the caesium fallout caused a 20 – 80 % increase above the natural background in the outdoor radiation level in these areas eleven years after the fallout. The increase in the outdoor radiation level in the centre of the city was only about 10 %. The mobile measurements also revealed unexpected patches of caesium contamination outside of the town. After investigation, this could be traced back to unauthorized use of non-slip sand swept from the streets in May 1986. In one private garden, a patch of non-slip sand was found containing caesium contamination in the order of 2 – 3 MBq/m^2. This was more than ten times the maximum deposition density from direct fallout in the area.

Caesium contamination in the Swedish town Gävle eleven years after the Chernobyl accident and some unexpected findings

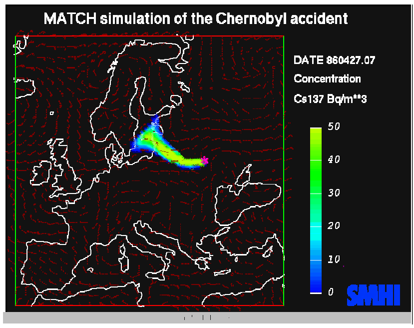
A presentation with picture slides and comments

Robert R. Finck

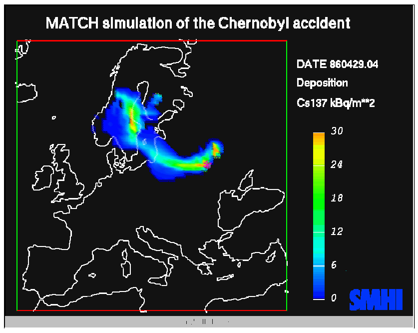
Department of Medical Radiation Physics, ITM, Lund University, University Hospital, SE-205 02 Malmö, Sweden

Dispersion modelling of the radioactive release from the Chernobyl accident

Calculations of the atmospheric dispersion and ground deposition of the Chernobyl release made by the SMHI MATCH Model developed ten years after the accident, using European weather observation data from the time of the accident



The radioactive cloud



The radioactive fallout on the ground

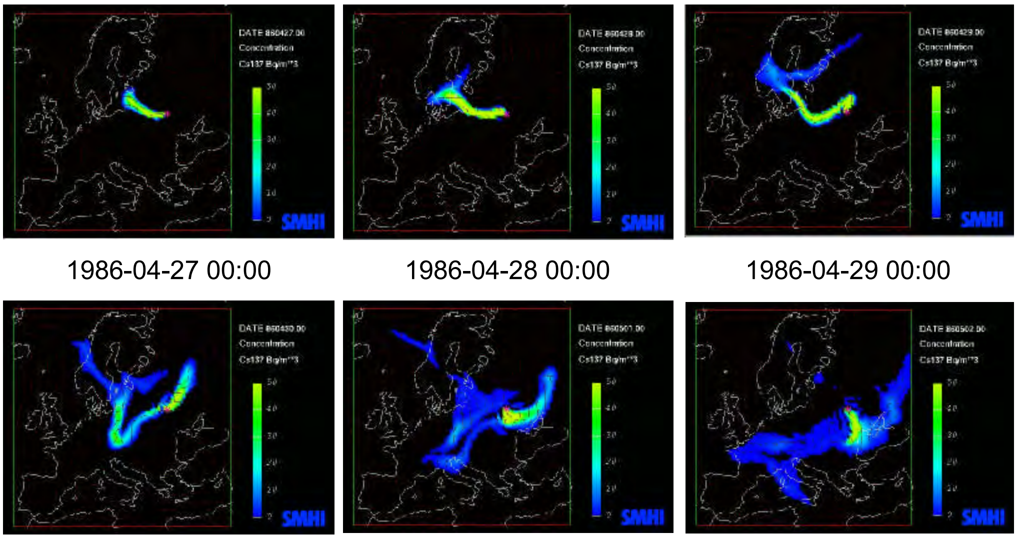
The radioactive cloud from the Chernobyl accident reached the southeast part of Sweden in the morning of April 27, 1986 and continued spreading northwards.

Sunday, April 27, 1986 was a beautiful day in Sweden and many were out and enjoyed the warmth of spring. No one knew then that a radioactive cloud from a nuclear accident far away was spreading across the country. The cloud had reached the islands Gotland and Oland at six o'clock in the morning and continued over southern Sweden. At the fixed monitoring station for gamma radiation on the southern tip of Öland, operated by the Swedish Radiation Protection Institute (SSI), the pen pointer slowly started to mark an increase on a printer paper. But no one noticed this. Somewhat later also the monitoring stations in Eksjö, Erken and Solna silently registered the rising radiation level.

The increased radiation levels were first noticed on Monday morning, April 28, at the Forsmark nuclear power station north of Stockholm. First it was assumed that something was wrong at the power station and an alarm was sent at 10:15 to the regional county administration and to SSI. Further investigations, however, could not find anything wrong at the Forsmark power station. At 11:30 contacts with in Finland and the Oskarshamn nuclear power station i southeast Sweden revealed that the radioactive contamination was widespread and that the source probably was outside Sweden.

During the afternoon, Swedish authorities tried to detect the origin of the radioactive cloud. Back trajectory calculations show that the cloud came from the region of Latvia. At 19:00 the Soviet Union confirmed that a reactor accident had happened in the Chernobyl reactor no 4 in Ukraine.

Simulation of the radioactive cloud from the Chernobyl accident by the SMHI Match model



1986-04-27 00:00 | 1986-04-28 00:00 | 1986-04-29 00:00

1986-04-30 00:00 | 1986-05-01 00:00 | 1986-05-02 00:00

In 1996, the Swedish Meteorological and Hydrological Institute (SMHI) had on behalf of SSI developed a dispersion model that could calculate the dispersion pattern from the Chernobyl release, using weather observation data from the time of the accident and a source term estimated by IAEA.

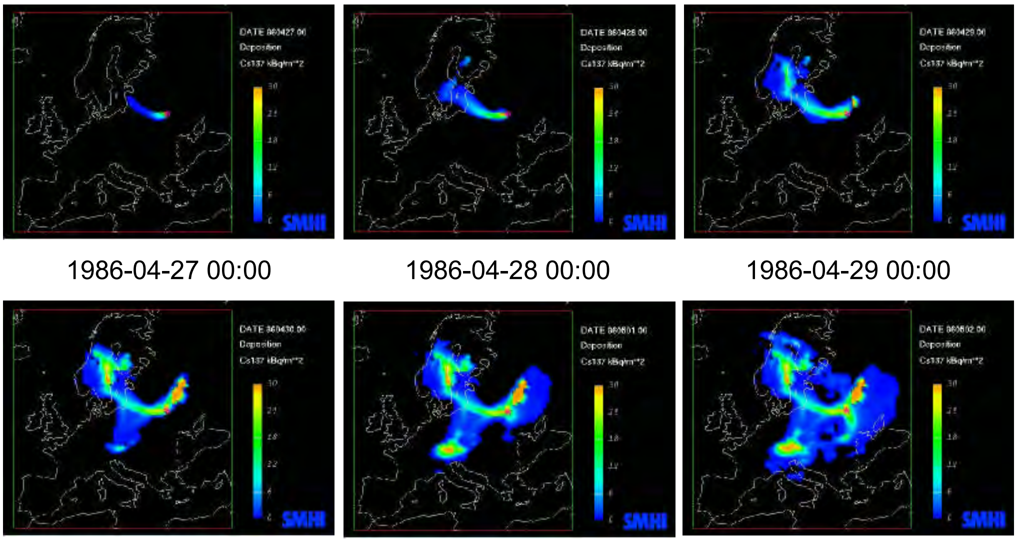
The picture above shows the calculated dispersion of the radioactive cloud at midnight on the 27, 28, 29, 30 April and on 1 and 2 May 1996.

The composition of radionuclides in the air was continually monitored by high volume air samplers at seven locations in Sweden (Ljungbyhed, Gothenburg, Grindsjön, Stockholm, Östersund, Umeå and Kiruna). The station in Stockholm gave the first reading, which showed the radioactive substances that were in the Chernobyl cloud. Through analysis of the air filters information of the levels and time-lapse of radionuclides at the seven sites was obtained. This was used to estimate the inhalation doses in Sweden.

Using air filter measurements, airborne gamma spectrometry and in situ high resolution gamma spectrometry, collective doses to the Swedish population was calculated by Finck et al, 1988*.

* Reference: Robert Finck, Kay Edvarson, Björn Bjurman, Lars-Erik De Geer, Ingemar Vintersved. "Collective Doses in Sweden After the Chernobyl Accident. Calculation For Inhalation and External Irradiation." Proceedings of the seventh International Congress of the International Radiation protection Association, IRPA, Radiation Protection Practice Vol III, Sydney, Australia, April 10 - 17, pp 1627-1630; 1988.

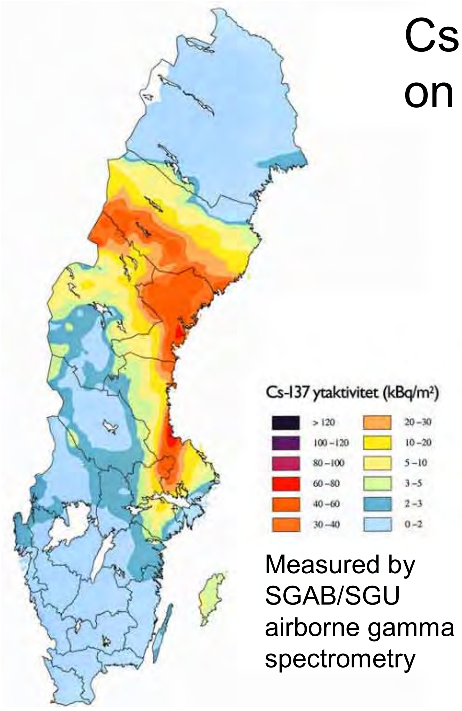
Simulation of the radioactive fallout from the Chernobyl accident by the SMHI Match model



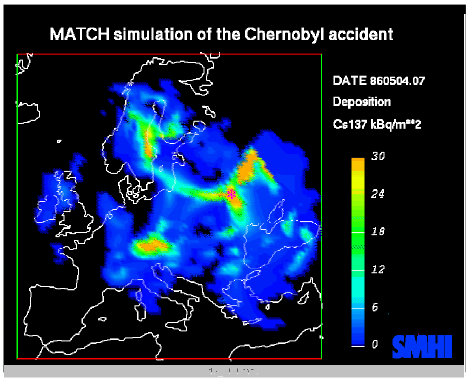
The picture above shows the calculated ground deposition of Cs-137 at midnight on the 27, 28, 29, 30 April and on 1 and 2 May 1996.

During the night between April 28 and 29 rainfalls caused increased deposition of radionuclides on the ground mainly along the Swedish coastline from the town Gävle and northwards.

Cs-137 from Chernobyl on the ground in Sweden



Measured by SGAB/SGU airborne gamma spectrometry



Calculated by SMHI Match dispersion model using weather observation data and a source term estimated by IAEA

The fallout was mapped by a fixed wing aircraft carrying a 16.8 litre NaI(Tl)-gamma spectrometer. The airborne mapping of Sweden was performed with east-west flight lines generally with 50 km spacing. In the Gävle area the spacing between flight lines was more dense. The mapping was mainly performed during the first month after the accident. Additional mapping was performed during the summer and autumn of 1986 and in 1987, 1988 and 1989.

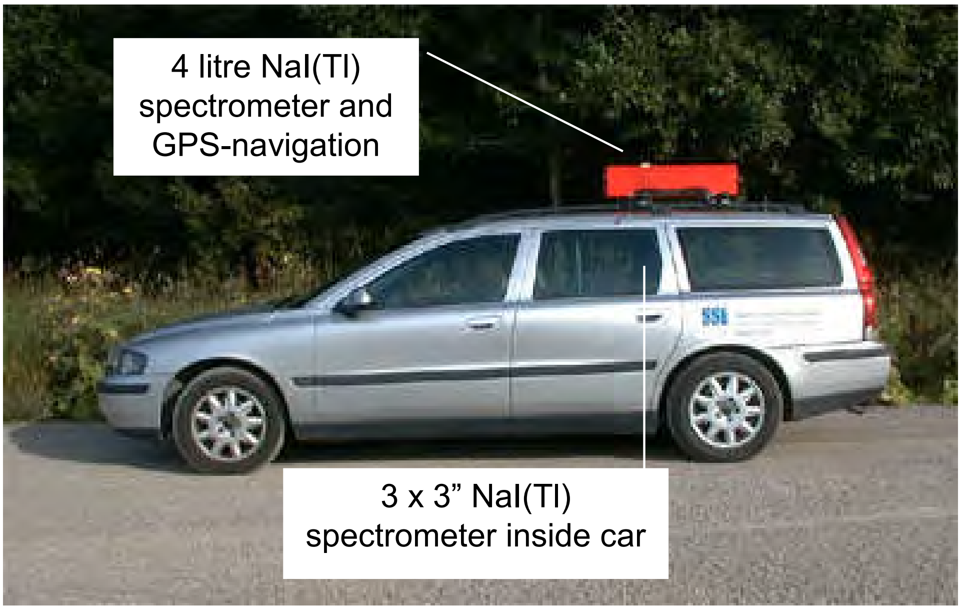
The heaviest deposition occurred just north-east of Gävle, resulting in a deposition density of about 100 kBq/m2 over more than 300 square kilometres with a maximum value of up to 200 kBq/m2 over about 2 square kilometres.

The radionuclide composition in the fallout was measured by in situ high resolution gamma spectrometry at about 70 locations all over Sweden. In Stockholm the fallout was continuously measured by in situ high resolution gamma spectrometry from April 28 to August 12, 1986.

The in situ measurements showed already in the first days of May that the fallout composition varied greatly from location to location. In Stockholm, where it had not rained, tellurium-132 (half-life 3.3 days), iodine-131 (8 days) and barium-140 (12.7day) dominated initially. In the area around Gävle, where the deposition occurred with rain, the relative deposition of Cs-134 and Cs-137 was much higher.

No specific large-scale decontamination activities of streets or land areas were performed, other than the usual street-sweeping of non-slip sand that was spread out on streets during winter-time and swept-up in the beginning of May.

Mobile gamma spectrometry



Eleven years after the Chernobyl accident car-borne measurements in the Gävle area using gamma spectrometers and GPS-navigation were performed. During the mobile measurements in Gavle in May 1997, a 3x3" NaI(Tl)-crystal inside a car and a 4 litre Nal(Tl) crystal mounted on the roof of a Volvo station wagon was used . The picture shows a later installation in 2003 in a Volvo V70, but the assembly and the detectors were the same as 1997.

Before and after each measurement round a reference measurement at the same location in the Regimental Park in Gävle was performed. This was to correct for varying shielding inside the car from the gas tank and the possible change of the load in the car. The car was refuelled full before each day's measurement. With the exception of a few sets of readings the driver was alone in the car.

The analysis system was Gammadata GDM 40 RPS 256 channels. Position determinations were made with the built-in GPS in the GDM system. The detector efficiency was calibrated against plates containing well-known amounts of uranium, thorium and potassium. Calibration with respect to caesium-137 was made by comparing the measured activity per unit area and dose rate in a well mapped reference area in the Regimental Park in Gävle.

The mobile measurements took 10 days to perform.

Backpack gamma spectrometer with 3”x3” NaI(Tl)-crystal and GPS, 1997

The first backpack gamma spectrometry system, Gammadata GDM 40, with a 3x3 inch NaI(Tl)-crystal was used for mapping small areas of Gävle..

The GDM-system was first of its kind and specially developed for SSI. SSI bought four units, of which one was mounted in a backpack system, one alternatively on a bicycle or a pram and two used for car-borne measuring.

A mother walking in the park with her baby in a pram ?

Measurements in the Regiments Park in Gävle with the Gammadata GDM 40 spectrometer in a pram.

”Under cover” gamma spectrometry pram with 3x3” NaI(Tl) and GPS, May 1997

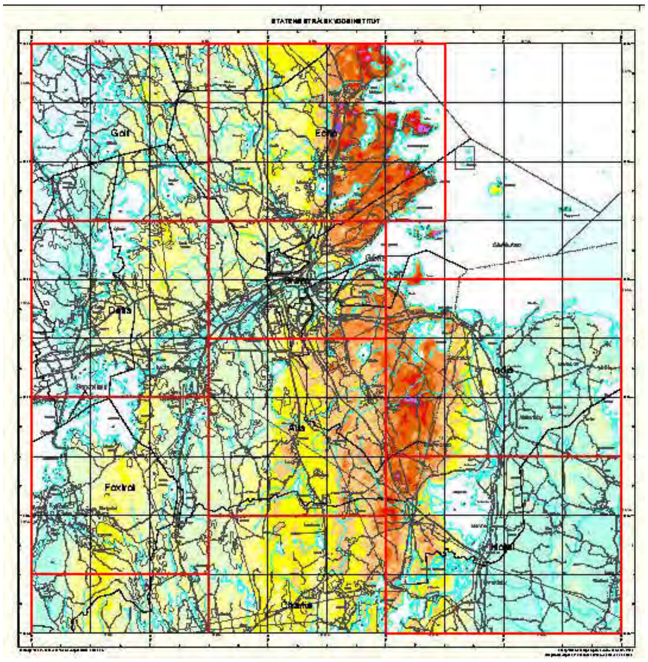
There is no child in the pram but a mobile gamma spectrometer with 3x3 inch NaI(Tl)-crystal. The system made it possible to measure in places in Gävle where it was impossible to drive a car.

High variability in ground deposition due to snow removal activities, snow melting, runoff and rain puddles

Picture of a "hot spot" at the air force base of Söderhamn (F15) measured in August 1987. The white curves represent isolines with the count rate 2000, 3000, 4500 and 5000 cps measured with a portable NaI(Tl)-scintillator 20 mm above ground. The average count rate outside the hot spot was 300 cps. In the centre of the hot spot the count rate exceeds 5000 cps. The length of the spot is about 30 m and the width about 5 m. A 1 m length scale is marked on the ground to the left. The isolines have been marked with white paper tape fixed to the ground.

A possible source of the elongated hot spot could be runoff of rainwater and melting snow. From weather records at the air force base of Söderhamn, it can be concluded that the ground was covered with 25 cm snow at the time of deposition (rain started at 28 April 1986 16.55 local time and stopped 29 April 03.45, giving a total of 24 mm), This was reduced to 14 cm at the end of rainfall. On the 23 April the ground was frozen from 6 - 82 cm depth below the soil surface. On 30 April the ground was thawed completely. The elongated shape of the hot spot is probably due to tracks from snow clearance along a path to the radar equipment. In these tracks, rainwater and meltwater have brought the radionuclides into pools of high activity. Similar hot areas were found at other locations on the airfield. The effect was also observed in completely undisturbed areas, which had a melting snow-cover during the time of wet deposition.

Reference: Robert R. Finck. "High Resolution Field Gamma Spectrometry and its Application to Problems in Environmental Radiology." Doctoral Dissertation, Lund university, Department of Radiation Physics, Malmö, Sweden, ISBN 91-628-0739-0; October 12, 1992.



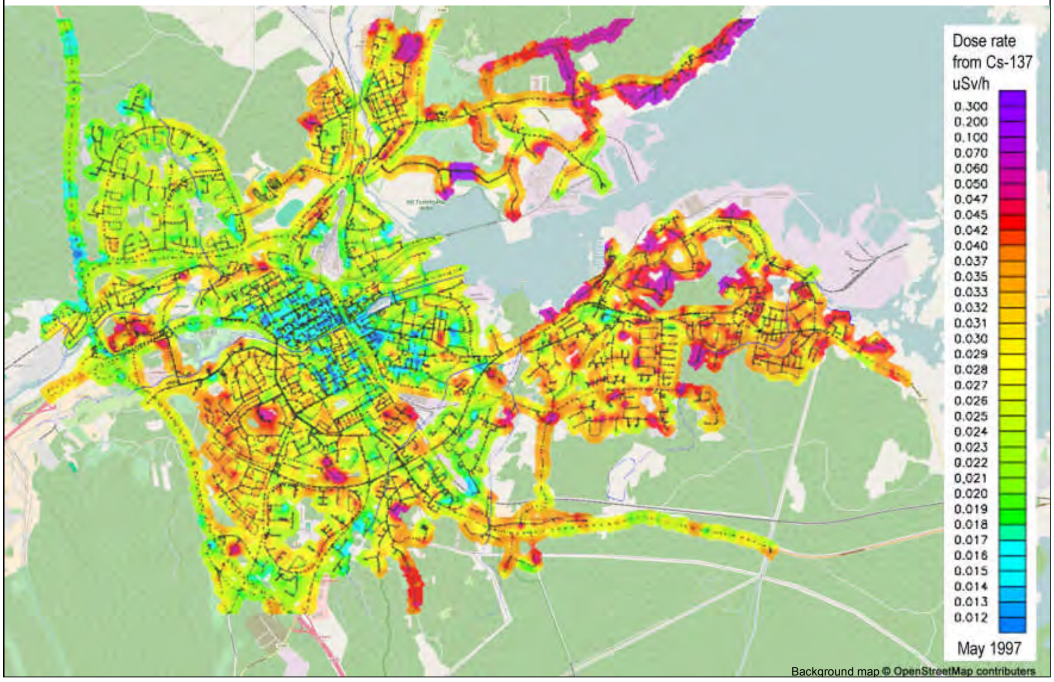
Cs-137 on the ground around Gävle mapped by SGAB / SGU using airborne gamma spectrometry

Picture showing the deposition of caesium-137 in the Gävle area, measured by airborne gamma spectrometry. Deposition values are recalculated to April 28, 1986.

Reference. H. Mellander, Airborne gammaspectrometric measurements of the fall-out over Sweden after the nuclear reactor accident in Chernobyl, USSR, Swedish Geological Co, Report TFRAP 8803, Uppsala; 1988.

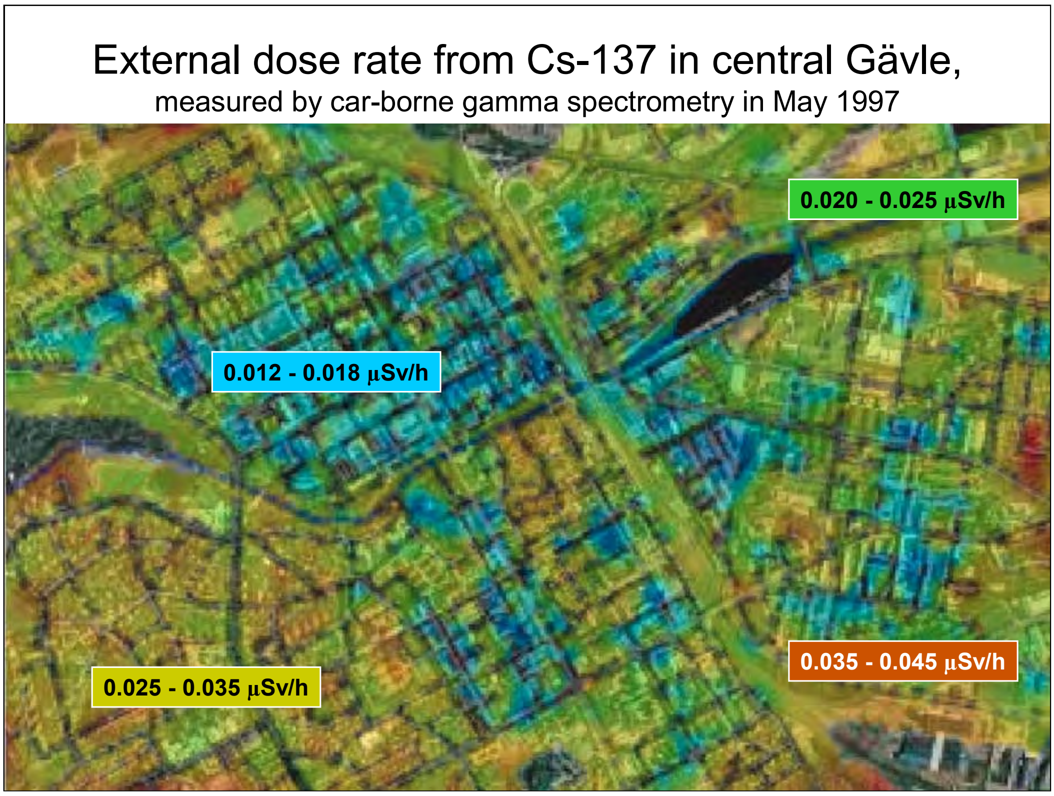
Joint Japan Sweden Radioecology Workshop at Gothenburg University, September 1-2, 2015
Caesium contamination in the Swedish city Gävle eleven years after the Chernobyl accident and some unexpected findings, Robert R Finck

External Dose rate from Cs-137 in Gävle,
measured by car-borne gamma spectrometry in May 1997



The picture shows the dose rate of caesium-137 along streets and roads in Gävle 1997, measured by car-borne gamma spectrometry.

Note the low levels in the city centre and the gradually increasing levels towards the east and northeast, which is due to the increasing ground deposition from the Chernobyl fallout. In the northeast, there are also some "hot" spots caused by contaminated material disseminated there.

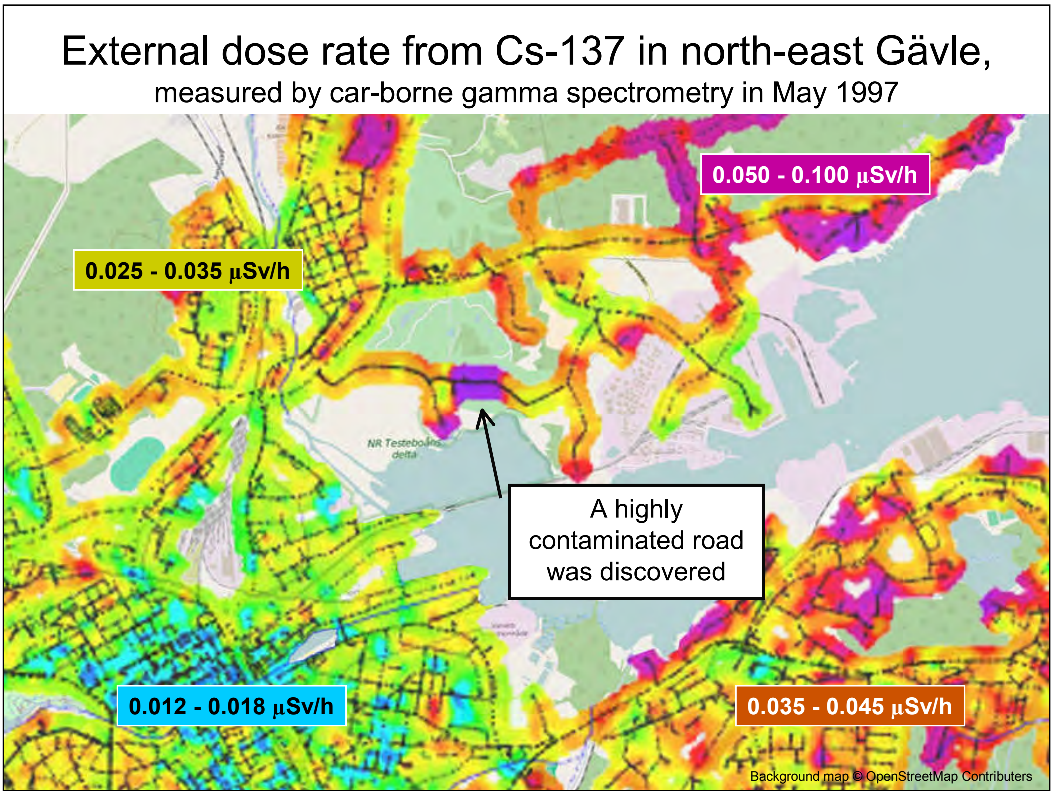


In the central parts of Gävle the dose rate from Cs-137 is low. That is because the buildings are high and all street areas are paved in asphalt and in some locations with cobblestones. The low dose rate is (primarily) due to high buildings that shield radiation from a distance, (secondarily) the original deposition on paved areas was lower than on grass and (thirdly) the removal of Cs-137 from the hard surfaces was more effective than from the grass areas.

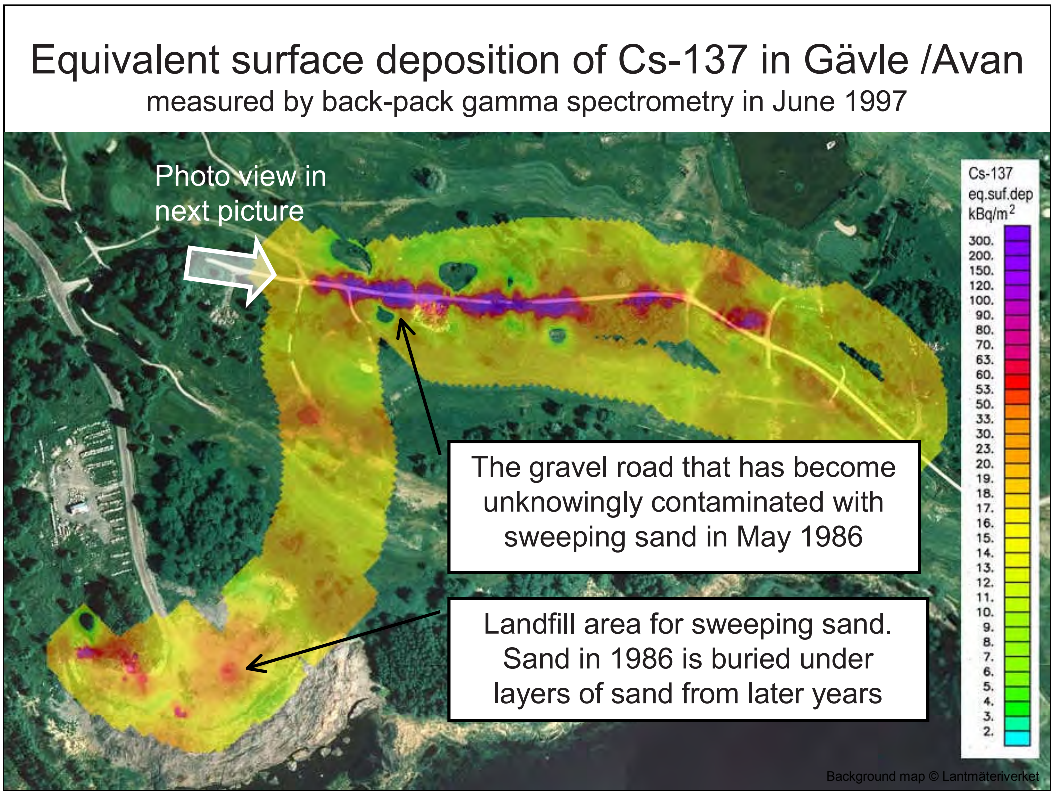
Southwest, west and northwest of the city centre are detached houses having open land surfaces with gardens that are often partly covered with grass. The deposition of Cs-137 has remained there and the shielding from buildings is not so dominant. This leads to higher dose rates of Cs-137 than in the centre of the city, despite the fact that there is a gradient in the deposition of C-137 which decreases towards the west.

In the southeast dose rates are higher, due to the combined effect of increased deposition eastward and larger open spaces around the villas and apartment buildings.

 1



The deposition of Cs-137 increases towards the northeast, resulting in increased dose rates. A "hot" spot appears along a gravel road. (See next slide)

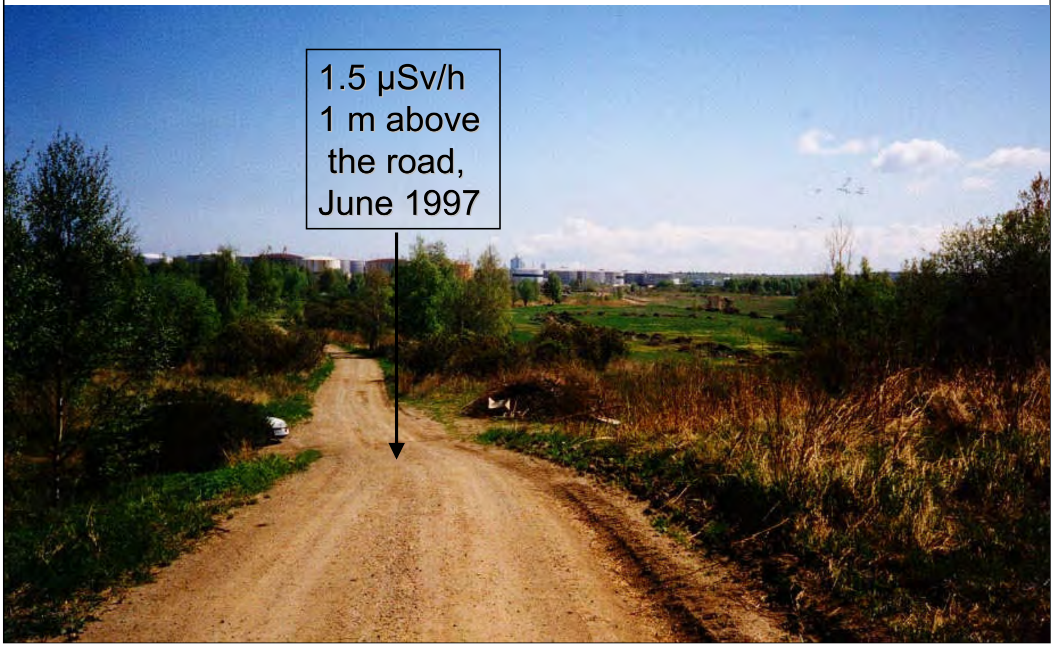


The contaminated gravel road was further mapped in June 1997.

Increased dose rates were measured in spots along the road, while the dose rate in the terrain was much lower. Even at the land fill area the dose rate was lower, which is due to several year layers of sand deposited on top of the sweeping sand from 1986.

Investigation revealed that at least one lorry load of sweeping sand had been laid on the gravel road and spread along the road. The sand on the road was sampled and measured by laboratory gamma spectrometry. It contained a small amount of Cs-134, corresponding to what should remain in Chernobyl fallout after 11 years, proofing that the origin of the contamination indeed was Chernobyl fallout and not a lost Cs-137 source.

The gravel road at Gävle /Avan covered by sweeping sand contaminated by Cs-137 from the Chernobyl fallout



Measured dose rates over the road, right here where the slope down begins.

What happened can be traced when measuring along the road and the roadside. At least a truckload of sweeping sand from Gävle must, in May 1986, have been tipped on the road where the down slope starts. Then a machine had pulled the sand along the road about as far as one can see in the picture. The amount of sand pulled along the road decreases towards the end of the road. The contaminated sand is unevenly distributed in patches along the road.

The measurement results from the road was communicated to the Gävle municipality administration. In the late summer of 1997 the findings were mentioned to the public in a radio program. After the program was broadcast, a person contacted the Gävle municipality and said that the he/she had got a truckload of sweeping sand in spring 1986. The sand had been laid on a patio at a summer cottage. A municipality officer contacted SSI to ask for control measurements and advice. Results from the measurements are shown in the next slide.

The place is located about ten kilometres southeast of Gavle.

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1

The most Cs-137 contaminated garden in Sweden?

Low dose rate close to the summer cottage

Dose rate 1.8 µSv/h just above the grass area, 0.5 µSv/h at 1 m.

0 - 3 cm grass 16 kBq/kg
3 - 4 cm soil 17 kBq/kg
4 - 10 cm sand 15 kBq/kg
~ 2 - 3 MBq/m^2

This was what we found:

Around the house the dose rate was low. No sand had been laid there. The sand had been placed on a patio next to the lake at some distance from the cottage. The deposited activity corresponded to 2-3 MBq/m^2.

SSI has not recommended any action at this location because the contaminated surface is small and the time a person will spend there is relatively short, although the site is used as a patio.

If the sand would have been spread around the house, then SSI would have recommended that it should have been removed and deposited in the landfill area.

This case shows that contaminated material can take unforeseen and unfamiliar ways to expose people.

Conclusions
City of Gävle 11 years after the fallout from Chernobyl

In the city centre, hardened areas were almost clean from Cs-137 deposition even if no measures to decontaminate had been made.

Around one-family houses with gardens, Cs-137 remained. Dose rates were 0.02 – 0.04 μSv/h in the streets and 0.04 – 0.08 μSv/h in the gardens, i.e. 40 – 80 per cent increase above the natural background.

Uncontrolled use of sweeping sand caused contamination of a road and a private garden up to 2 – 3 MBq/m^2, i.e. more than 10 – 20 times the fallout in the surroundings.

Several places were found to have uneven or high contamination (flooded areas, landfills with sewage sludge, ash, sweeping sand and surfaces affected by snow removal activities, etc)

Summary:

In 1997 the Swedish Radiation Protection Authority (SSI) performed mobile gamma spectrometry in the whole city of Gävle and parts of the surroundings. Hardened areas, such as asphalt covered streets in the centre of the city were found to be almost clean from caesium deposition, but areas with one-family houses with gardens were still contaminated, although the caesium had penetrated somewhat into the ground. Dose rates from radiocaesium in the streets in areas with one-family houses were typically in the order of 0.02 – 0.04 µSv/h and double this value above grass covered garden areas. The normal background in Gävle is in the order of 0.1 µSv/h, so the caesium fallout caused a 20 – 80 % increase above the natural background in the outdoor radiation level in these areas eleven years after the fallout. The increase in the outdoor radiation level in the centre of the city was only about 10 %. The mobile measurements also revealed unexpected patches of caesium contamination outside of the town. After investigation, this could be traced back to unauthorized use of non-slip sand swept from the streets in May 1986. In one private garden, a patch of non-slip sand was found containing caesium contamination in the order of 2 – 3 MBq/m2. This was more than ten times the maximum deposition density from direct fallout in the area.

Final conclusion:

The experiences from measurements of the radioactive fallout in Gävle shows that it is important to examine how the fallout occurs in the environment and to conduct studies of this for a long time because unexpected phenomena may occur which may lead to exposure of humans.

3.9 Radio cesium fixation process to soil analyzed by monitored radioactivity data of spinach in Fukushima

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† Presenter: juan-mantero.cabrera@gu.se

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2 Department of Radiation Physics. Institute of Clinical Sciences. Sahlgrenska Academy at University of Gothenburg, Gothenburg, Sweden

3 Centro Nacional de Aceleradores (CNA), Seville, Spain

This work shows the magnitude and temporal evolution of the radionuclide concentrations detected in the contaminated air masses with origin in the Fukushima accident at their arrival to Seville (Spain). In the collected aerosol filters and during about two weeks, were detected the presence of the following radionuclides: ^{134}Cs, ^{136}Cs, ^{137}Cs, ^{131}I and ^{132}Te (together with its short-lived daughter ^{132}I) at minute levels and with characteristics ^{134}Cs/^{137}Cs and ^{136}Cs/^{137}Cs isotope ratios. The associated ^{131}I fallout due to this episode was also roughly estimated from additional wet and dry deposition measurements, while the presence of ^{131}I in gaseous form was evaluated by collection with a pumping system equipped with a charcoal filter. All these results will be discussed together with the results produced at the same time by two more laboratories (Caceres and Barcelona) also belonging to the Spanish environmental monitoring network.

All samples were analyzed by low-level gamma-ray spectrometry using different types of hyper-pure germanium detectors: from P-type detectors with relative efficiencies of 30-40% and resolutions of 1.77-1.86 keV at 1.33 MeV of 60Co, to extended range (XtRa) or n-type germanium detectors with efficiencies of 37.8% and 25%, respectively. All detectors were shielded with 10 cm of old lead, and two of them were equipped with an anticoincidence device in order to increase their sensitivity. The Radiochemical and Radioactive Analysis Laboratory at the INTE, Barcelona, and the Environmental Radioactivity Laboratory of the University of Extremadura (LARUEX) at the Veterinary Faculty, Caceres, are accredited in accordance with the ISO 17025 Standard. The three laboratories have participated in several national and international intercomparison exercises involving the measurement of different environmental matrices by gamma-ray spectrometry with very satisfactory results.

Apart from air filter measurements, the presence of ^{131}I with origin in the Fukushima episode was detected in several key links in the human food chain: samples of milk (goat and cow) and derivative dairy products, as well as in various broadleaf plants. The maximum levels measured for this radionuclide were 1.11 Bq/L in samples of milk and 1.42 Bq/kg wet weight in broadleaf plants, with obviously negligible radiological implications.

Influence of the Fukushima Dai-ichi nuclear accident on Spanish environmental radioactivity levels

J. Mantero and R. García-Tenorio

CNA Centro Nacional de Aceleradores

Summary

- 1. The spanish environmental Monitoring Network
- 2. The accident
- 3. Systems at the University of Seville.
- 4. Methodology & Sampling
- 5. Results
- 6. Conclusions

1. The spanish environmental Monitoring Network

- This system consists of two different networks:

1) PVRA

Environmental monitoring network in the vicinity of nuclear power plants and facilities of the nuclear fuel cycle.

1. The spanish environmental Monitoring Network

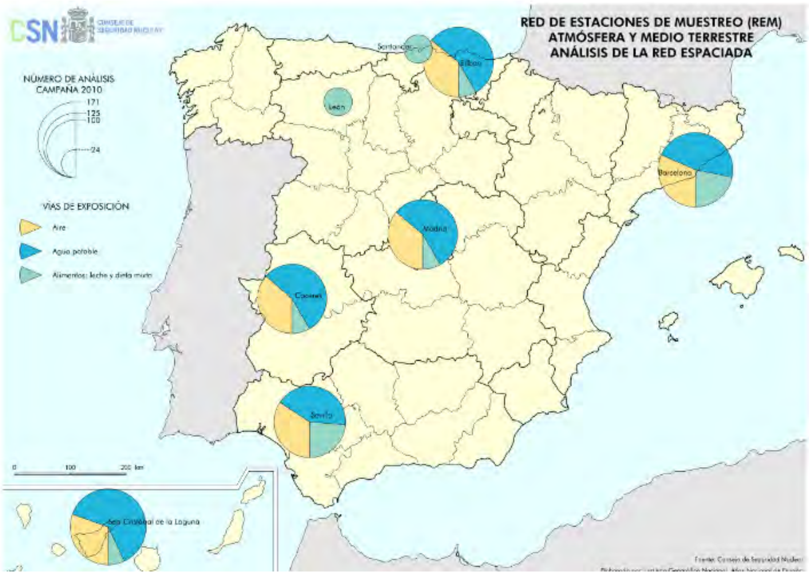
- 2) REVIRA: red densa

Environmental monitoring network nationwide not associated to radioactive facilities.

1. The spanish environmental Monitoring Network

- 2) REVIRA: red espaciada

Environmental monitoring network nationwide not associated to radioactive facilities.



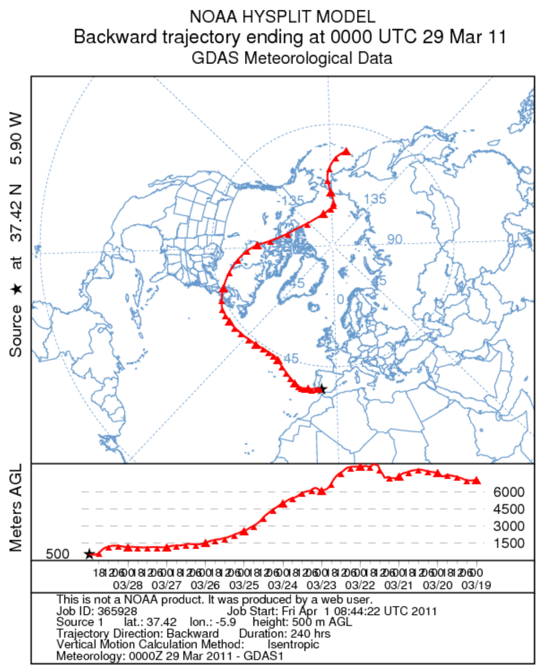
2. The accident

Earthquake+ Tsunami

Explosion of Unit 1 followed by another units and venting events during 5 more days

The cloud arrived to the Iberic Peninsula by 25-26 March

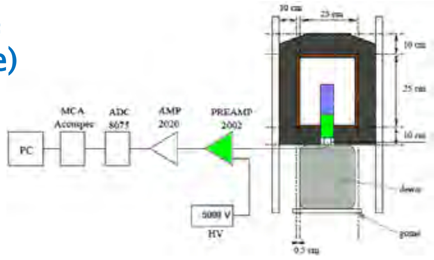
DISSEMINATION OF THE RELEASES OVER NOTHERN HEMISPHERE



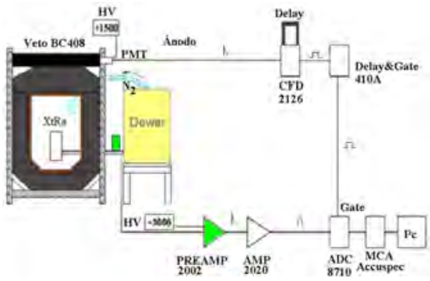
3. Systems at the University of Seville.

Measurement system used for γ-spectrometry

Reverse Electrode Germanium (REGe)



eXtended Range Germanium (XtRa)



	REGe	XtRa
Relative Efficiency	31,4%	37,1 %
FWHM (KeV) for 1332 KeV ^{60}Co	1,98	1,76
Ge volume (cm^3)	130	160

4. Methodology & Sampling

Air Samples collectors

High Volume system

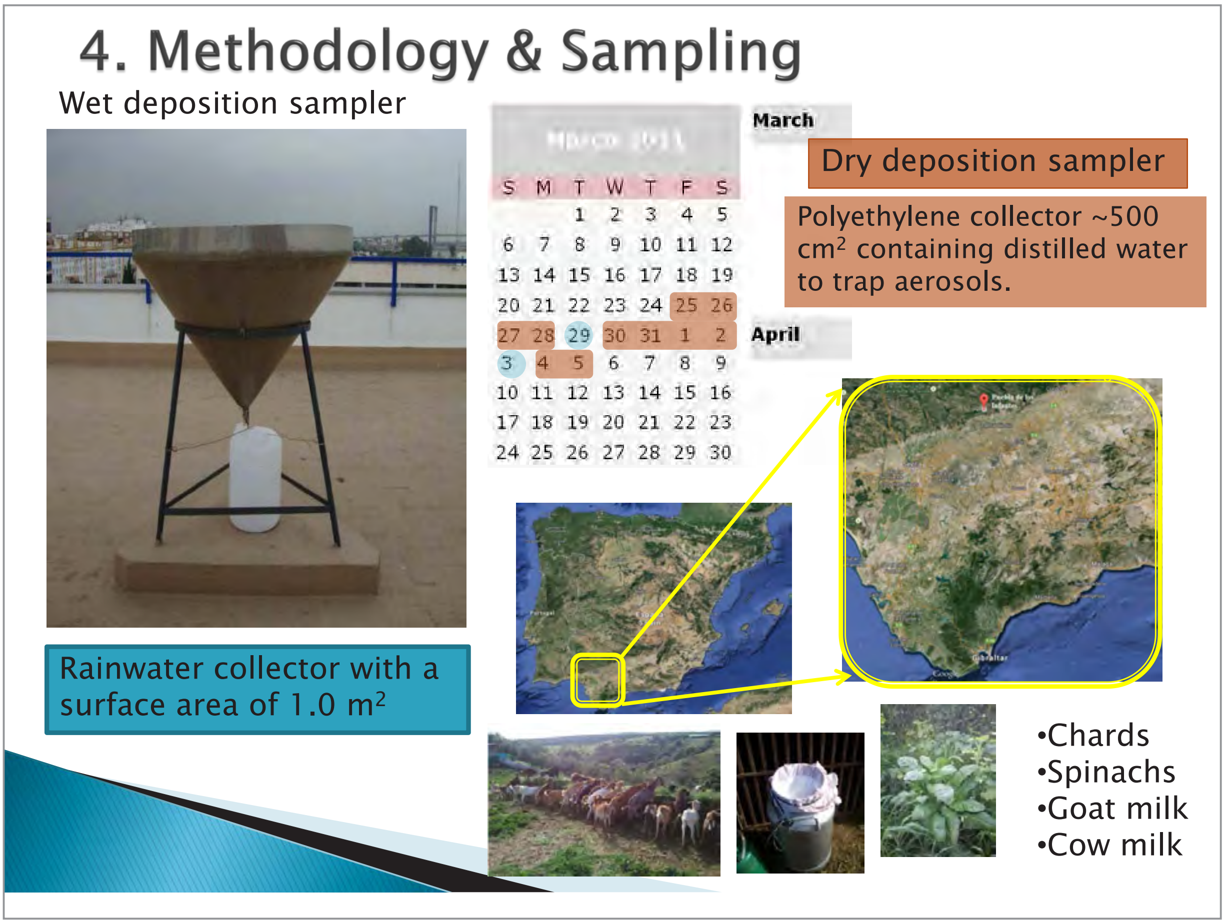
~ 75000-100000 m^3/week

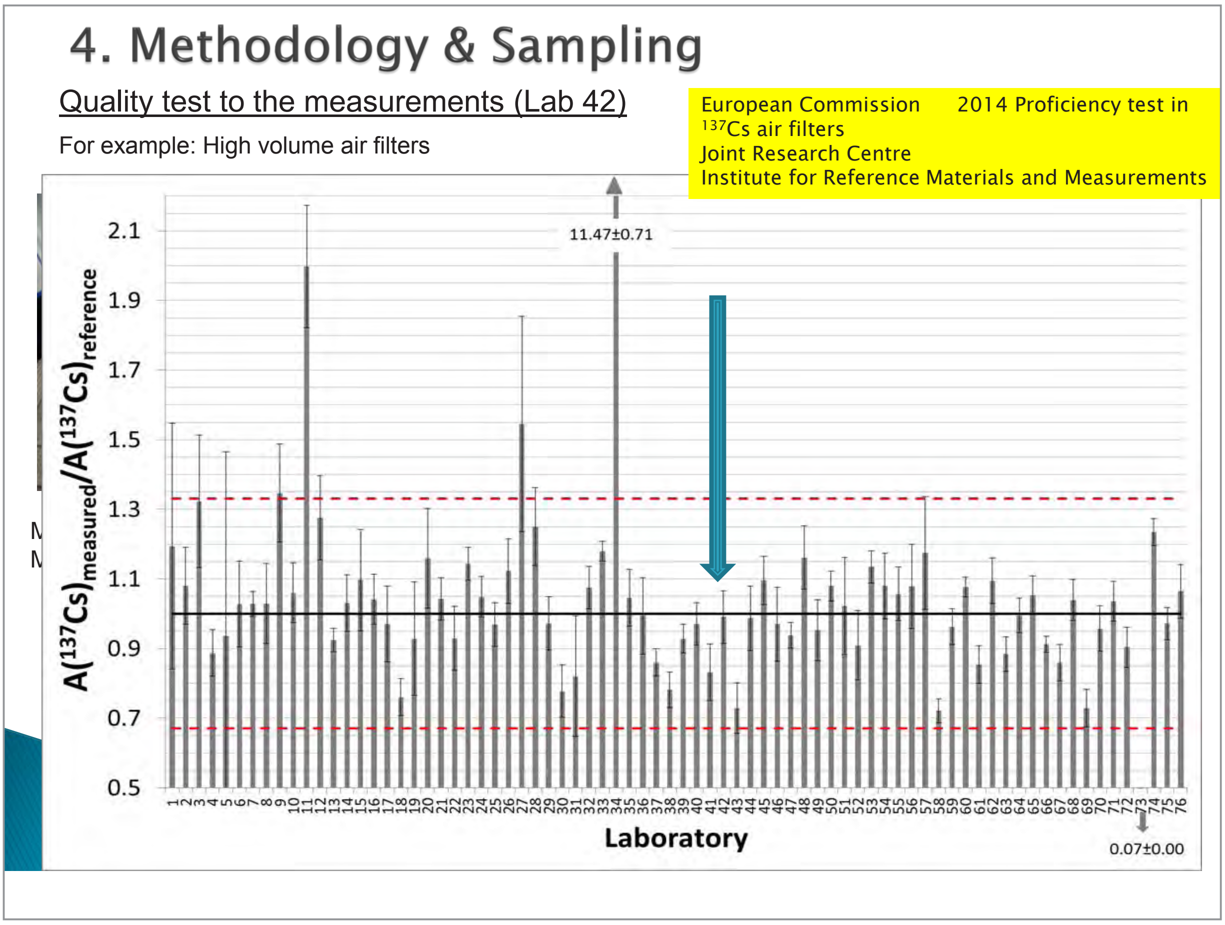
440 x440 mm polypropylene filters

Low Volume system

~ 200-250 m^3/week

•**aerosols** onto filters with a 19.6 cm^2 cellulose surface (0.8 μm, Millipore).
•**gases** as Iodine trapped in charcoal cartridges.


4. Methodology & Sampling
Wet deposition sampler
Rainwater collector with a surface area of 1.0 m²
March
April
S M T W T F S
Dry deposition sampler
Polyethylene collector ~500 cm² containing distilled water to trap aerosols.
•Chards
•Spinachs
•Goat milk
•Cow milk

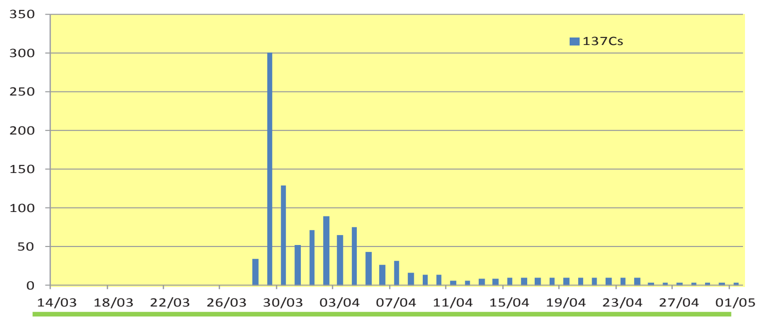

4. Methodology & Sampling
Quality test to the measurements (Lab 42)
For example: High volume air filters
European Commission 2014 Proficiency test in 137Cs air filters
Joint Research Centre
Institute for Reference Materials and Measurements
A(137Cs)measured/A(137Cs)reference
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
11.47±0.71
Laboratory
0.07±0.00

5. Results

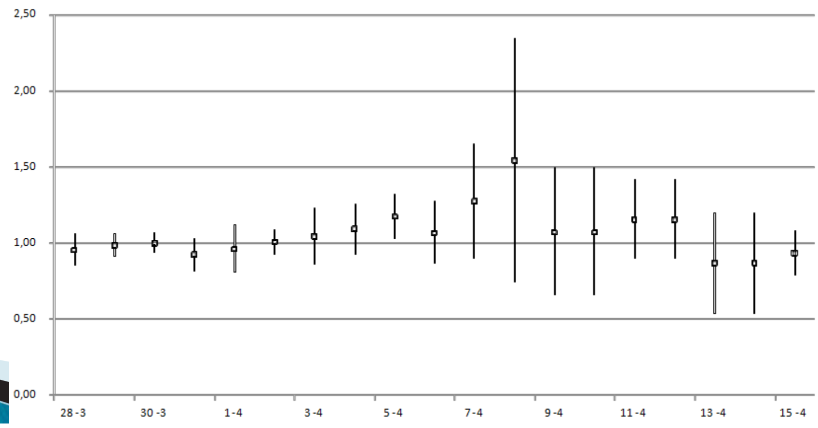
Cs isotopes in air filter samples from Sevilla

$^{136}Cs/^{137}Cs \leq 0.3$ according to Ro5 European Network

^{137}Cs activity concentration (μBq/m^3) in air samples



$^{134}Cs/^{137}Cs$ in air samples



5. Results

^{131}I (particulate) in air filter samples in Sevilla

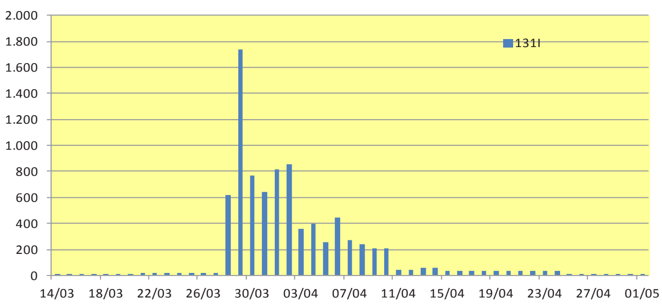
^{131}I (gas) in air filter samples

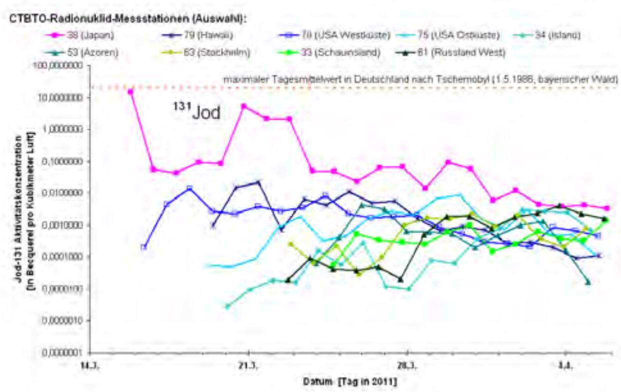
Date Start Sampling	Collection time	Volume (m^3)	^{131}I gas (μBq/m^3)
10:00 14 March	7 days	250	N.D.
10:00 21 March	7 days	245	2000 ± 185
10:00 28 March	3 days	114	8310 ± 660
10:00 31 March	4 days	156	4590 ± 380
10:00 4 April	4 days	148	N.D.
10:00 8 April	5 days	182	N.D.

AMD~0.5 mBq/m^3

$^{131}I(gas)/^{131}I$ (total) rose from 0.75 to 0.9

^{131}I activity concentration (μBq/m^3) in air samples





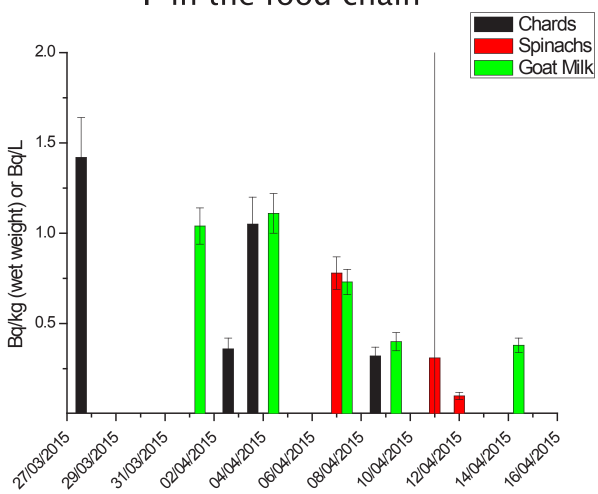
5. Results

^{131}I Fall out

Wet-fallout		
Station	**Date**	**^{131}I (Bq/m^2)**
Sevilla	29 March	3.30 ± 0.27
Sevilla	3 April	3.65 ± 0,38
Village-60 km	3 April	2.97 ± 0.27
Dry-fallout		
Station	**Date**	**^{131}I (Bq/m^2)**
Sevilla	26-28 March	< 3.0
Sevilla	28-29 March	< 2.6
Sevilla	30- 1 April	< 1.4
Sevilla	1-3 April	<1.8

Less than 20Bq/m^2

^{131}I in the food chain



5. Results

Comparison Cáceres-Barcelona-Sevilla

Maximum values measured in aerosol filters at each station for the considered radioisotopes.

Station	Sampling period of maximum concentration	Isotope	Maximum concentration (μBq m^{-3})	Uncertainty (k = 1)
Caceres	28th–29th April	I-131	3080	250
		Cs-137	690	60
		Cs-136	41	22
		Cs-134	620	50
	27th–28th April	Te-132	330	110
Seville	28th–29th April	I-131	1740	40
		Cs-137	300	18
		Cs-136	34	4
		Cs-134	296	11
		Te-132	240	17
Barcelona	28th–30th April	I-131	391	6
	1st–4th April	Cs-137	49	2
	1st–4th April	Cs-136	Not detected	
		Cs-134	54	4
	30th March–1st April	Te-132	13	3

6. Conclusions

- Detectable levels of some of the anthropogenic gamma-emitters (^{131}I, ^{137}Cs, ^{134}Cs, ^{136}Cs and ^{132}Te) originating from the Fukushima accident were measured in the troposphere over Spain.
- The characteristic activity ratios encountered for the contaminated plume which reached Spain are a ^{134}Cs/^{137}Cs close to unity, while the ^{131}Igaseous/ ^{131}I particulate ratio was greater than unity.
- The highest volumetric activity concentrations in aerosols were observed for ^{131}I (maximum concentrations of the order of mBq/ m^3), where ^{137}Cs and ^{134}Cs concentrations were at least one order of magnitude lower.
- Consequently, the associated fallout had negligible radiological consequences in Spain.
- The only radionuclide detected in key components of the trophic chain (vegetables, milk) was ^{131}I at levels several orders of magnitude lower than the maximum permitted levels of radioactive contamination of foodstuffs and feedstuffs following a nuclear accident in Europe.

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Influence of the Fukushima Dai-ichi nuclear accident on Spanish environmental radioactivity levels

A. Baeza [a,*], J.A. Corbacho [a], A. Rodríguez [a], J. Galván [b], R. García-Tenorio [b], G. Manjón [b], J. Mantero [b], I. Vioque [b], D. Arnold [c], C. Grossi [c], I. Serrano [c], I. Vallés [c], A. Vargas [c]

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3.10 Radioecology competence needs at radiation accidents – the case of the Chernobyl accident management in Sweden

Gunnar Bengtsson
Presenter: gunnarbengt@telia.com
Former Director General of SSI (Swedish Radiation Protection Institute)

Radioecology competence needs at radiation accidents – the case of the Chernobyl accident management in Sweden

Gunnar Bengtsson, PhD

Presentation at

Joint Japan Sweden Radioecology Workshop

University of Gothenburg Department of Radiation Physics

September 1-2, 2015

Who will pay for never used competence?

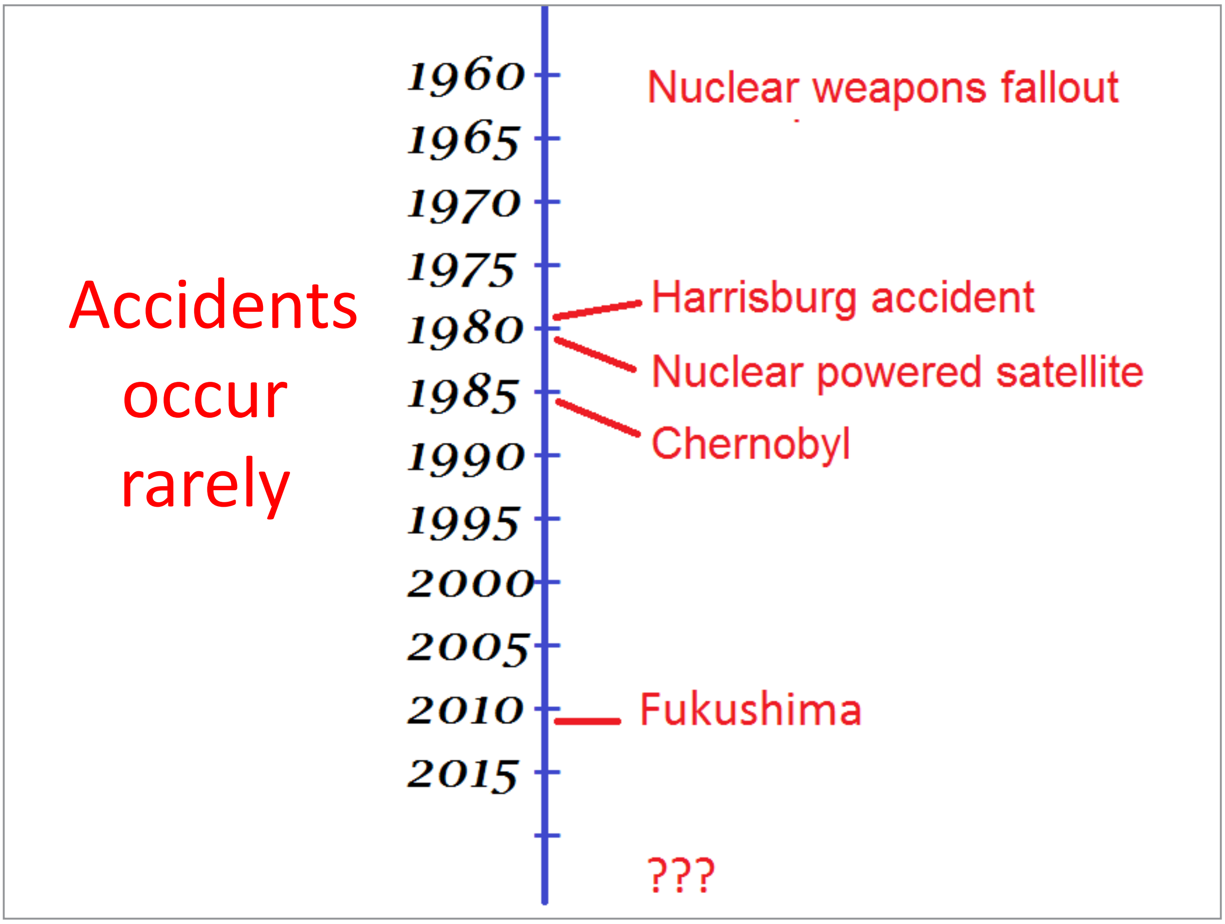
- Authority tasks at the Chernobyl accident
- Rare recurrence of radiation accidents
- Authority competence needs
- Meeting the needs - ideally
- The second best approach
- Summing up

Swedish radiation protection authority 29 years ago April-May 1986

Pandemonium (all devils loose..)

- 100 000 phone calls in a week
- Daily press conferences
- All at once
  – Coordinate 700 persons across the country
  – Assess risks today and after a year
  – Provide bases for decisions to government, authorities, businesses and the public
  – Initiate long term evaluation

Provide guidance for politicians



Competence that is rarely used

Example of a research environment

- Formation of an organisation
- Use over a couple of decades
- Reorganisation or replacement to meet tasks that are more on the current agenda
- Researchers move to other job or areas of interest, or retire

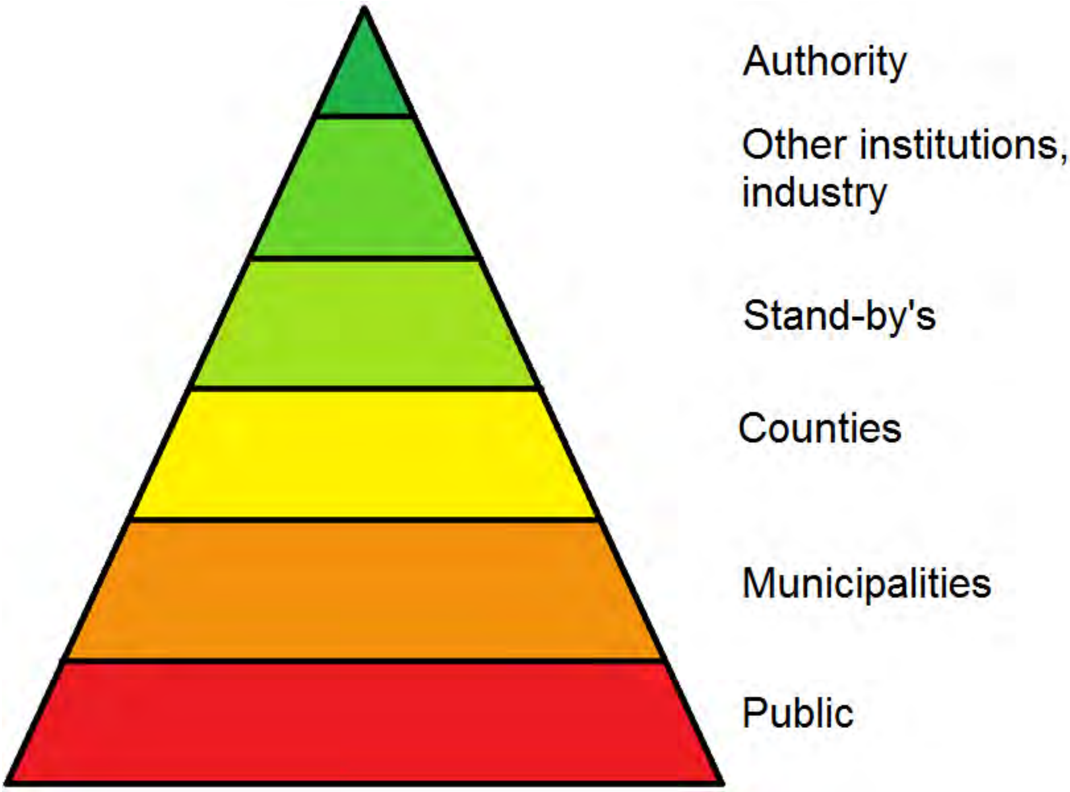
Main competence: dangerous or not?

Authority competence needs

People with knowledge who can

- Cooperate very broadly
- Dialogue with authority on risk assessment and projections
- Quickly be available for action and act
- Use their international network
- Discuss with media and the public to increase credibility of authority communication

Options for providing competence



Meeting the needs
Ideal

- Environments where knowledge can develop
- People who can contribute in crisis
- …. and practise inbetween

Million dollar question

Who will pay for something that is hardly ever used?

Supporting the authority

Second best

- Critical mass at institution with appropriate competence, that can be made available
- Synergi with other emergency preparedness
- Stand-by's: left the field but could be reassigned
- Apps for knowledge, e g becquerel budgets
- Networks with interested parties, e g civil defence, social media
- Plans for quick training of broader groups
- ….

Summary

- Unreasonable expectations on authority
- Decades between needs
- Define and prioritize tasks and maintain minimal competence
- Prepare to support competence further down the competence pyramid

3.11 Application of the in-growth core method to investigate caesium absorption in tree roots in a northern forest in Fukushima

Osamu Hashimoto†, [1]

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Significant quantities of radioactive caesium (^{137}Cs) were deposited in forests after the Fukushima Dai-ichi nuclear power plant disaster of March 2011. To measure the translocation of ^{137}Cs from soil to tree roots, we applied the in-growth core method generally used to measure the biomass of roots, and examined the efficiency of this process. The study area was a Japanese cedar plantation in Date city, Fukushima Prefecture. The in-growth core method was applied to two different types of soils, one containing ^{137}Cs ($^{+}$Cs) and the other with no ^{137}Cs ($^{-}$Cs). Ten cylindrical cores 5 cm in diameter were buried in the forest floor containing $^{+}$Cs or $^{-}$Cs soils with no roots for a period of 1 yr (12 June 2013–11 June 2014). On 11 June 2014, the fine roots were separated from the soils at 0–3 cm, 3–10 cm, and 10–20 cm to measure radioactivity. At each depth, there were significant differences in the average soil ^{137}Cs concentrations between $^{+}$Cs and $^{-}$Cs. The average ^{137}Cs concentration of the $^{+}$Cs soil was at least three-fold higher than that of $^{-}$Cs. There was a positive correlation between the ^{137}Cs concentrations of the soils and that of tree roots (Figure 1). Our results indicate that the tree roots absorbed ^{137}Cs mainly from the soil and that if the soil ^{137}Cs concentrations had been controlled, this would have reduced the ^{137}Cs in the tree roots.

Keywords: Radiocaesium; tree roots; Fukushima Daiichi nuclear power plant accident; in-growth core method

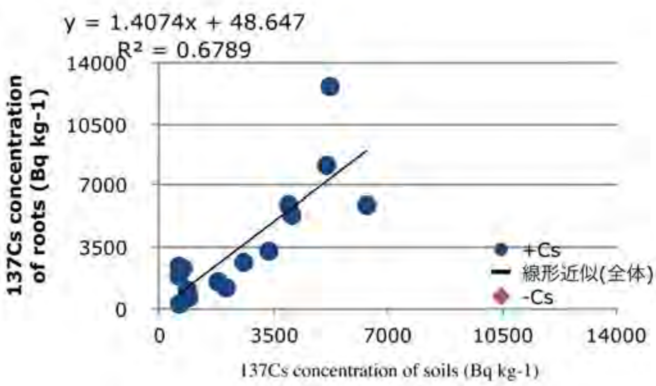
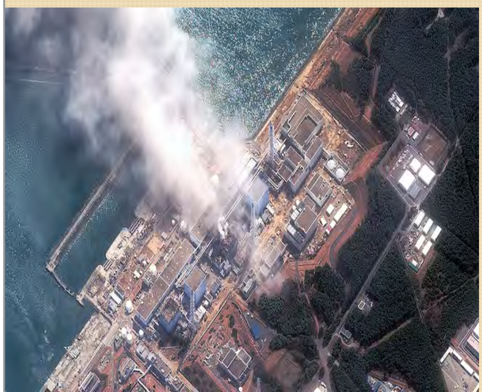


Fig. 1 Relationship between ^{137}Cs concentrations of soils and tree roots

Application of the in-growth core method: understanding cesium absorption through tree roots in Fukushima forest

University of Tokyo
Osamu Hashimoto

The accident of Fukushima dai-ichi nuclear power plant



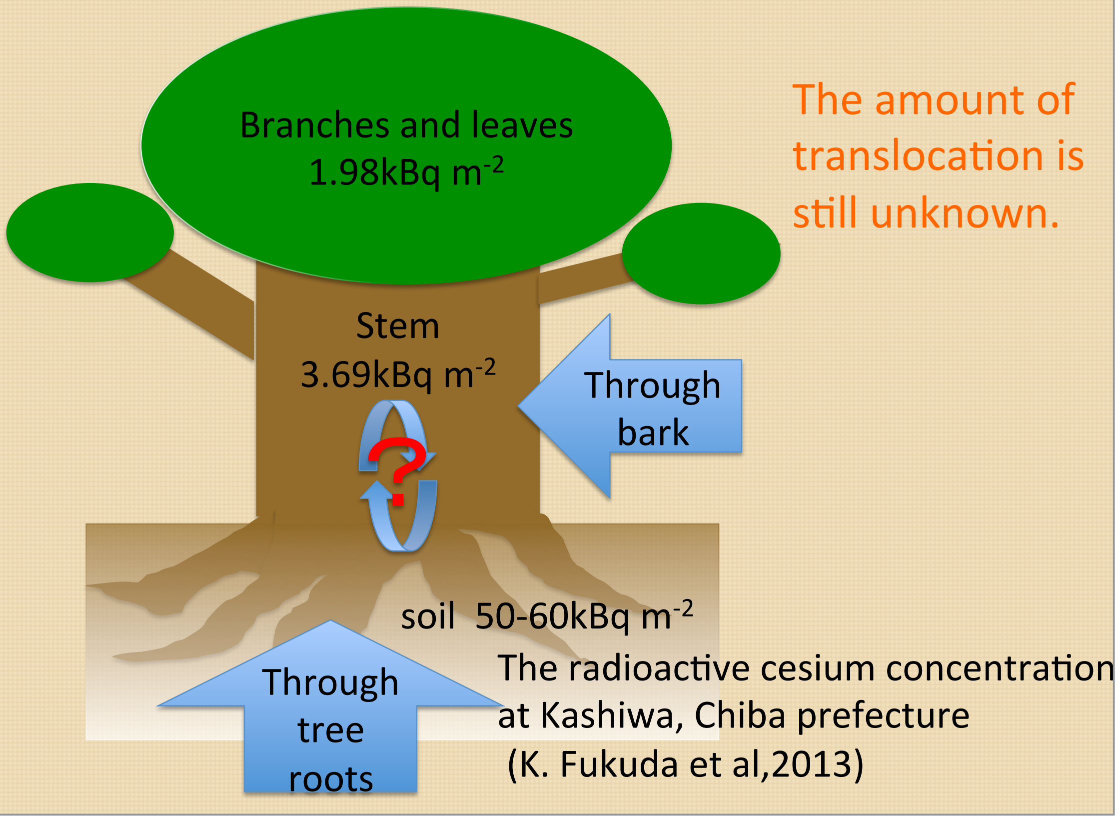
Occurred in 11, March 2011

Released radioactive materials
Noble gas 500PBq
Radioactive Cesium(^{134}Cs, ^{137}Cs) 20PBq
Radioactive Iodine 500PBq
(PBq=10^{15}Bq)(TEPCO 2012)

Forest covered 71% of polluted land area(Ohta, 2011)

Half-life
^{131}I 8.1 days
^{134}Cs 2.06 years
^{137}Cs 30.2 years

Two pathways of Cs absorption

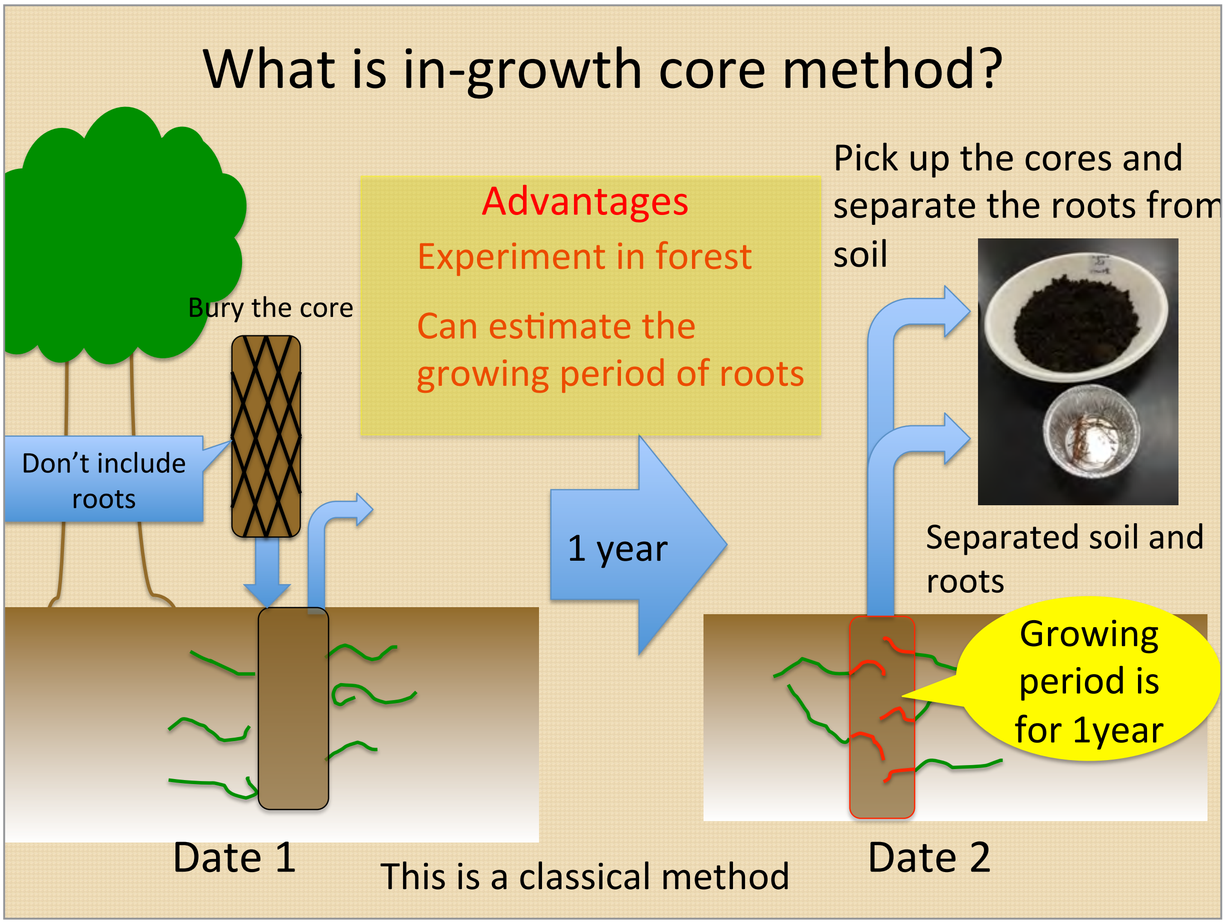


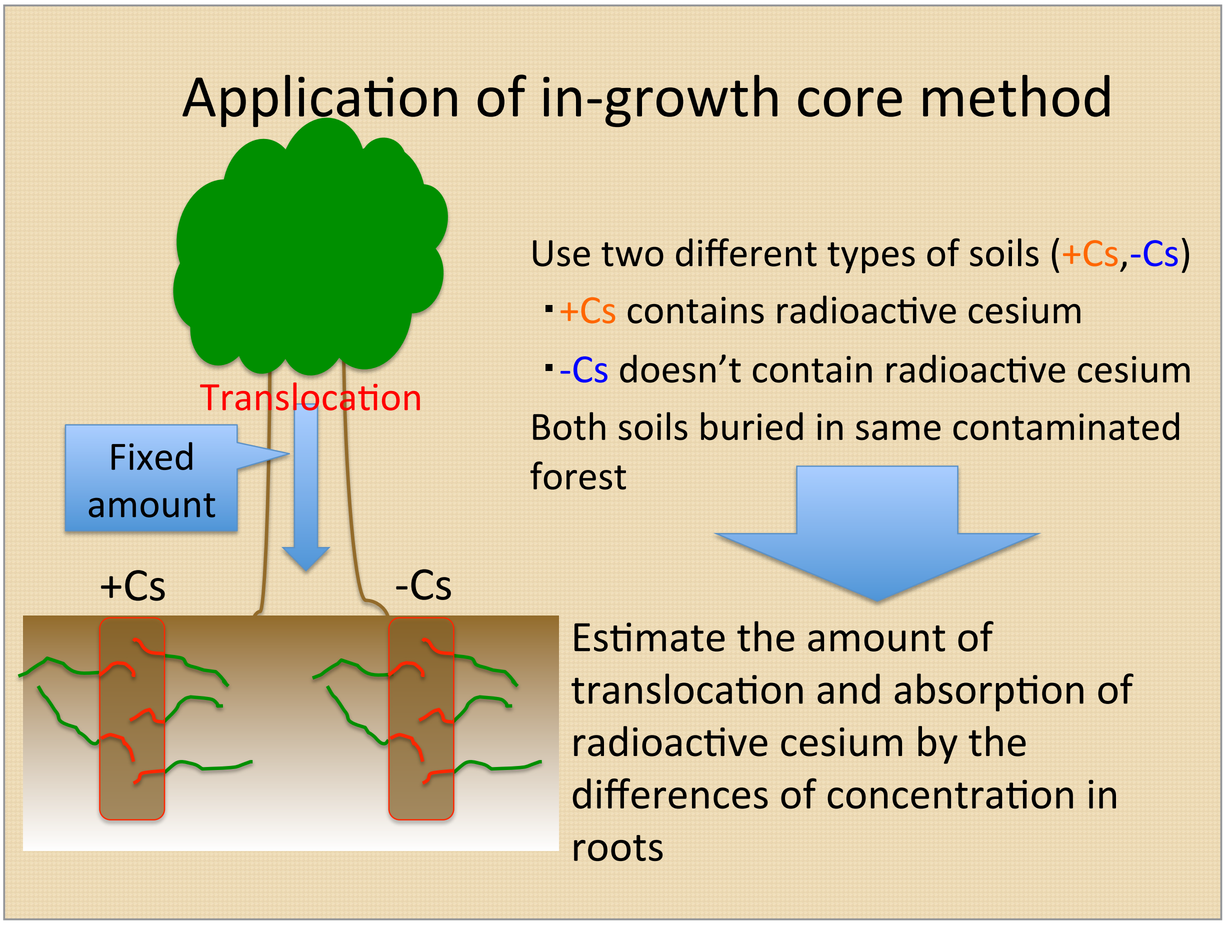
Barriers of research techniques in root studies

- Difficulty in observing temporal change of accumulation in root.
- Difficulty in estimating growing period.
- Difficulty in tracing an individual after sampling.

Studies on the relationship of roots in forest and radioactive Cs are limited.

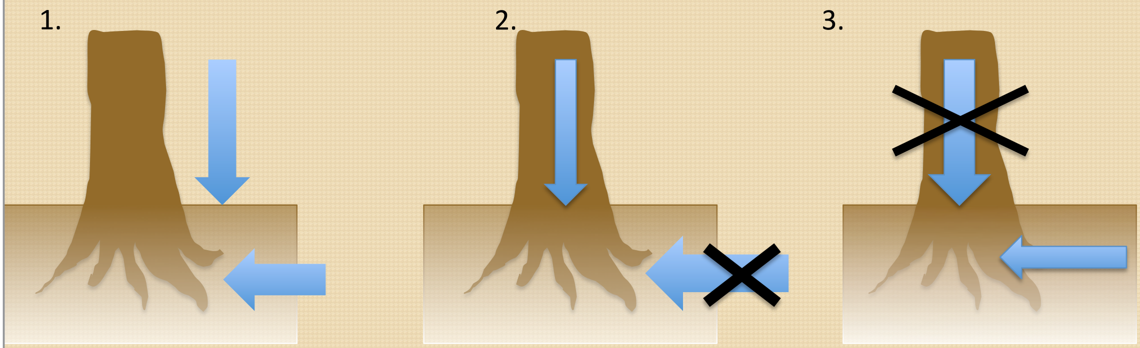
To investigate the relationship of radioactive Cs and roots in forest, the method to solve these difficulty is needed.


What is in-growth core method?
Advantages
Experiment in forest
Can estimate the growing period of roots
Pick up the cores and separate the roots from soil
Bury the core
Don't include roots
1 year
Separated soil and roots
Growing period is for 1year
Date 1
This is a classical method
Date 2

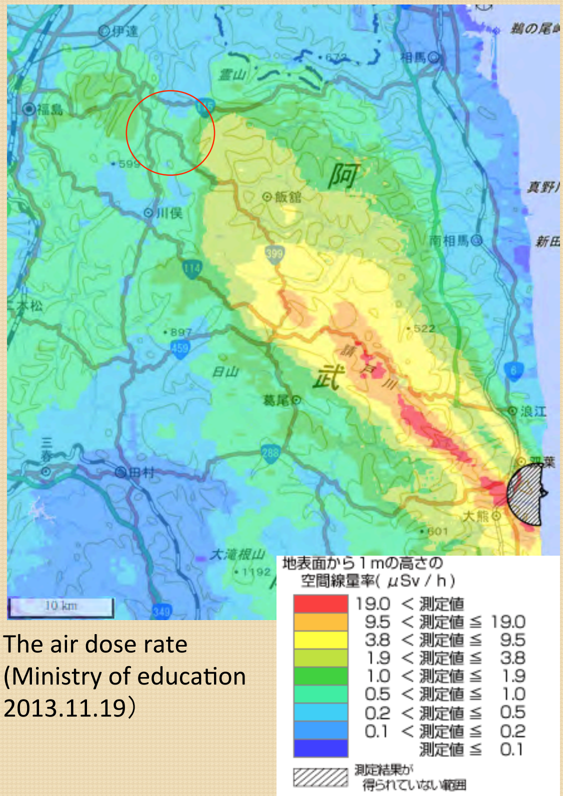

Application of in-growth core method
Use two different types of soils (+Cs,-Cs)
・+Cs contains radioactive cesium
・-Cs doesn't contain radioactive cesium
Both soils buried in same contaminated forest
Translocation
Fixed amount
+Cs
-Cs
Estimate the amount of translocation and absorption of radioactive cesium by the differences of concentration in roots

Hypothesis

	+Cs	−Cs		Absorption	Translocation
Hypothesis 1	++	+	→	Yes	Yes
Hypothesis 2	+	+	→	No	Yes
Hypothesis 3	+	-	→	Yes	No



Study site



The air dose rate
(Ministry of education
2013.11.19)

Study site： Upper part of the Kami-Oguni River headwater catchment.

50km northwest of FDNPP.

Elevation: 350m

Vegetation：Cedar plantation

Age: About 50 years

DBH: Around 25cm

Height: Around 30m

Stand density: 2100/ha

Method soils and mesh bags

Soils

+Cs: Collected from study site(Day of collection : 2013.6.12)

-Cs: Collected from cedar plantation in Nantan city, Kyoto prefecture(500km southwest)

Mesh bag

Length: 20cm Diameter: 5cm mesh size: 4mm

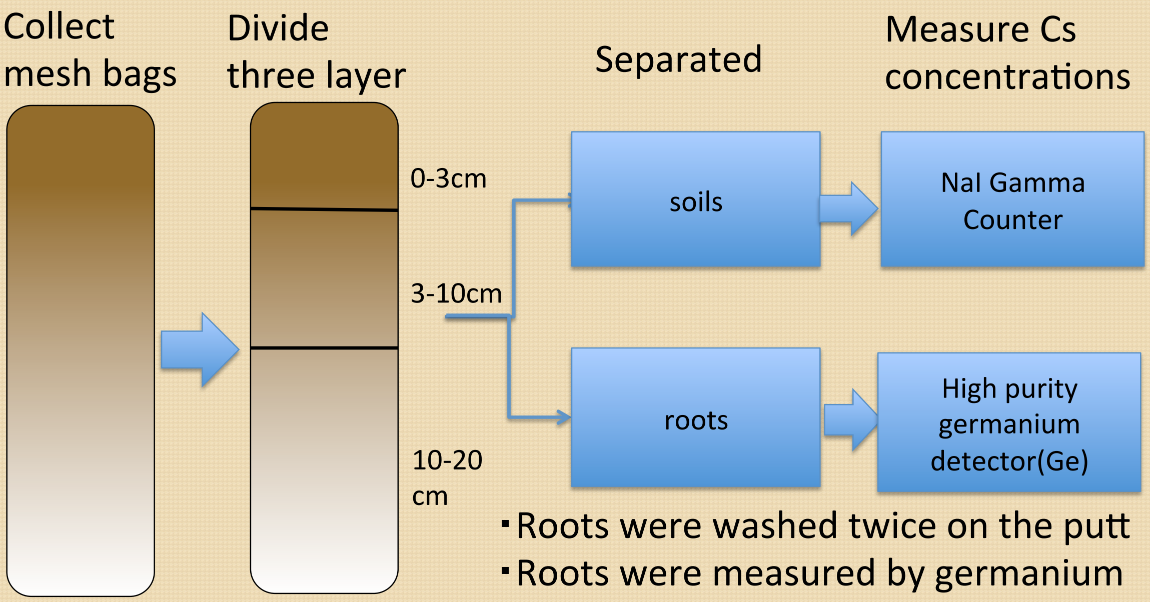

(picture) Mesh bag

10 mesh bags were buried for each soils.

Buried period : 12 June ~ 11 June 2014

Soils for +Cs and -Cs were collected separately at 0-10cm and 10-20cm in depth, then buried at the same depth.

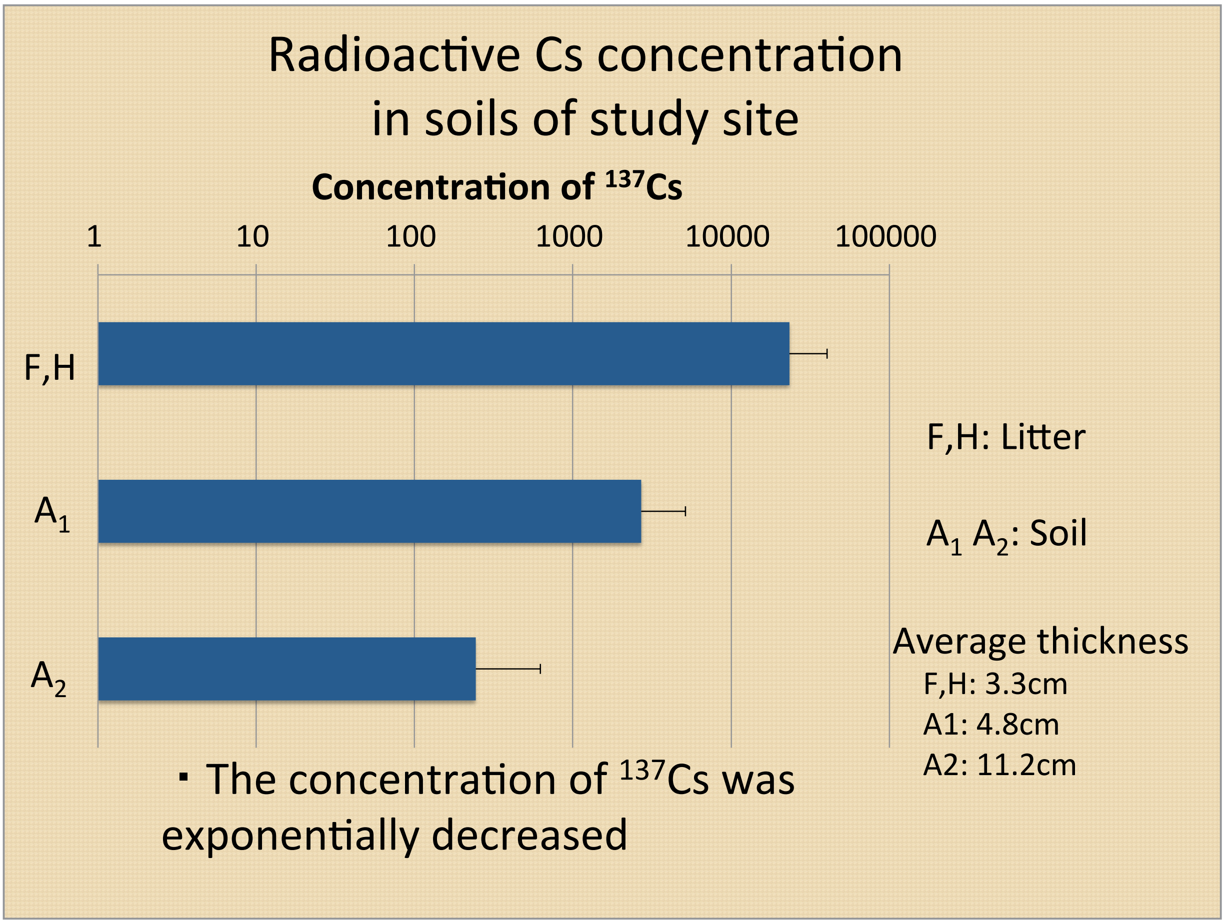
Measurement of Cs concentrations

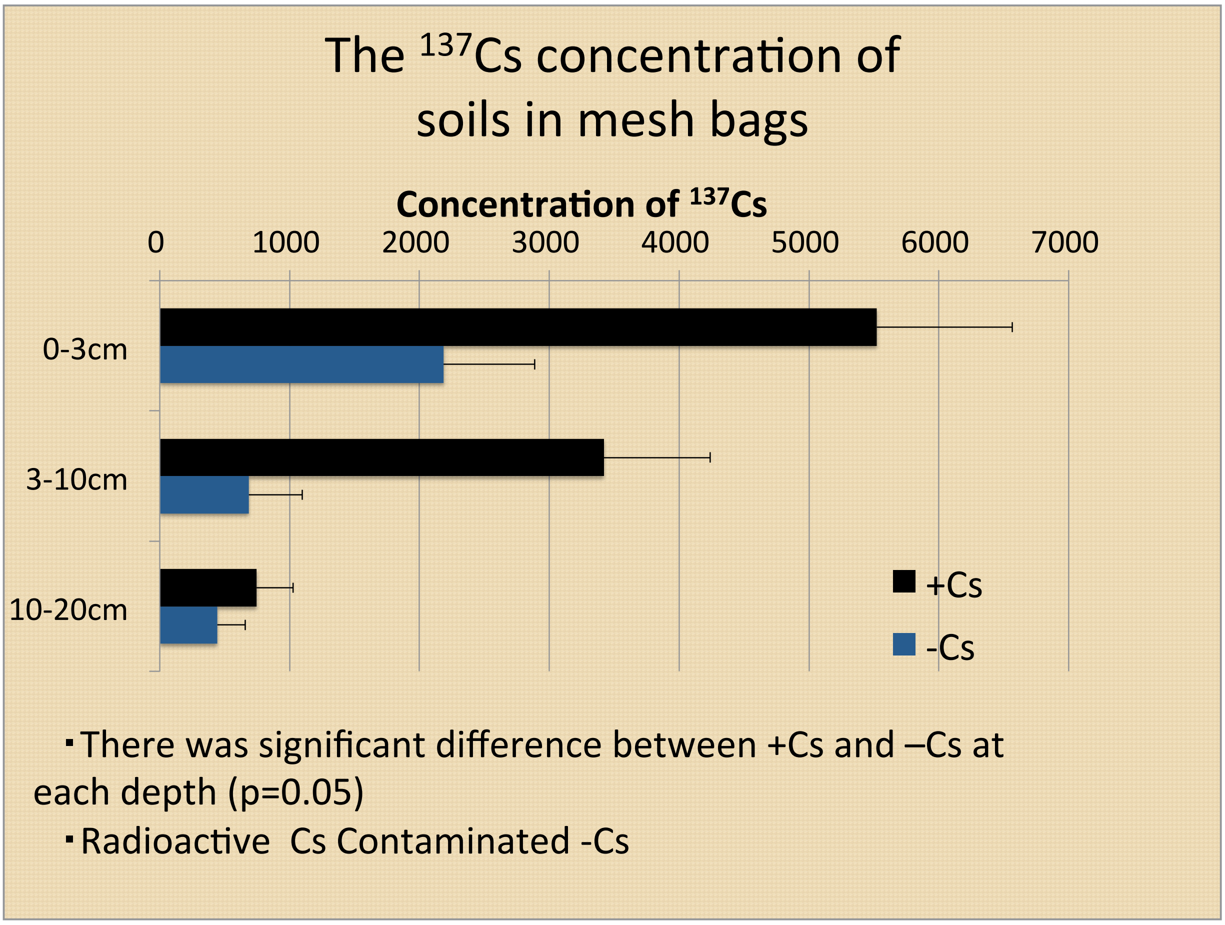


・Roots were washed twice on the putt

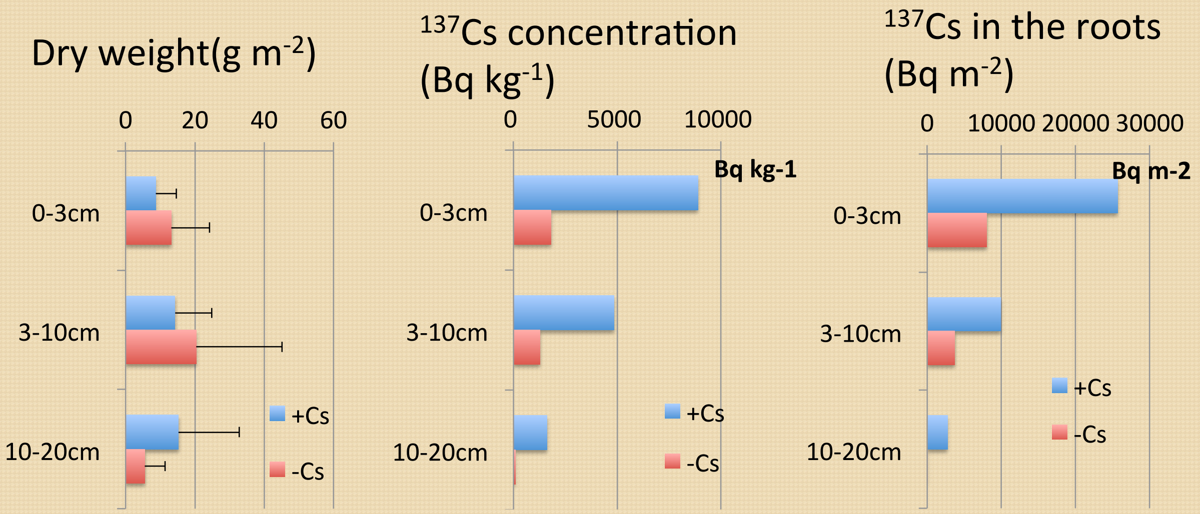
・Roots were measured by germanium detector

Soils were measured by NaI Gamma Counter


Radioactive Cs concentration in soils of study site
Concentration of 137Cs
1
10
100
1000
10000
100000
F,H
A1
A2
F,H: Litter
A1 A2: Soil
Average thickness
F,H: 3.3cm
A1: 4.8cm
A2: 11.2cm
・The concentration of 137Cs was exponentially decreased

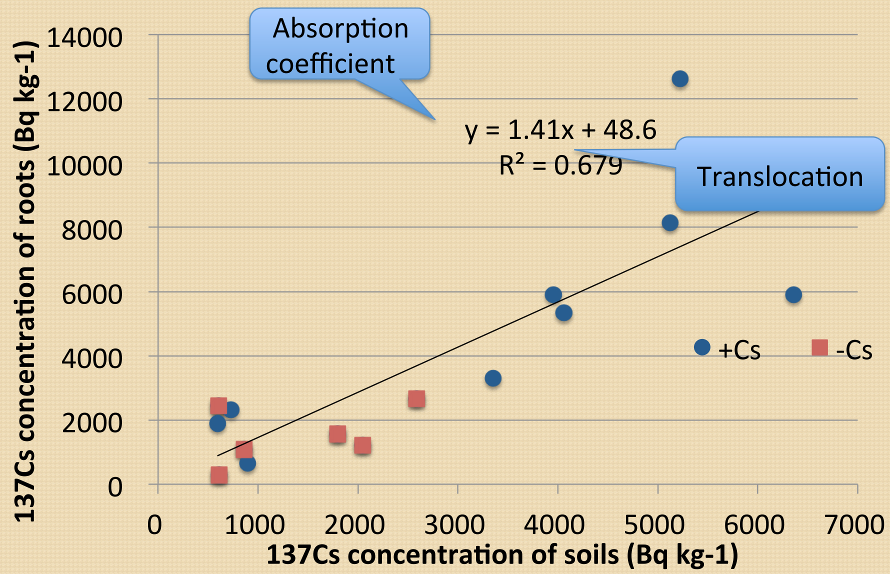

The 137Cs concentration of soils in mesh bags
Concentration of 137Cs
0
1000
2000
3000
4000
5000
6000
7000
0-3cm
3-10cm
10-20cm
+Cs
-Cs
・There was significant difference between +Cs and –Cs at each depth (p=0.05)
・Radioactive Cs Contaminated -Cs

Roots in mesh bags



- Detected about ^{137}Cs
- Ten mesh bags were summarized in one at 10-20cm of –Cs
- Ten mesh bags were summarized in three at others
- The amount of +Cs' ^{137}Cs 2 to 20 times than –Cs'

Relationship of soils and roots



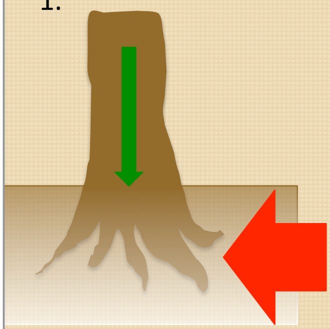
- Relationship between soils and roots was proportional
- There was a high correlation between roots and soils
- The ^{137}Cs concentration of roots were more than the ^{137}Cs concentration of soils

Cs accumulation path to tree root

	+Cs	−Cs		Absorption	Translocation
Hypothesis 1	++	+	→	yes	yes

Absorption > Translocation

1.



・Roots emerged in '-Cs' were contaminated by Cs

・The amount of absorption was much larger than the amount of translocation

Summary

Applying the in-growth core method was supposed to have revealed the findings below:

・Relationship between soils and roots was proportional

→There was a high correlation about Cs between roots and soils

・The amount of absorption were much larger than the amount of translocation

→The accumulation pathway was mainly absorption

3.12 Spatiotemporal variation of radiocaesium on the forestfloor in mixed deciduous forests in Fukushima, Japan

Momo Takada†,[1], Toshihiro Yamada[1], Toshinori Okuda[1]

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Radioactive fallout from the Fukushima nuclear power plant accident remains in the neighbouring forests, where large amounts of radiocaesium were deposited on the forest floor. To understand the dynamics of radiocaesium within a forest community and its outflow from the forest to other ecosystems, the spatiotemporal variation of radiocaesium on the forest floors needs to be clarified. This study examined the spatial distribution of radiocaesium on a forest floor and the downward migration of radiocaesium in the forest soil. Field surveys were conducted in Fukushima Prefecture from July 2013 to November 2014. Study sites were placed in six mixed deciduous forests dominated by Quercus crispula and Abies firma. There was marked spatial heterogeneity of the radiocaesium distribution on the forest floor. The activity of radiocaesium in the soil decreased with increasing distance from trees, while it increased with tree size around the bases of deciduous broadleaf trees. This pattern is thought to be affected by throughfall and stemflow containing radiocaesium. Radiocaesium migration from the litter layer to the soil layer was observed. During our study, the activity of radiocaesium in the litter layer decreased by 90%, while the activity in the soil layer increased. At all study sites, the migration rates from the litter layer to the soil layer were much larger than those within the soil layer, suggesting that most radiocaesium persists near the soil surface.

Keywords: Spatial heterogeneity, vertical distribution, radiocaesium migration

3.13 Predicting the future radiocesium distribution in Fukushima from the distribution of global fallout in forested areas in Japan

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Forests are thought to retain ^{137}Cs for long periods. Whether this is true for ^{137}Cs fallout in forest areas from the accident at Fukushima Dai-ichi nuclear power plant (FDNPP) is an issue of major concern for the people of Fukushima and its surrounding areas. To answer this question, we investigated soil samples that had been systematically collected from 316 forest sites in Japan just before the accident, These samples contained a signal from the global 137Cs fallout (^{137}Cs-GFO) derived from above ground nuclear weapons tests during the 1950s and 60s. The radioactivity levels due to ^{137}Cs-GFO in the three layers of soil samples (0–5, 5–15 and 15–30 cm in depth) at each site were measured. The 316 sampling sites throughout Japan were divided into 10 areas, and the effects of rainfall and geomorphology on ^{137}Cs-GFO inventories were tested. In addition to the analysis of ^{137}Cs-GFO, the behaviour of ^{137}Cs emitted from FDNPP (^{137}Cs-Fk) within a whole tree was examined to determine the effects of biological processes on ^{137}Cs transport from trees to soils. The radioactivity due to ^{137}Cs-Fk in the above- and below-ground parts of three 26 year-old Quercus serrata trees and the associated soils in a contaminated area of Fukushima was determined.

The average ^{137}Cs-GFO inventory of forest soils in Japan was 1.7 kBq m–2 as of 2008. Reported ^{137}Cs-GFO inventories vary substantially (0–7.9 kBq m–2) across the country. There is a large accumulation of ^{137}Cs-GFO in the north-western part of the country, facing the Sea of Japan. Winter rainfall has influenced this high accumulation of ^{137}Cs-GFO. The vertical distribution of ^{137}Cs-GFO indicates that 44% of ^{137}Cs-GFO has remained within the top 5 cm of the soil profiles, whereas the remaining 56% was found in layers at depths of 5–30 cm, indicating that a considerable downward migration of ^{137}Cs-GFO has occurred in forest soils in the past fifty years in Japan. However, multiple linear regression analysis of geomorphological factors related to soil erosion, such as the inclination angle or catchment area calculated from a Digital Elevation Model, revealed almost no significant effects on the distribution of ^{137}Cs-GFO.

The radioactivity due to ^{137}Cs-Fk in the fine roots collected from the 0–10 cm layer was 1600–2400 Bq/kg, which was comparable to the levels in one-year old branches (1400–2200 Bq/kg). The radioactivity in the fine roots was seven times higher than in the soil of the 50–100 cm layer (220–350 Bq/kg). This difference in the radioactivity of the fine roots among the soil layers was remarkably small when compared with the difference of 1000 times or more in the radioactivity of the soil in the same layers (one outlier sample in the 40–60 cm layer was excluded). The findings indicated that ^{137}Cs-Fk had circulated throughout the whole tree within three years of the accident. Considering that root litter was retained inside the soil, we estimated that 137Cs contamination on the above-ground parts of trees could be transported to soils through the roots.

Most of the ^{137}Cs-GFO deposited fifty years ago has remained in the sites where it was deposited and has gradually migrated downward in the soil. There are two possible major driving forces that could explain the downward migration of ^{137}Cs-GFO. One is the migration of ^{137}Cs associated with vertical water movement and the other is the transportation of ^{137}Cs by root litter or root exudates. Further research is required to analyse these processes and obtain reliable predictions of the future distribution of ^{137}Cs-Fk.

Keywords: Radioactive contamination, Fukushima Dai-ichi nuclear power plant, forest soil, trees, secondary migration

Workshop in Sweden
2-Sep-2015

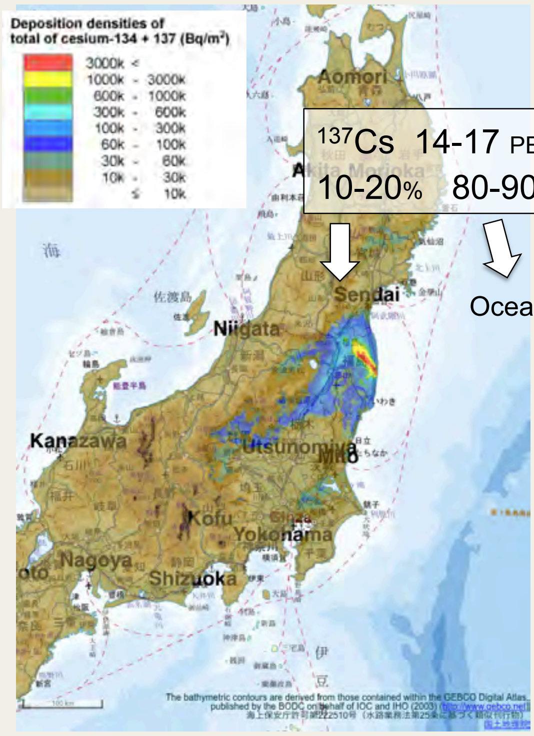
Predicting the future radiocesium distribution in Fukushima from the global fallout distribution in forest area in Japan

Satoru Miura
University of Tokyo

1

Background

As of May 31, 2012

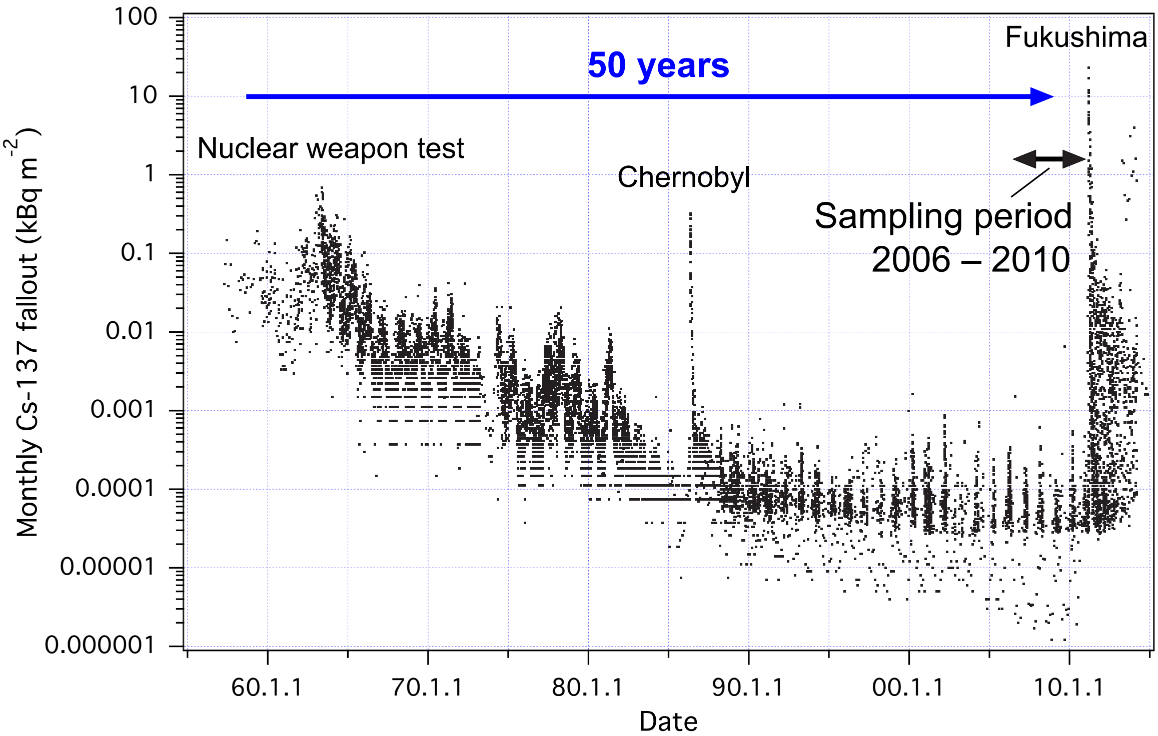


^{137}Cs 14-17 PBq
10-20% 80-90%
Ocean

- Fallout in forests – people concern the whereabouts.
- Japan – tectonic active, steep land, high precipitation.
- ^{137}Cs emitted by nuclear weapon test (global fallout) – a tracer of soil erosion.

2

Monthly fallout of ^{137}Cs in Japan, 1957-2014



Created from data of Environmental radiation database (Nuclear Regulation Authority. http://search.kankyo-hoshano.go.jp/servlet/search.top)

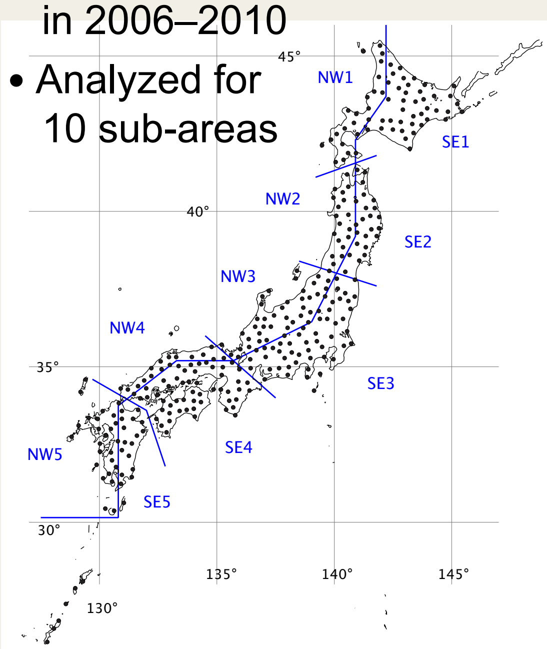
Objectives

1. A nationwide distribution of global fallout (^{137}Cs-GFO) 50 years after deposition.
2. What is the major process for the secondary migration?

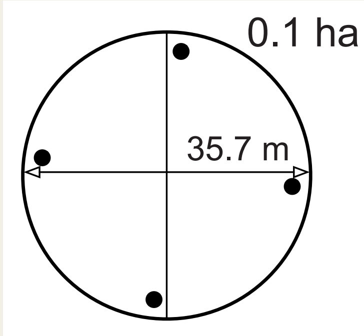
4

Materials and method

- 316 sites – 1 site / 800 km^2 in 2006–2010
- Analyzed for 10 sub-areas

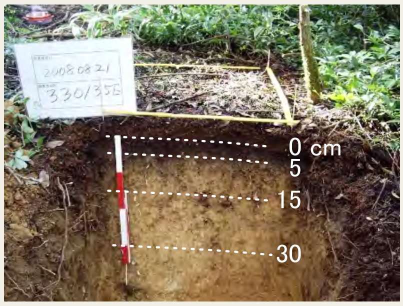


- 4 sub-plots per site



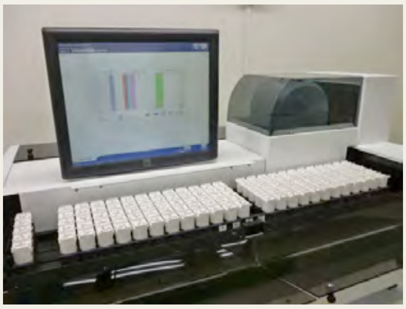
- Mineral soils of 3 layers per pit
  0 – 5 cm
  – 15
  – 30

3470 samples

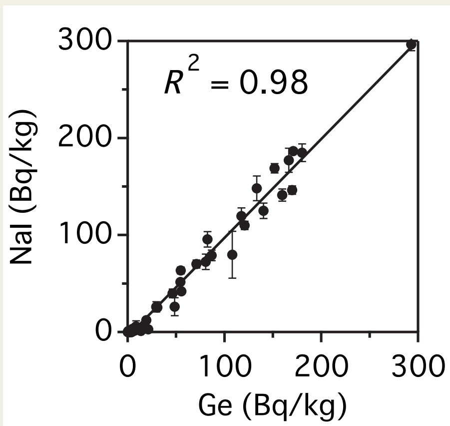


Radioactivity determination

- Measured samples in 20 mL vial by NaI gamma counter in 30 min.



- Verified 60 samples with Ge detector measurements.



- Cs accumulation in each soil layer(i):

$$Cs\_inv_i = Cs\_conc_i \, (m_i \, wc_i \, (1 - Gr_i/100))$$

^{137}Cs-GFO accumulation in soil (0–30 cm)

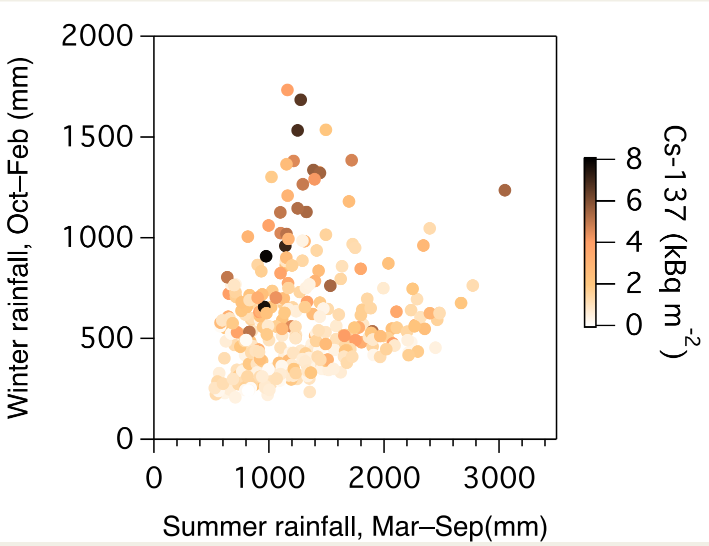
1.7 kBq m^{-2}
Forest soils in 2008 (this study)

↕

1.5 – 4.0 kBq m^{-2}
Global fallout measurement
at 7 observatories by 1970
(decay-corrected as of 2008)

7

Effect of seasonal rainfall on accumulation



Effect of **winter rainfall** was significant.

8

Effects of **landform** and **vegetation** was **weak**

Multi-regression analysis

Landform factors : **elevation**, **azimuth from south**, **slope inclination**, topographic wetness index, others

Vegetative factors : stand age, stand volume, shrub layer, understory layer

	Country	SE1	NW3	SE4
R square adjusted	0.00	0.27	0.16	0.27
Root mean square error	1.4	0.7	1.7	0.7
p-value (Prob>F) for whole model	0.431	0.004	0.039	<.001
Observation (N)	306	40	39	52
p-value (Prob>|t|) for parameters				
Elevation	0.196	0.001	0.007	0.075
Azimuth from south	0.734	0.808	0.702	<.001
Slope inclination	0.274	0.579	0.107	0.017

: significant

Vertical distribution of ^{137}Cs in soil

5 cm downward during the past **50 years**.

10

Summary

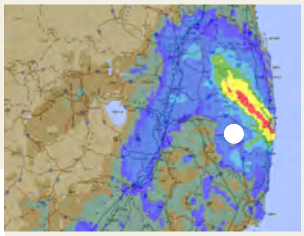
- 1.7 kBq m^{-2} of ^{137}Cs - consistent with measurements.
- ^{137}Cs has remained in the forests for 50 years.
- 5 cm vertically downward migration of ^{137}Cs in soil.

Secondary migration processes

1. Erosion on slope
2. Physical migration in soil
3. Bioturbation by soil animals
4. Bioturbation by tree roots

11

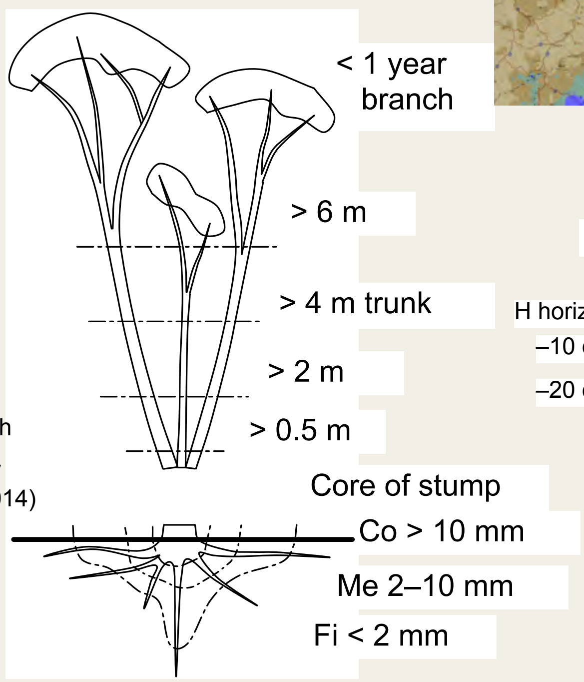
Materials and method

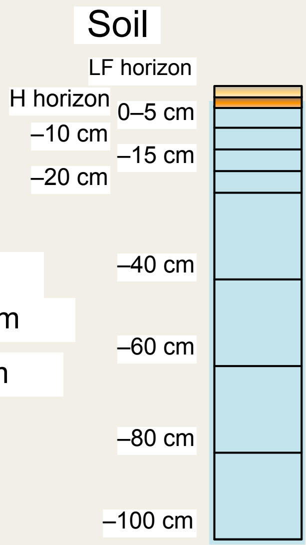


Study site: Miyakoji, Fukushima
20 km west from FDNPP
^{137}Cs, 100–300 kBq/m^2
(July 2011)

3 deciduous oak trees
(*Quercus serrata*)
in Mar–Apr 2014

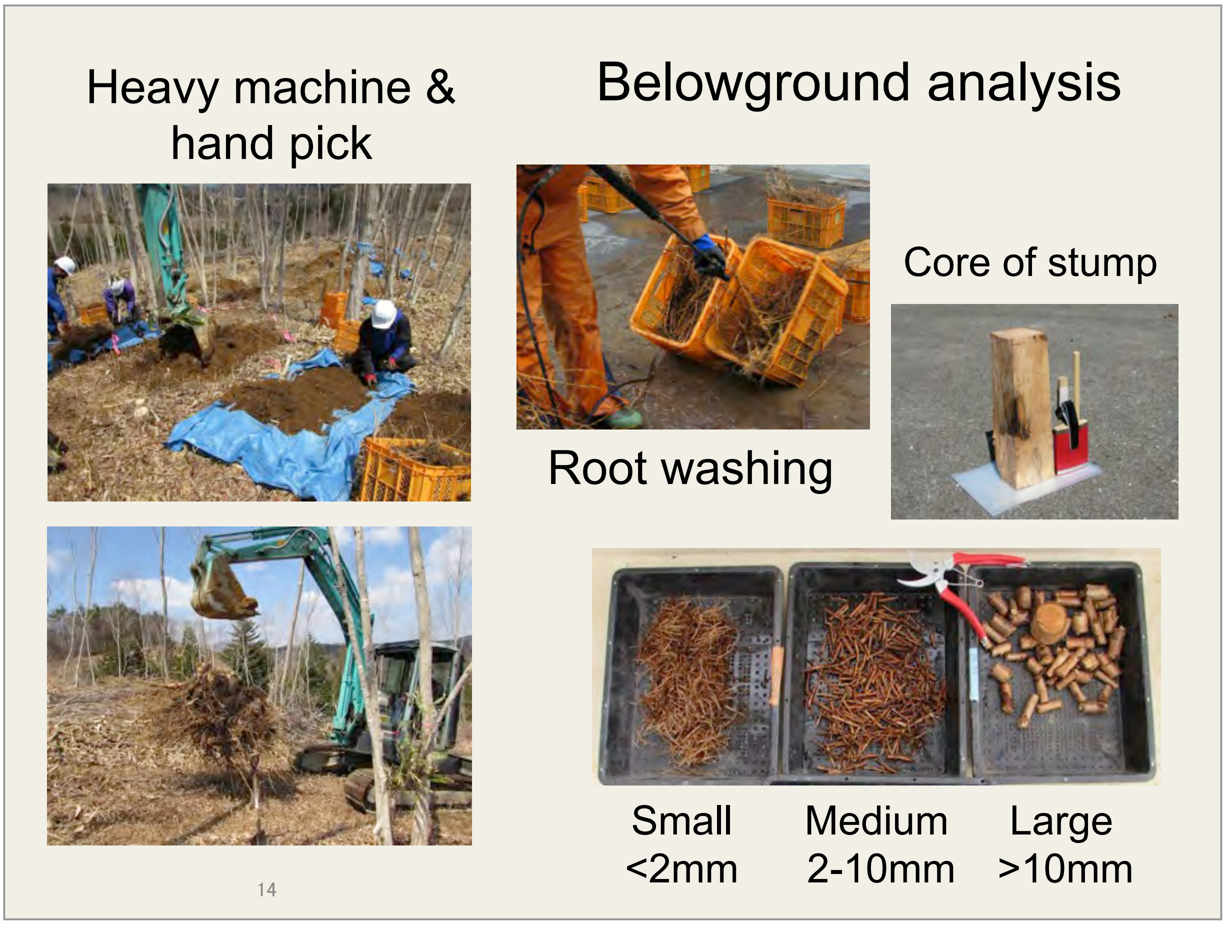
- 5 parts of aboveground
- 4 parts of belowground
- Litter: LF, H layers
- Soil: 0–5 , –10, –15, –20, –40, –60, –80, –100cm
- Fine & medium roots along depth
- Determined ^{134}Cs, ^{137}Cs activity (decay-corrected at 1 Apr 2014)

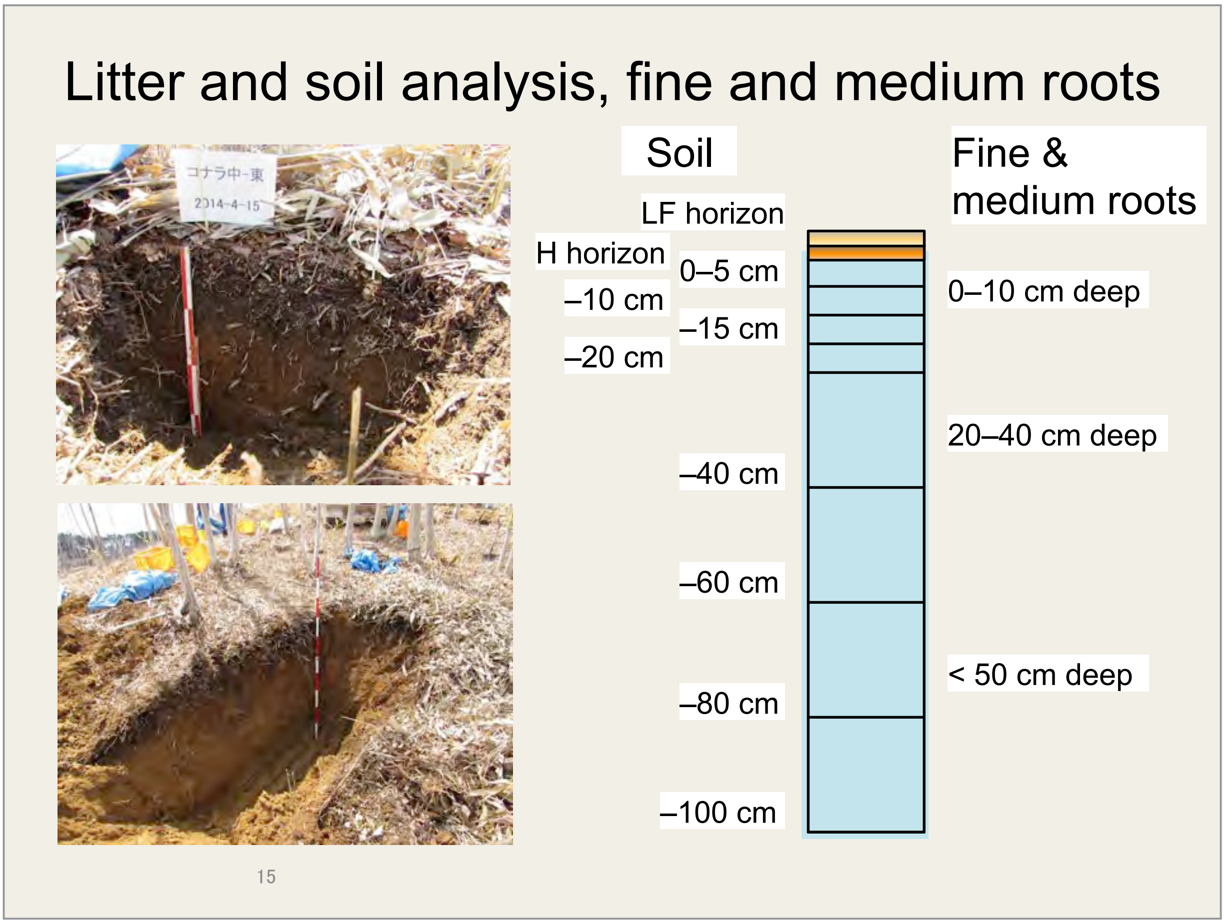


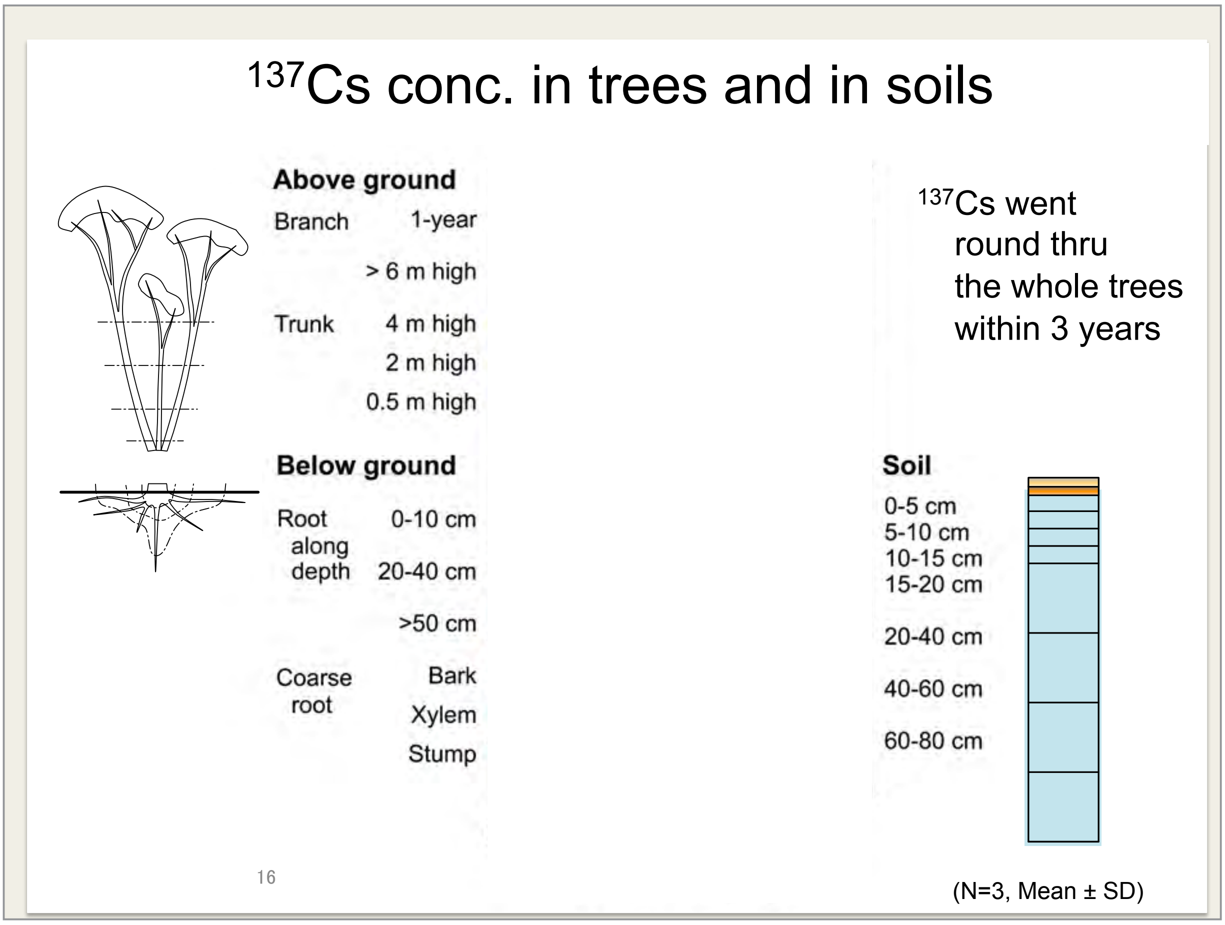


12


Aboveground analysis
13


Heavy machine &
hand pick
Belowground analysis
Core of stump
Root washing
Small
<2mm
Medium
2-10mm
Large
>10mm
14


Litter and soil analysis, fine and medium roots
コナラ中-東
2014-4-15
Soil
LF horizon
H horizon
–10 cm
–20 cm
0–5 cm
–15 cm
–40 cm
–60 cm
–80 cm
–100 cm
Fine & medium roots
0–10 cm deep
20–40 cm deep
< 50 cm deep
15


137Cs conc. in trees and in soils
Above ground
Branch 1-year
> 6 m high
Trunk 4 m high
2 m high
0.5 m high
Below ground
Root along depth 0-10 cm
20-40 cm
>50 cm
Coarse root Bark
Xylem
Stump
137Cs went round thru the whole trees within 3 years
Soil
0-5 cm
5-10 cm
10-15 cm
15-20 cm
20-40 cm
40-60 cm
60-80 cm
16
(N=3, Mean ± SD)

Fine root biomass (recent reviews)

Fine root turnover, 0.5 – 1.0 y

		Fine root biomass ($g\ m^{-2}$)	Source
Global			Finér *et al.* (2011)
	Boreal	385 ± 260 (84)	
	Temperate	576 ± 381 (221)	
	Tropical	501 ± 226 (10)	
Japan			Noguchi *et al.* (2007)
	Temperate	49 – 746 (14)	

➡ Root litterfall, if contaminated?

17

Conclusion and future research

1. Forests in Japan has acted as **a long term reservoir** of fallout over the past 50 years.
2. Although ^{137}Cs has remained in forests for a long period, migrating vertically **5 cm downward** during 50 years after deposition.
3. Probable ^{137}Cs transport from tree roots to soils. **Cs migration processes** in soils should be clarified.

18

Thank you for your attention.

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Graduate School of Agricultural and Life Sciences, University of Tokyo

19

3.14 Variability in Chernobyl deposited Cs-137 and its influence on the human exposure

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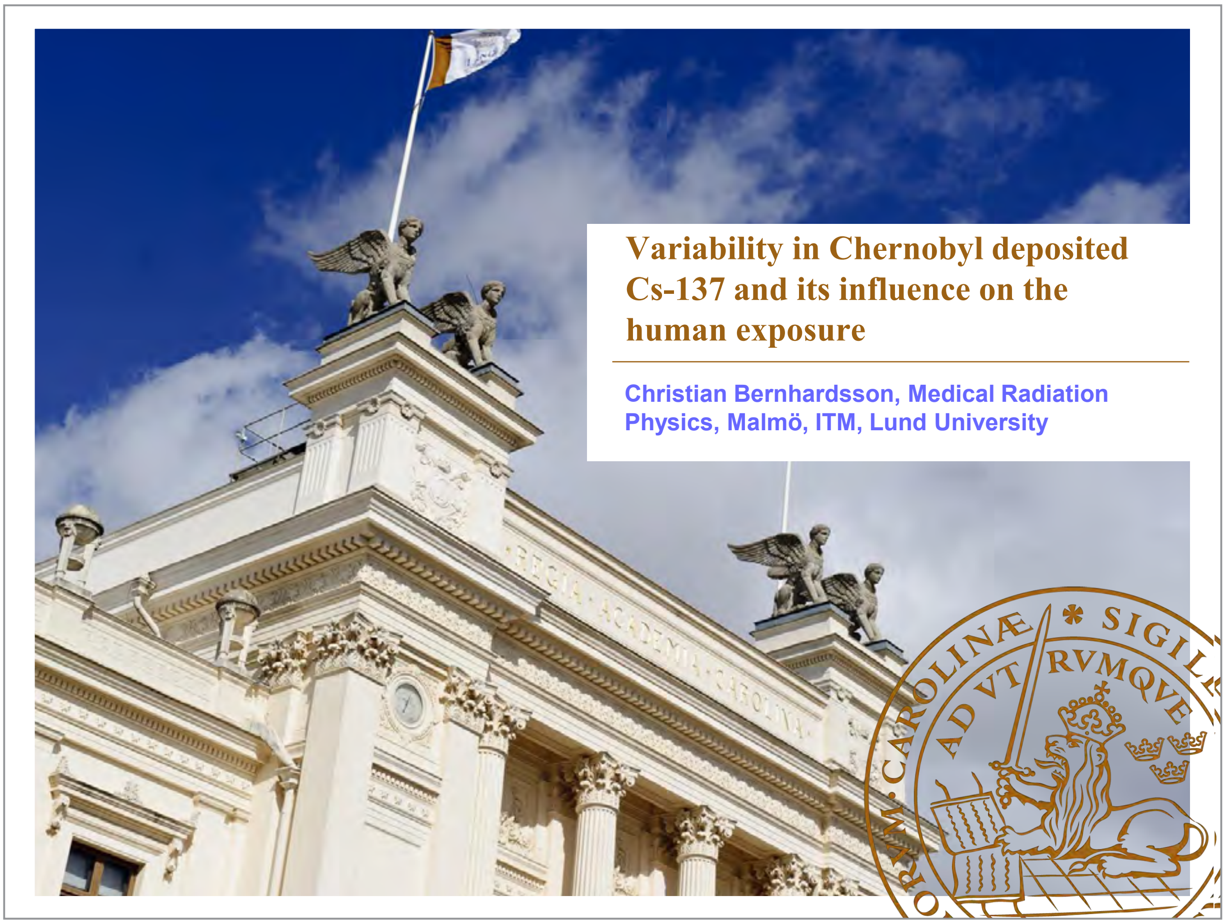

Outline of the presentation

- Illustrating the variability in the Cs-137 deposition horizontally on the ground after the Chernobyl accident.
- Illustrate the relationship between internal- and external effective doses to the public in the *early*- and *late* phases after radioactive fallout events.
- Emphasize important factors in the procedures to calculate risks by means of prospective- and retrospective dosimetry methods.
- Implications on justified population protection after radioactive fallout events, *e.g.* sheltering, relocation, decontamination, financial support…

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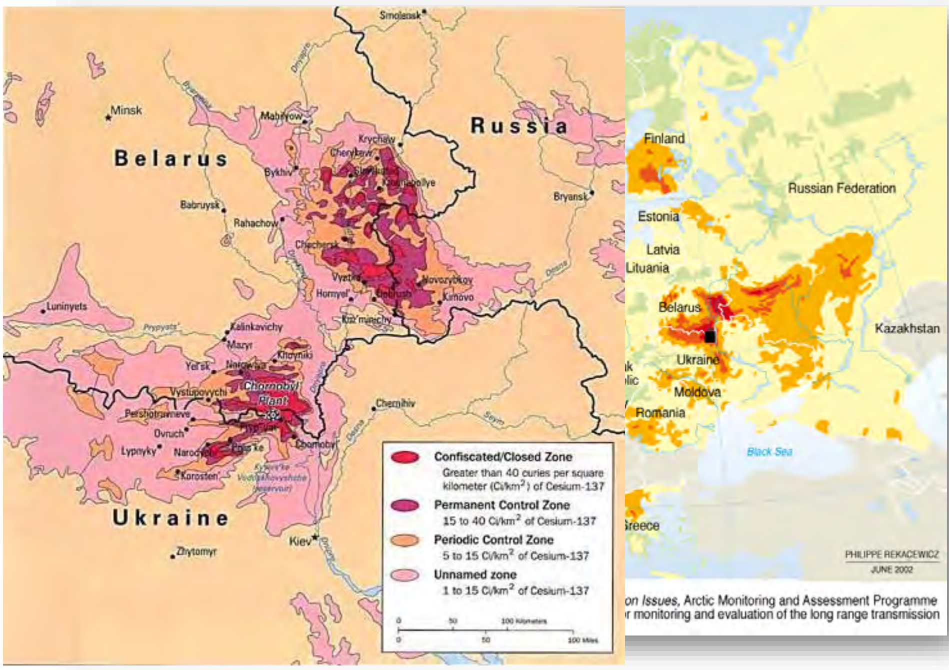
Chernobyl ^{137}Cs deposition



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^{137}Cs deposition and 70 yr prognosis

1986

+70 yrs.

2056

Atlas (2009). Cs-137 contamination maps of Belarus and Russia. Issued by the joint program of activities to mitigate the Chernobyl catastrophe within the Union States for 2006-2010 from the budget of the Union State of Belarus and Russia.

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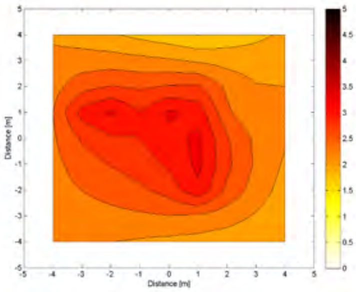
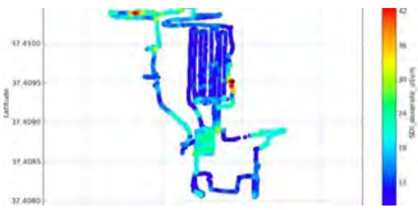
Actual variability in deposition and radiation fields



Conventional mapping (hand-held NaI(Tl)-detector), 10x10 m^2 area

Back-pack NaI(Tl)/$LaBr_3$



Back-pack mapping and fusion of map and data points. >100 m^2 area.

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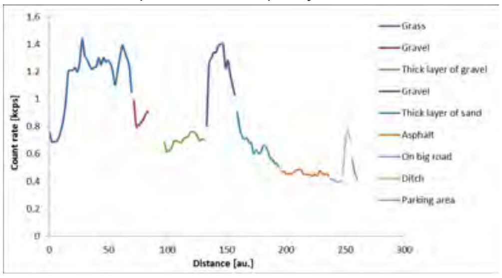
Actual variability in deposition and radiation fields

- Varies over time by *e.g.*
  - nature processes (early/late), radionuclide composition, human influence, location (migration, resuspension)…
- Correct estimates and prognosis of the deposited radionuclides are decisive for the inhabitants health
  - both immediately after, and in the future.

Radiation exposure above partly decontaminated road



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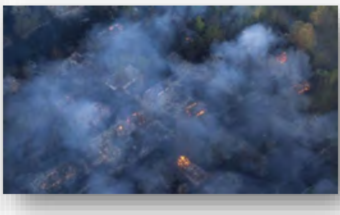
Forest fires in former Soviet countries - an issue for several reasons



Relationship between internal- and external effective doses (over time)

- Due to the variability in the radiation fields, the external (and internal) doses varies for different population groups, *e.g.* in:

Forest

Farmland

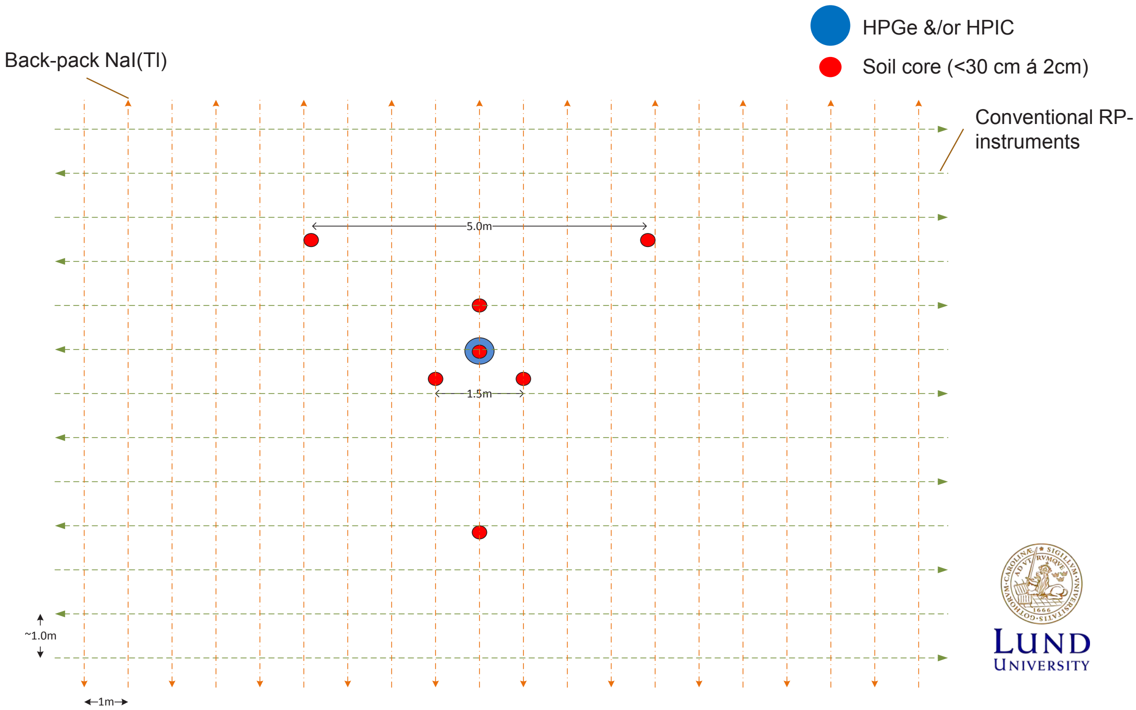
Kitchen garden

House

School

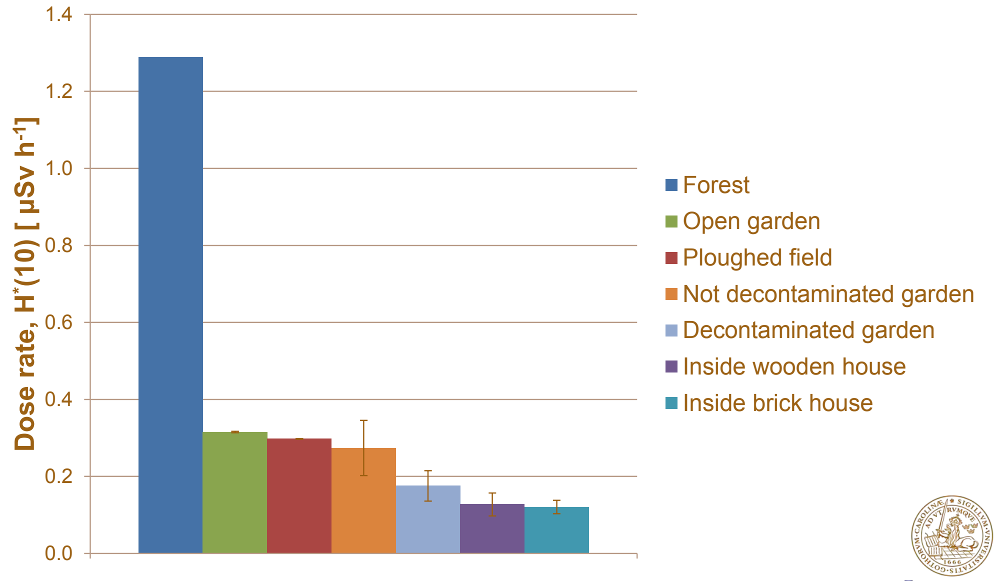
Office/administration

Assessment of the actual variability in deposited Cs-137 over a surface

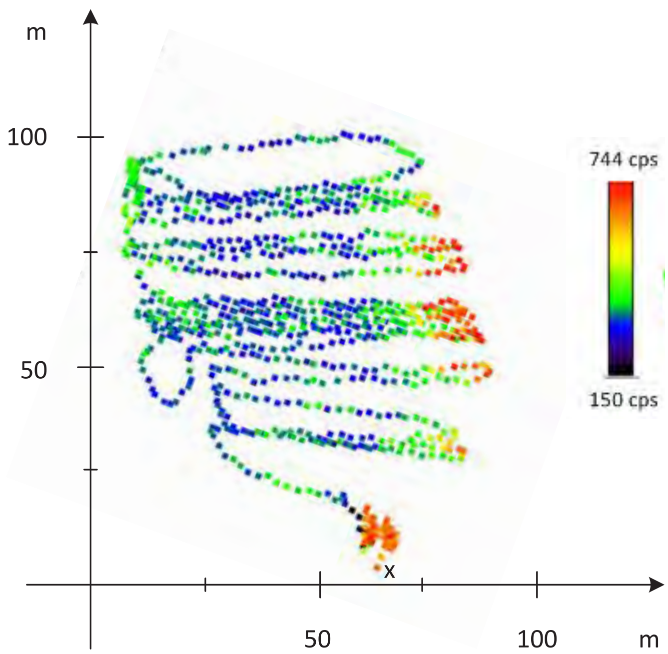


Examples of the actual variability in deposited Cs-137 in different locations

Example from one settlement in Belarus



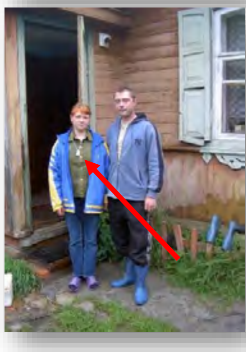
Example of the actual variability in deposited Cs-137 within one location



Relationship between internal- and external effective dose (over time)

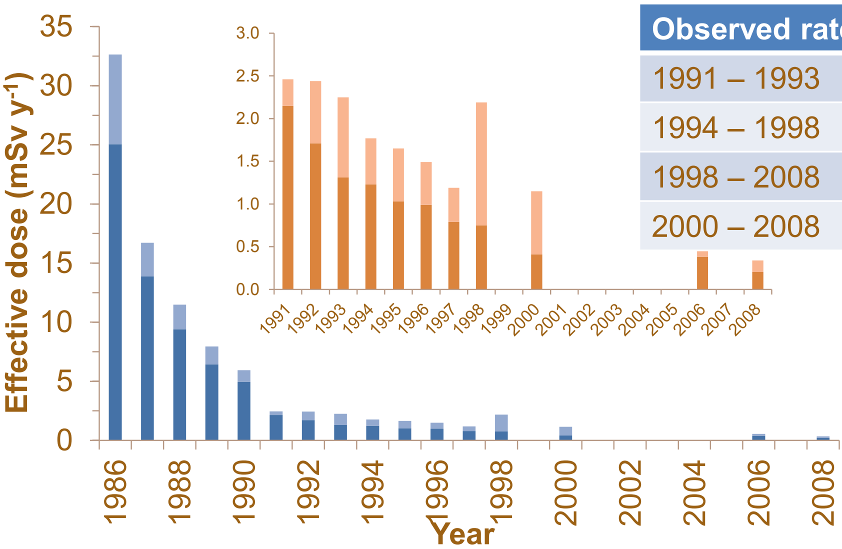
Whole body irradiation:

- Internal effective dose
  - Whole body counter, partial body counter, measurement of excretion, measurement of foodstuff
- External effective dos
  - Individual dosemeters, mathematical models (based on *in situ* measurements, predictions), new retrospective/prospective dosimetry methods
- When to apply what method?



Relationship between average internal- and external effective doses (over time)

- Average annual effective doses (individual measurements in Bryansk region villages)



Observed rate of decrease (E_{ext})	
1991 – 1993	-20% y^{-1}
1994 – 1998	-12% y^{-1}
1998 – 2008	-9% y^{-1}
2000 – 2008	-3% y^{-1}

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Example of the variability within a settlement

Type of garden	Average dose rate (µSv/h)	C_v	Max (µSv/h)	Min (µSv/h)
Decontaminated	0.19	26%	0.35	0.12
Not-decontaminated	0.24	35%	0.60	0.11
Abandoned	0.52	49%	1.08	0.23

- Human influence on the ground surface reduce the intra-site variability in the external dose rate.

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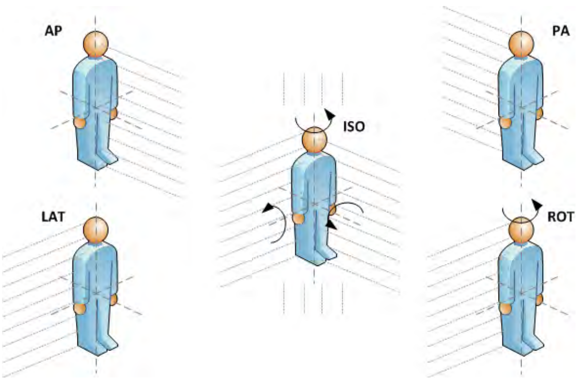
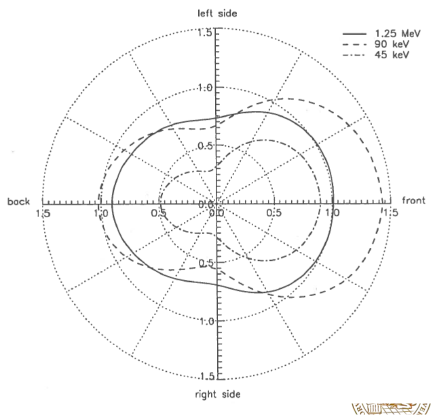
The radiation exposure situation changes with time in different locations

- The effective dose per unit absorbed dose varies in different locations and over time (a downward migration effect) both on E_{avg} *and geometry.*

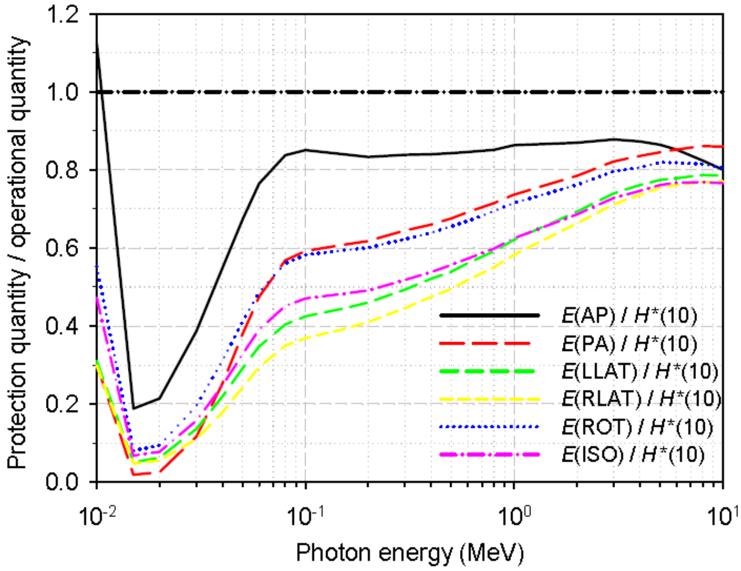


Idealised exposure geometries



Angular variation of E_{eff} for photons with different energy

Exposure geometry and E_{avg} influence on the effective dose



ICRP Publication 116

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Approach for effective dose assessments

- **Individual effective dose assessments**
  - Requires a large (devoted) sample group.
  - Representative person: *probability is less than 5% that a person drawn at random from the population will receive a greater dose.*
- **Model calculations**
  - Requires information on location factors and occupancy factors.
  - Requires information on the effective dose distribution.

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Some key points for consideration

- The variability within a specific surface is generally higher than between different surfaces,
  - *surface dependent and human interference.*
- Reference surfaces are important,
  - *the exposure situation varies over time by natural decay, human interference, and migration down in soil,*
  - *several places in inhabited and uninhabited areas.*
- When evaluating actions for population protection, the variability must be taken into consideration and the concept of reference person should be applied,
  - *internal-/external exposure varies over time, and their relative magnitude to the total effective dose.*

3.15 Radio cesium fixation process to soil analyzed by monitored radioactivity data of spinach in Fukushima

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Dialysis patients might constitute a critical group at a severe internal contamination of radioactive elements. On the other hand dialysis might be an effective tool for decreasing the dose to contaminated persons.

Eight persons were studied for the clearence of ^{137}Cs by dialysis, 6 by haemo dialysis (HD) and 2 by haemo filtration (HF) or haemo dialysis filtration (HDF). For the 6 HD patients whole volume of dialysis liquid (about 120 l) was collected. The two HF patients were given reindeer meat contaminated with ^{137}Cs by the Chernobyl accident and nuclear test fallout before dialysis (ca 15 Bq) to establish the retention of ^{137}Cs. Dialysis fluid was collected in 20 minutes or 40 minutes intervals. ^{134}Cs was used as radochemical yield determinant. The activity was measured by HPGe-detectors. This study showed that HD and especially HF and HDF are effective methods for removing radiocaesium from the blood pool.

We also studied a HD patient undergoing ^{131}I treatment of thyroid carcinoma. Ten dialysis occasions were studied for this patient. The results showed a very effective clearance of 131I using HD. There are also other aspects to consider in such a case, e.g., the change in dosimetry to avoid over- and undertreatment and exposure of personnel during dialysis.

Keywords: Dialysis, Radiocaesium, Radioiodine, Clearance, Man

The effect of dialysis on ^{137}Cs and ^{131}I in man

- **E. Holm**

- *Department of Radiation Physics, Gothenburg University*

Objectives

- Investigate if dialysis is an effective method for removing radionuclides from the body at internal contamination.(Emergency situation)
- Find out if persons with end-stage renal disease constitute a critical group with respect to internal contamination of radionuclides.
- Does dialysis have an impact on the isotope therapy for patients with thyroid cancer?

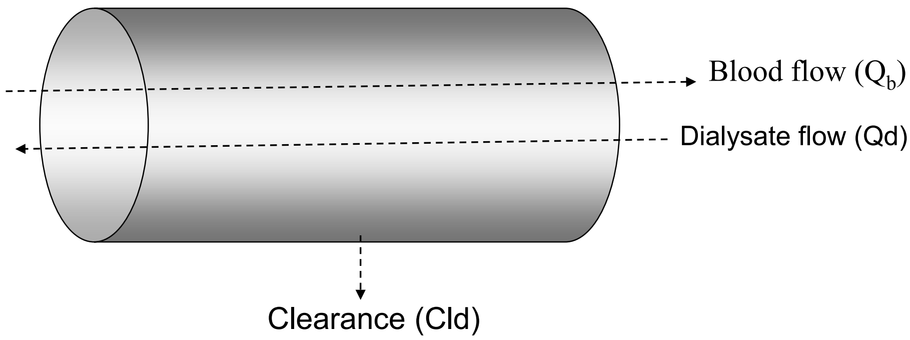
DIALYSIS

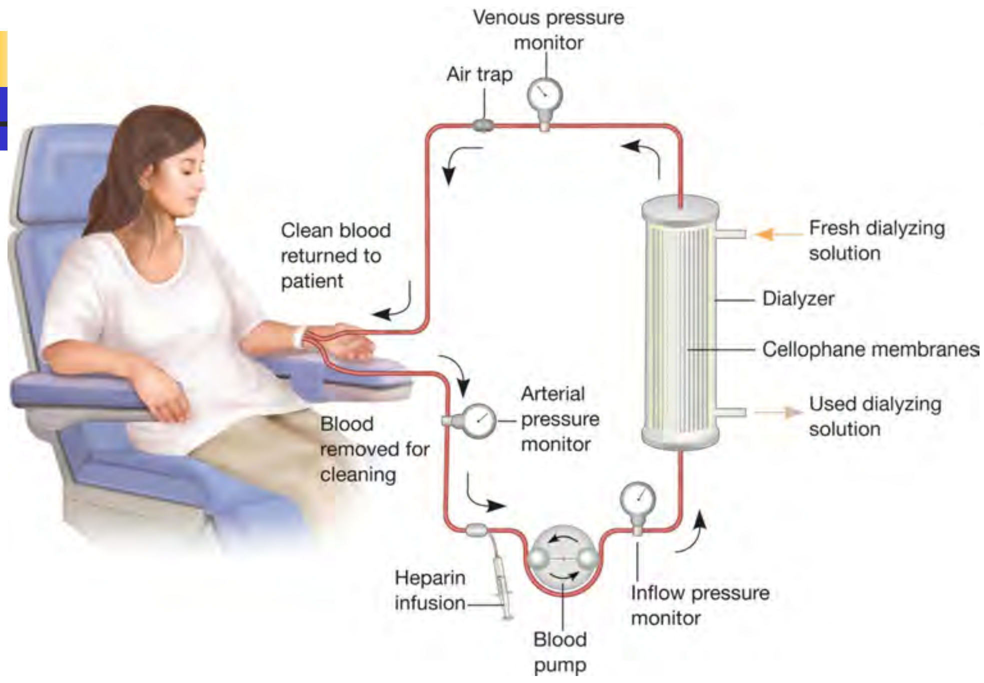
- Haemodialysis, HD
- Peritoneal dialysis, PH
- Haemofiltration, HF
- Heamodialysisfiltration, HDF

- In HD the blood flows on one side of a semipermeable membrane (1-1.5 m^2) and the dialysis fluid on the other side.
- In PD the peritoneum acts as a semipermeable membrane with an effective area of 1.5 m^2

- In HF the blood is led into small fibres and the very low pressure on the other side of the membranes of the fibres will see to that there is a transport of fluids from the blood over the membrane with a velocity of 80-180 ml/minute.
- In HDF the membrane consists of a capillary tube like in HF but a dialysis fluid flows on one side of the membrane and blood on the other side like in HD.
- The HDF and HD treatments are more effective than the HF treatment in removing small molecules

. Haemodialysis. The principle of clearance of the blood according to dialysis treatment. There is a constantly exchanged dialysis concentrate and water on one side of the membrane, on the other side the blood flows in opposite direction.





Composition of extracellular fluid and of contemporary haemodialysis fluids (references in parenthesis). †Osmotic active substance.

		Contemporary haemodialysis fluids	
	Interstitial fluid [Diem et al.,1970]	Extreme range [Stewart,1989]	Typical range [Stewart,1989]
Sodium (mmol/l)	145	109 - 148	128 – 140
Potassium (mmol/l)	4.0	0 – 4.0	1.0 – 2.0
Calcium (mmol/l)	1.5	0 – 1.75	1.5 – 1.75
Magnesium (mmol/l)	0.5	0 – 1.5	0.5 – 0.85
Chloride (mmol/l)	114	87 - 117	95 – 109
Bicarbonate (mmol/l)	31	0 – 46.7	35 – 40
Glucose† (mmol/l)	-	0 – 30	11

Method

- Whole volume of dialysis liquid (about 120 l) or the volums during intervals (ex. 20 min.) were collected.
- ^{137}Cs was collected on cotton-wound cartridge filters impregnated with copper ferro cyanide or precipitated from the solution with copper ferrocyanide. ^{134}Cs was used as radochemical yield determinant
- The filters were incinerated and measured by Hp-Ge gamma spectrometry
- For ^{131}I the samples were measureed directly by HpGe gama spectrometry and the results decay corrected to the time of administration.

Study No. 1

- 14 persons undergoing dialysis.
- Dialysis fluid analysed for ^{137}Cs
- Whole body counting of patients

Study No 2

- 8 Persons undergoing dialysis
- 2 persons consumed reindeer meat (about 15 Bq of ^{137}Cs) contaminated from nuclear test fallout and the Chernobyl accident
- Collection of dialysis fluid at intervals
- Whole body counting of one person

The selected dialysis patients. The table show the gender (Male or Female) of the patient, type of and length of dialysis treatment, weight of patient, the used filter during dialysis treatment ant the volume of dialysate achieved during one dialysis session.

Patient	Gender	Type of dialysis	Number of months of dialysis	Weight of patient [kg]	Filter	Volume of dialysate [l]
1	M	HD	PD 77 + HD 6	70.6	α 600	160
2	M	HD	0	41.2	α 600	100
3	M	HD	1	84.3	α 600	165
4	M	HD	6	76.1	α 600	160
5	F	HD	20	68.7	α 600	155
6	M	HD	90	70.1	α 700	160
7	M	HF	23	82.9	α 700	160
8	M	HF	75	70.6	α 700	120

Study No 3

- One patient with the thyroid gland removed due to cancer
- Thereafter treated with 350 MBq of ^{131}I
- This patient was also underwent dialysis for end-stage renal disease. These two things happen together independently for 1 person out of one million.
- Dialysis fluid (HD) collected at intervals

Results Study No 1

Table 1. Patient data and results for a previous study (Josefsson et *al*., 1995)

Patient	Sex	Body mass(kg)	Time on dialysis (months	Treat ment	Body content ^{40}K (Bq)	Body content ^{137}Cs (Bq)	Effective half-life ^{137}Cs (days)	Exc rate Bq/
1	M	49	42	HD	2700	24	67	0.2
2	M	74	2	HD	3500	28	120	0.1
3	M	50	15	HD	3300	41	110	0.2
4	M	78	1	HD	NM	NM	-	0.2
5	F	48	18	HD	NM	NM	-	0.2
6	F	84	180	HF	4100	ND	-	0.5
7	F	60	10	HD	2500	ND	-	0.2
8	M	68	9	HD	3800	54	130	0.2
9	M	85	7	HD	4300	78	75	0.7
10	M	78	14	HD	3700	53	201	0.1
11	M	60	58	PD	2900	66	120	0.3
12	M	78	19	PD	3000	92	232	0.2
13	M	63	9	PD	2800	110	780	0.1
14	M	69	15	PD	2900	79	89	0.6

Results Study No. 1 contd.

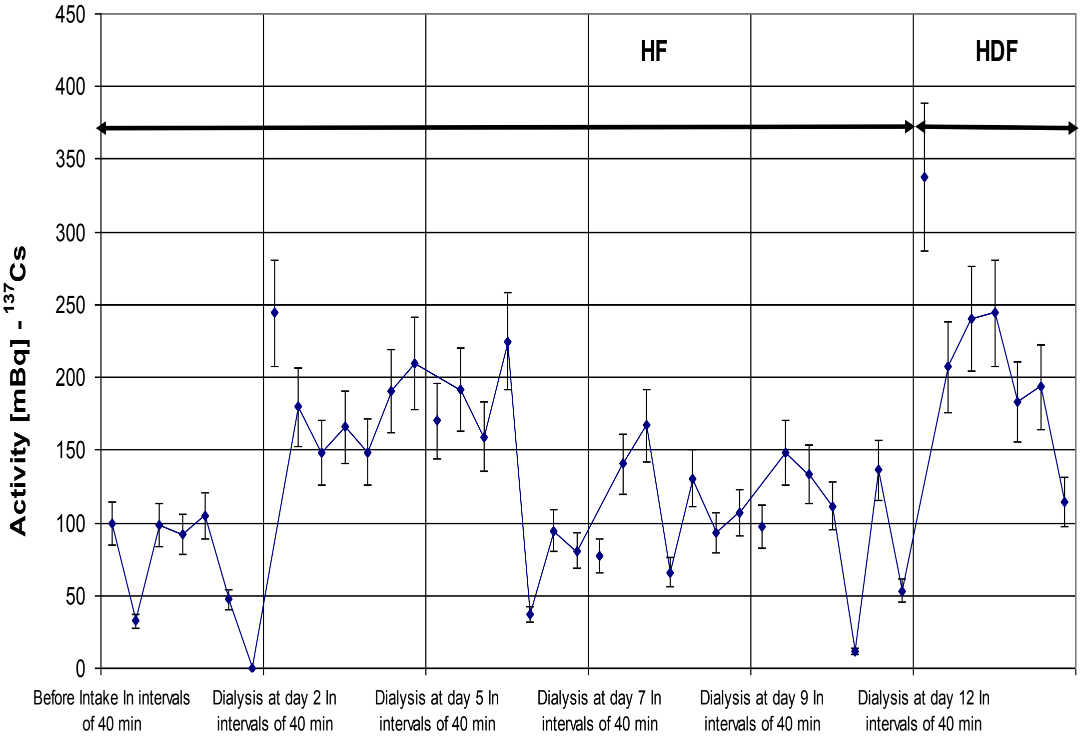
- The effective half-life for radiocaesium was about the same as for persons with normal renal functions.
- 15 hours of haemodialysis during a week achieve the same elimination of ^{137}Cs as normal kidney
- Haemodialysis is more effective than peritoneal dialysis

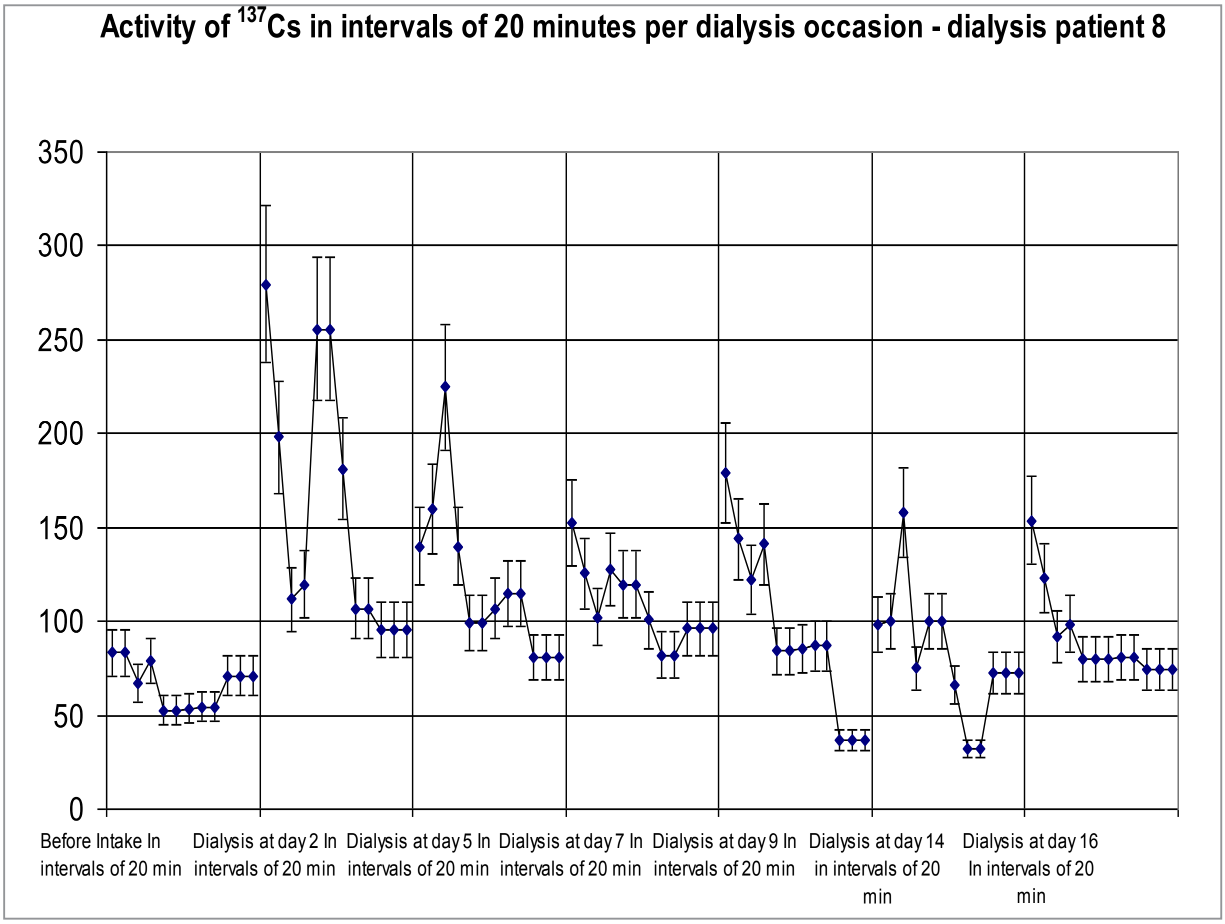
Results for Study No 2

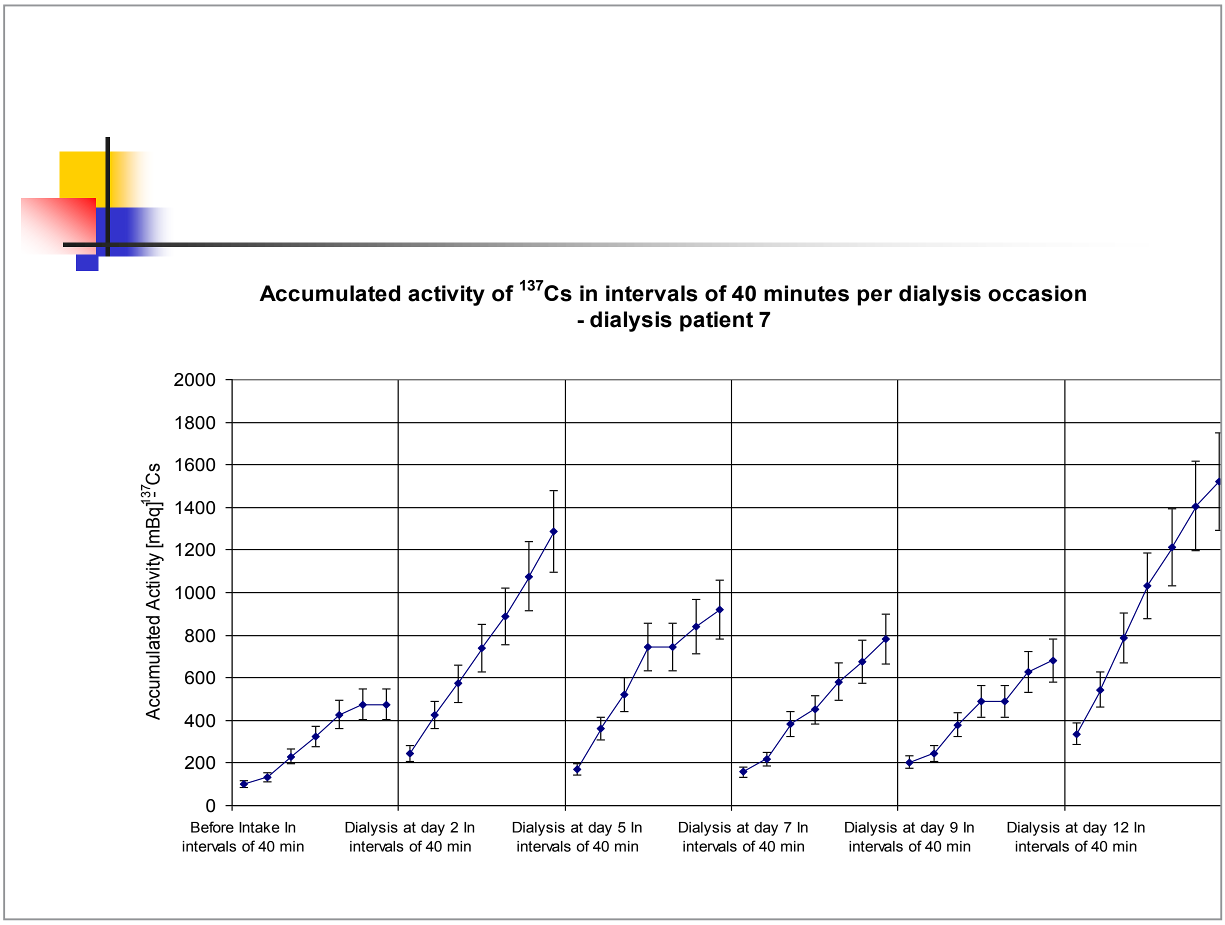
The activities of ^{137}Cs in the individual dialyates of the selected dialysis patients.

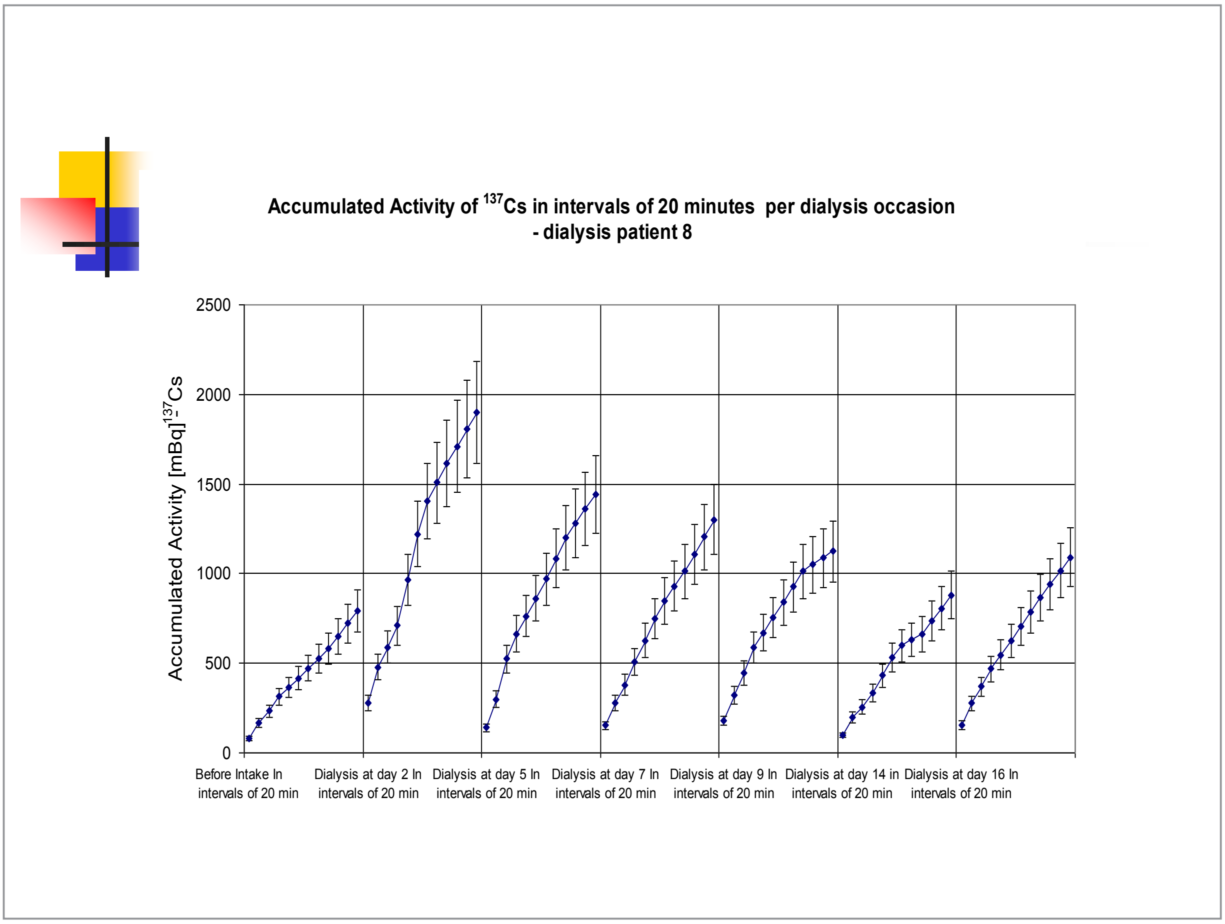
Patient	Gender	Type of dialysis	Number of months of dialysis	Weight of patient [kg]	Filter	Volume of dialysate [l]	A (^{137}Cs) [mBq]
1	M	HD	PD 77 + HD 6	70.6	α 600	160	611±92
2	M	HD	0	41.2	α 600	100	not meas.
3	M	HD	1	84.3	α 600	165	515±77
4	M	HD	6	76.1	α 600	160	905±136
5	F	HD	20	68.7	α 600	155	732±110
6	M	HD	90	70.1	α 700	160	380±57
7	M	HF	23	82.9	α 700	160	399±60
8	M	HF	75	70.6	α 700	120	256±38

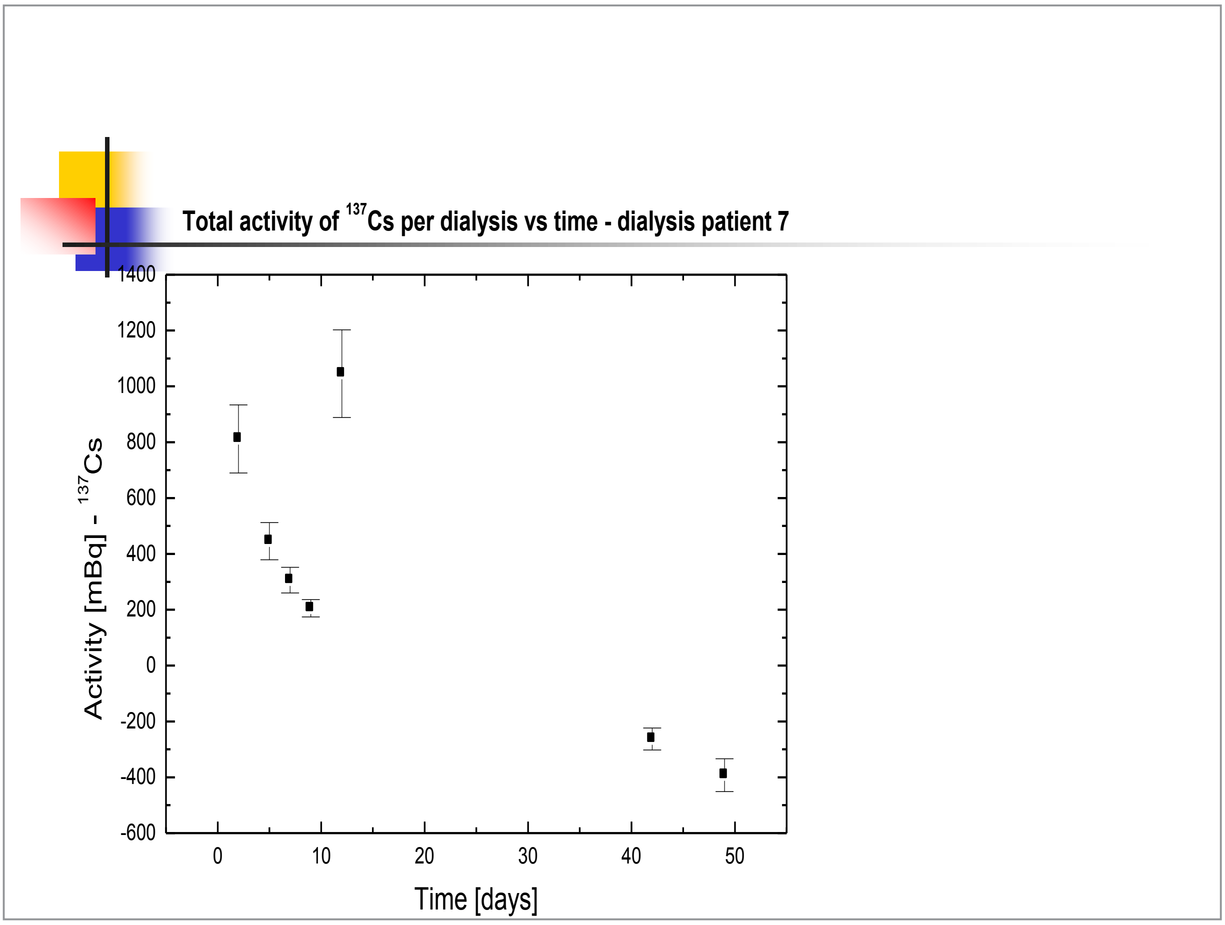
Activity of ^{137}Cs in intervals of 40 minutes per dialysis occasion - dialysis patient 7

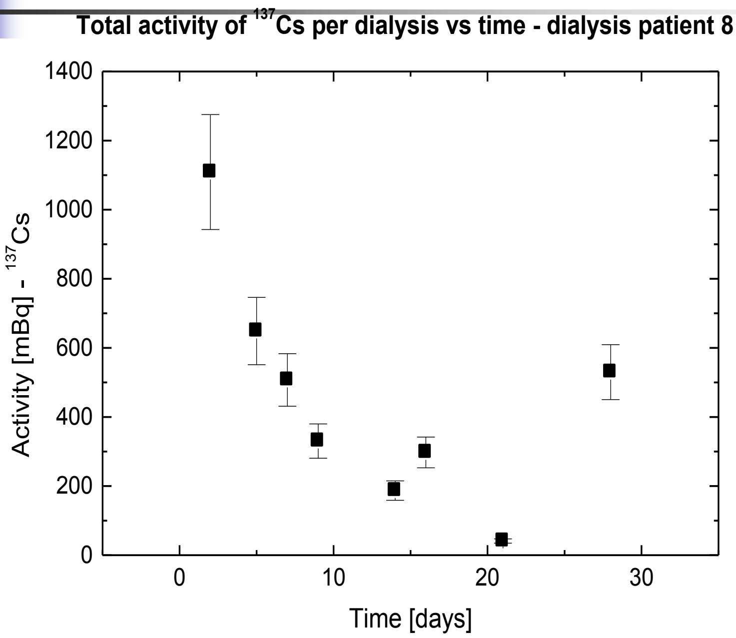



Activity of 137Cs in intervals of 20 minutes per dialysis occasion - dialysis patient 8
350
300
250
200
150
100
50
0
Before Intake In intervals of 20 min
Dialysis at day 2 In intervals of 20 min
Dialysis at day 5 In intervals of 20 min
Dialysis at day 7 In intervals of 20 min
Dialysis at day 9 In intervals of 20 min
Dialysis at day 14 in intervals of 20 min
Dialysis at day 16 In intervals of 20 min


Accumulated activity of 137Cs in intervals of 40 minutes per dialysis occasion - dialysis patient 7
Accumulated Activity [mBq] 137Cs
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Before Intake In intervals of 40 min
Dialysis at day 2 In intervals of 40 min
Dialysis at day 5 In intervals of 40 min
Dialysis at day 7 In intervals of 40 min
Dialysis at day 9 In intervals of 40 min
Dialysis at day 12 In intervals of 40 min

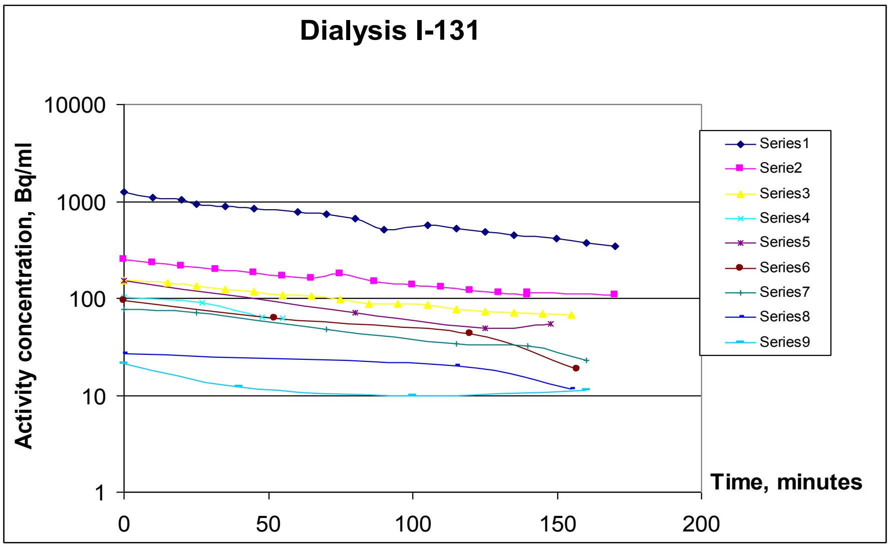

Accumulated Activity of 137Cs in intervals of 20 minutes per dialysis occasion
- dialysis patient 8
Accumulated Activity [mBq]137Cs
2500
2000
1500
1000
500
0
Before Intake In intervals of 20 min
Dialysis at day 2 In intervals of 20 min
Dialysis at day 5 In intervals of 20 min
Dialysis at day 7 In intervals of 20 min
Dialysis at day 9 In intervals of 20 min
Dialysis at day 14 in intervals of 20 min
Dialysis at day 16 In intervals of 20 min


Total activity of 137Cs per dialysis vs time - dialysis patient 7
Activity [mBq] - 137Cs
1400
1200
1000
800
600
400
200
0
-200
-400
-600
0
10
20
30
40
50
Time [days]

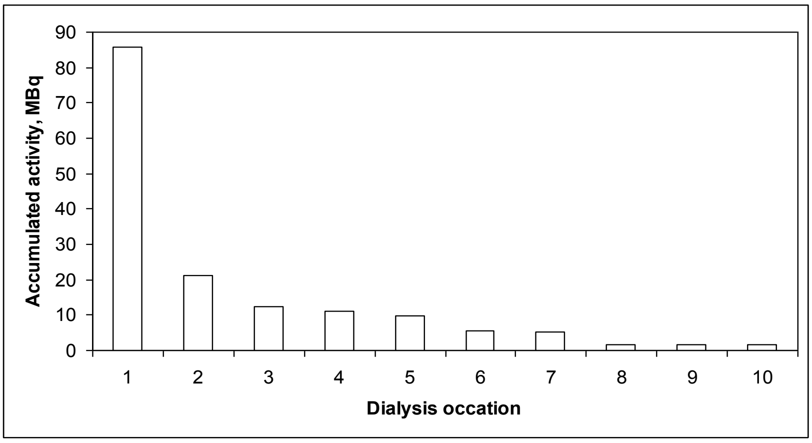


Results for Study No 3

Activity concentration (Bq/ml) of 131I at 20 min. interval during 9 dialysis occasions. Data decay corrected to time of administration



Total activity (MBq) of ^{131}I in dialysis liquid at each treatment decay corrected to time of administration.



Conclutions for ^{137}Cs

-Dialysis is an effective tool for removing ^{137}Cs from the body

-HDF is more effeftive than HF, HD, and PD with respect to removing small molecules

The effective half-life in the body using dialysis is only 8-11 days compared to normally 70-100 days

Conclutions for ^{131}I

- HD is an effective method for removing ^{131}I from the blood pool.
- Dialysis has an important impact on the therapeutic dose
- Of the administered 350MBq, 156MBq were recovered in the dialysis liquid
- The remaining activity might be found in the filter or evaporated during treatment or transport of the samples.
- Or may be the fractional uptake is lower for a person with the thyroid gland removed and the remaining activity was removed with faeces?
- If a person is consuming stable Iodine the uptake is probably lower.
- The dialysis patients do not constitute a critical group for internal contamination of ^{131}Cs or ^{131}I since the removal by dilaysis is effective.
- However the effect of the ^{131}I treatment might be less effective especially if dialysis is performed shortly after administration.

Suggestions for further work

- Repeat study with larger amount of ^{137}Cs consumed
- Study patients wih normal kidneys undergoing dialysys such as at poisioning.
- Study patients for ^{131}I with normal Thyroid function
- Study other radionuclides used in nuclear diagnostic medicine, $^{99}Tc^{m}$ (^{99}Tc), ^{75}Se etc.
- What is the effect of dialysis on natural radionuclides, U, Ra, Po etc?

Thank you for your Attention

3.16 Uranium levels in mining lakes in Southern Sweden

Rimon Thomas†, [1], Juan Mantero[1], Mats Isaksson[1], Christoffer Rääf[2], Eva Forssell-Aronsson[1], Elis Holm[1]

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1 Department of Radiation Physics. Institute of Clinical Sciences. Sahlgrenska Academy at University of Gothenburg, Gothenburg

2 Department of Medical Radiation Physics, Institute of Translational Medicine, Lund University, Malmö

Sweden is a major metal mining country in the European Union and the mining activity results in large quantities of generated waste. The effect of mining activities on hydrological regimes has been studied at many locations worldwide where one of the major threats is the acid mine drainage water. In this work, acid mine water open pits will be studied, so called pit lakes. There is a growing awareness of the environmental risk associated with these mining lakes, where several studies are focused on metallic elements and/or remediation activities, but few data related to radionuclides behavior at pit lakes can be found in the literature today.

This work is the first stage of a project financed by the Swedish Radiation Safety Authority (SSM) that will generate a database with results of naturally occurring uranium isotopes (^{238}U, ^{234}U and ^{235}U) in waters from these sites that may enhance their activity concentrations affecting the surrounding areas through drainage waters or even contribute to increase the external doses received by people visiting these sites for recreation purposes.

Alpha spectrometry with PIPS detector was performed within a set of 25 water samples belonging to 15 different pit lakes from the Southern part of Sweden. A wide range of ^{238}U activity concentration was found, with values from 2 to 700 mBq/kg. Since the average value of the ^{238}U activity concentration in non-affected lake water is around 30 mBq/kg, some of the studied pit lakes have enhanced U levels in superficial water. Other parameters as temperature, pH, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen and salinity are also determined in the samples.

Keywords: radioecology, uranium isotopes, water, mining lakes

URANIUM LEVELS IN MINING LAKES IN SOUTHERN SWEDEN

RIMON THOMAS PHD STUDENT

Behavior of radionuclides in mining lakes in Sweden

R. Thomas[1], J. Mantero[1], M. Isaksson[1], C. Rääf[2], E. Forssell-Aronsson[1], E. Holm[1]

[1]*Department of Radiation Physics. Institute of Clinical Sciences. Sahlgrenska Academy at University of Gothenburg, Gothenburg*

[2]*Medical Radiation Physics, Institute of Translational Medicine, Lund University, Malmö*

University of Seville, Centro Nacional de Aceleradores (CNA) and CITIUS Lab

Risø Lab

Project funded by SSM

Mining in Sweden – A brief history

1200: Earliest documented mining

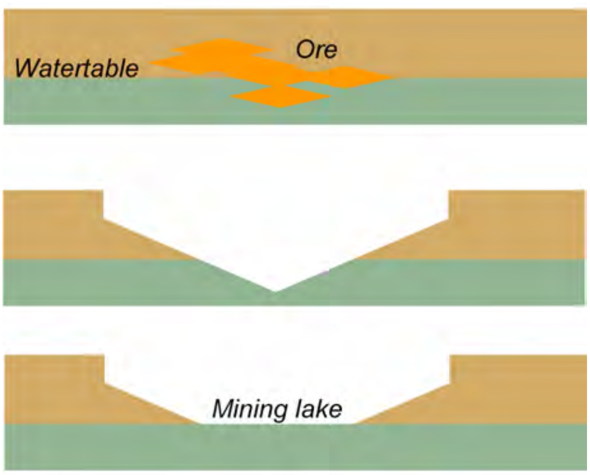
1600: Falu copper mine responsible for ~66% of the worlds copper production

1750: 70% of Swedens export was iron from mines

1924: Bolidengruvan became the biggest and richest goldmine in Europe

➢ Up to 3000 mines have been recorded in Swedish history

What is a mining lake?



Mineral Extraction

Examples:

Pyrite

$$FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+$$

Sphalerite

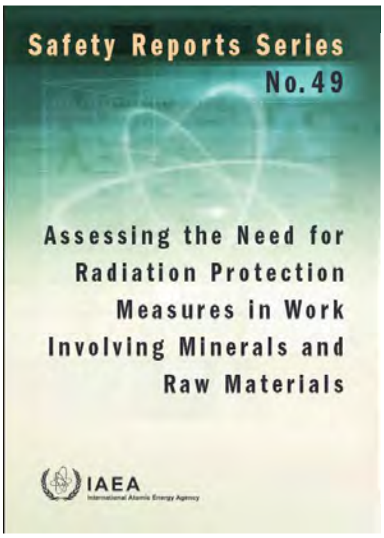
$$ZnS + 2O_2 \rightarrow Zn^{2+} + SO_4^{2-}$$

Galena

$$PbS + 2O_2 \rightarrow Pb^{2+} + SO_4^{2-}$$

Chalcopyrite

$$CuFeS_2 + 4O_2 \rightarrow Cu^{2+} + Fe^{2+} + 2SO_4^{2-}$$



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Uranium-238 levels in literature

- Non affected waters, approximately 25mBq/L
- Affected waters from Uranium mining, 16100mBq/L [Strømman et al. 2013]
- Guideline from WHO in drinking waters, 180mBq/L

Uranium, Thorium and Polonium levels in many non-Uranium Swedish mines currently unknown…

Up until now

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Project status

Sampled 40 mining sites

✓Water

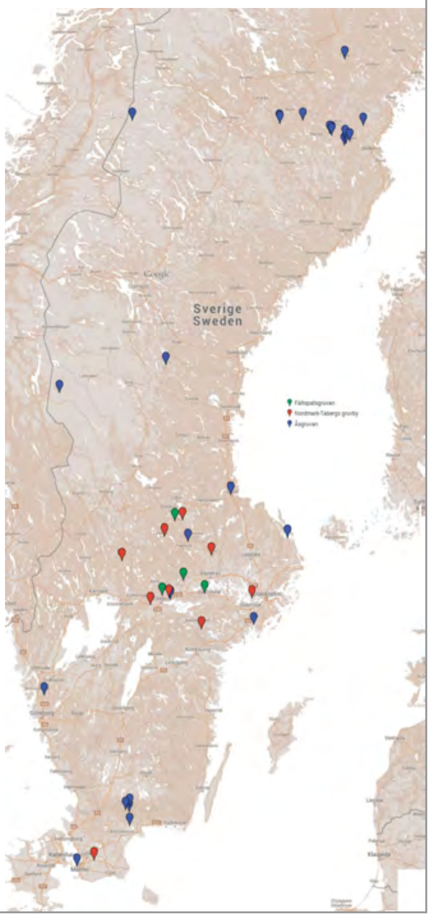
✓Sediments

✓Soil

Measurements:

External dose (μSv/h)

pH, ORP(mV), C(μS/cm), DO(mg/L)



Results – Water samples

24 water samples analyzed so far,

	U-238	U-234	Th-230 and Th-232	Po-210
In the range of [Bq/Kg]	0.1 – 1250	0.1 – 1600	No significant results	

Next step

- ➢ Move to a new (permanent) radiochemistry lab
- ➢ Finish the sample preparation and measure & analyze all the samples
- ➢ For some relevant lakes:
  - Use the data for dose assessment
- ➢ Choose one lake, for a deeper study:
  - Seasonal variation
  - Depth profile of uranium

3.17 Biokinetics and radiobiological effects of low dose exposure from radiohalogens in rodents

Johan Spetz†, [1], Britta Langen [1], Eva Forssell-Aronsson[1]

† Presenter: johan.spetz@gu.se / britta.langen@gu.se

1 Dept of Radiation Physics, Institute of Clinical Sciences, Sahlgrenska Academy at University of Gothenburg, Sweden

Iodine is essential for the normal function of the thyroid gland. Hence, radioactive iodine is taken up in the thyroid at a high rate, but it also accumulates in other tissues if to a much lower extent. Exposure to ^{131}I through inhalation or ingestion can occur after a nuclear power plant accident, which can cause thyroid cancer or other thyroid disorders later on in life. Radiohalogens such as ^{125}I, ^{131}I and ^{211}At are also used in clinical research and applications. Accurate knowledge of their biodistribution is important for absorbed dose calculation, risk estimation of exposure, and for optimal treatment planning. Dosimetric estimation requires known biokinetics and biodistribution of these radionuclides in various tissues. This has been relatively well determined for mice, despite the difficulty to sample small organs and entirely excise them separately in mice. Thus the difference in size between rats and mice makes organ sampling easier in rats. Still there has been limited amount of data for rats.

In this work, we studied the biodistribution of ^{125}I, ^{131}I and free ^{211}At in rats and determined absorbed doses from these radionuclides to various organs and tissues. Male Sprague Dawley rats were injected simultaneously with 0.1–0.3 MBq ^{125}I- and 0.1–0.3 MBq ^{131}I-, or 0.05–0.2 MBq ^{211}At. The rats were killed and dissected 1 hour to 7 days after injection. Radioactivity measurements were performed on the organs and tissues collected, activity concentrations were determined and mean absorbed doses were calculated. We also studied biological effects (genome-wide transcriptional regulation) of i.v. administered 0.064–42 kBq ^{211}At in female BALB/c nude mice after 24 h. Furthermore, we studied the effect that time-of-day of exposure initiation has on biological response in various tissues in BALB/c nude mice 24 h after i.v. injection with 90 kBq ^{131}I.

The biodistribution of ^{125}I- was similar to that of ^{131}I-. All three radionuclides were accumulated selectively in the thyroid gland; but the activity concentration of radioiodine was about five times higher than that of ^{211}At. The activity concentration of ^{211}At was higher than that of radioiodine in all extrathyroidal tissues. The mean absorbed dose was highest to the thyroid. ^{131}I gave the highest dose to the thyroid at $t=\infty$, and ^{211}At gave the highest dose to all other tissues studied.

Regarding biological effects of internalized radiohalogens, we found a non-monotonous dose-response behavior with a stronger effect at lower absorbed dose than at higher absorbed dose (Figure 1). We also demonstrated that the time-of-day when ^{131}I was administered strongly influenced the genome-wide transcriptional regulation in various tissues. However, it remained unclear whether circadian rhythm also had an impact on the biokinetics of ^{131}I uptake. Future studies will investigate if bio- distribution depends on time-of-day of administration.

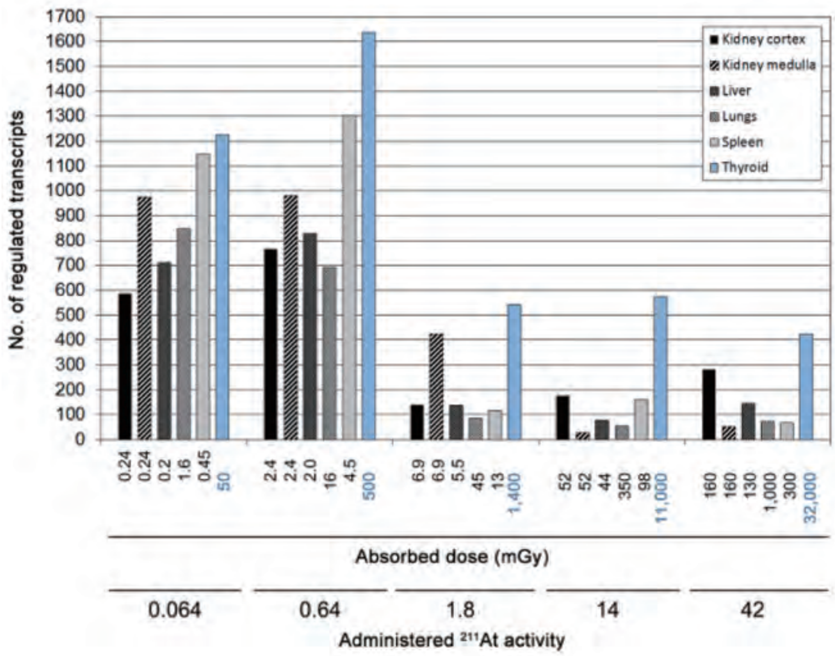


Fig.1 Dose-response of transcriptional regulation after 24 h following 211At administration.

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BIOKINETICS AND RADIOBIOLOGICAL EFFECTS OF LOW DOSE EXPOSURE FROM RADIOHALOGENS IN RODENTS

Johan Spetz, Britta Langen, Eva Forssell-Aronsson

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Overview

- Biokinetics of ^{125}I, ^{131}I and ^{211}At *in vivo*
  - *Radioactivity measurements in normal organs*
  - *Activity concentrations and absorbed doses in normal organs*
- Biological effects of low-dose radionuclide exposure *in vivo*
  - *Gene expression and microarray method*
  - *Dose-response of ^{211}At in mouse normal tissues*
  - *Dose-response of ^{131}I in mouse normal tissues in dependence of time-of-day of exposure initiation*

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Background

- Iodine is essential for thyroid function
  - *Also taken up to a smaller extent in other organs*
- Exposure to radioidine can occur after nuclear powerplant accidents
- Radiohalogens are also used in medical applications and research
  - *e.g. ^{125}I, ^{131}I, ^{211}At*
- Biodistribution knowledge neccessary for *e.g.* dosimetry & risk estimation

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CANCER BIOTHERAPY AND RADIOPHARMACEUTICALS
Volume 00, Number 00, 2013
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DOI: 10.1089/cbr.2013.1483

Original Article

Biodistribution and Dosimetry of Free ^{211}At, $^{125}I^-$ and $^{131}I^-$ in Rats

Johan Spetz, Nils Rudqvist, and Eva Forssell-Aronsson

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Study design

- Male rats i.v. injected with ~200 kBq ^{125}I, ^{131}I and ^{211}At
- Animals killed at 1 h to 7 d after injection
- Organs excised and radioactivity measurements performed

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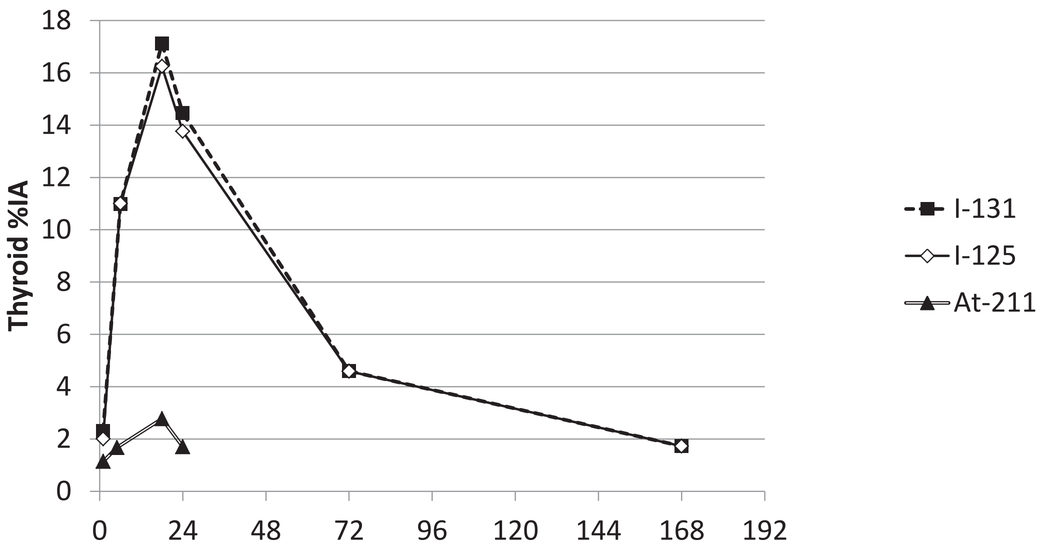
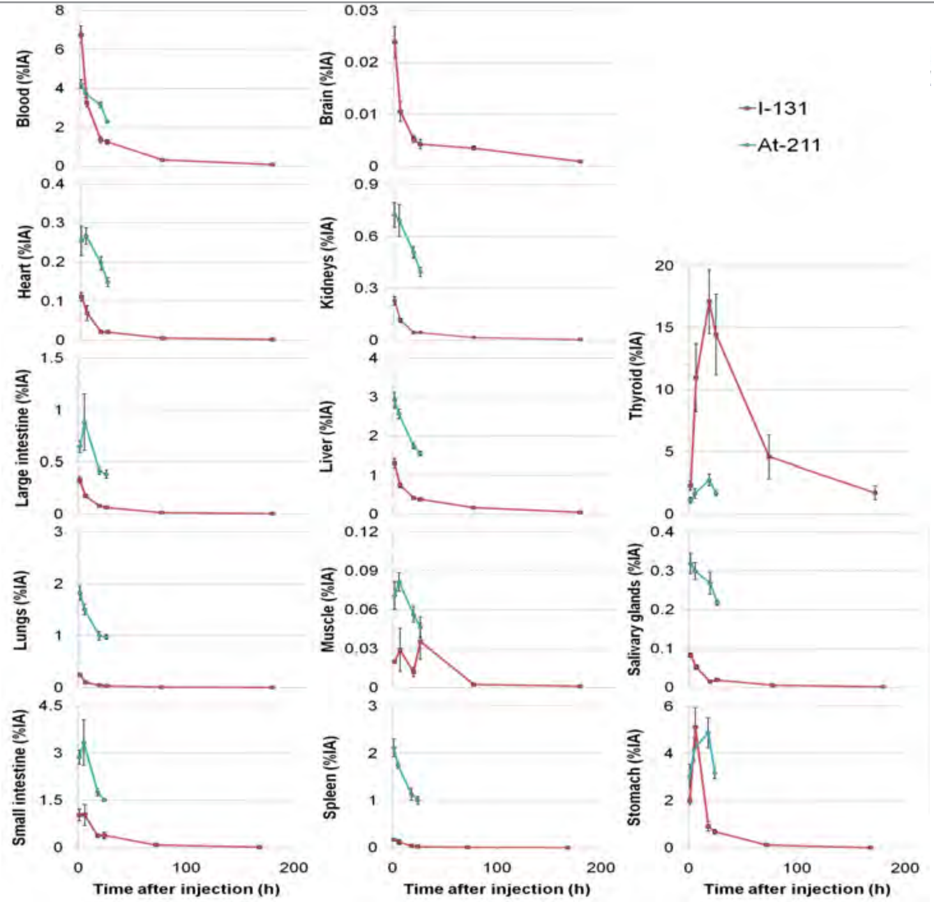
Wallac 1480 WIZARD 3” NaI(Tl) gamma counter

Study design

- Male rats i.v. injected with ~200 kBq ^{125}I, ^{131}I and ^{211}At
  - *Kept on iodine-deficient food for 3 weeks before injections*
- Animals killed at 1 h to 7 d after injection
- Organs excised and radioactivity measurements performed
- Absorbed doses calculated using the MIRD formalism

Radioactivity in thyroid





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Absorbed doses (mGy/MBq)

Tissue	^{131}I	^{211}At
Blood	8.6 (0.4)	98 (3)
Brain	0.82 (0.07)	-
Heart	16 (1)	190 (20)
Kidney	7.0 (0.4)	390 (20)
Large intestine	4.2 (0.2)	210 (40)
Liver	5.9 (0.4)	230 (20)
Lung	6.5 (0.3)	1100 (100)
Muscle	7.1 (1.2)	130 (10)
Salivary glands	5.0 (0.5)	280 (10)
Small intestine	10 (2)	340 (50)
Spleen	4.6 (0.6)	1000 (50)
Stomach	64 (5)	1200 (100)
Thyroid	21000 (2000)	18000 (4000)

Note. Data are given as the mean (SEM).

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Overview

- Biokinetics of ^{125}I, ^{131}I and ^{211}At *in vivo*
  - *Radioactivity measurements in normal organs*
  - *Activity concentrations and absorbed doses in normal organs*
- Biological effects of low-dose radionuclide exposure *in vivo*
  - *Gene expression and microarray method*
  - *Dose-response of ^{211}At in mouse normal tissues*
  - *Dose-response of ^{131}I in mouse normal tissues in dependence of time-of-day of exposure initiation*

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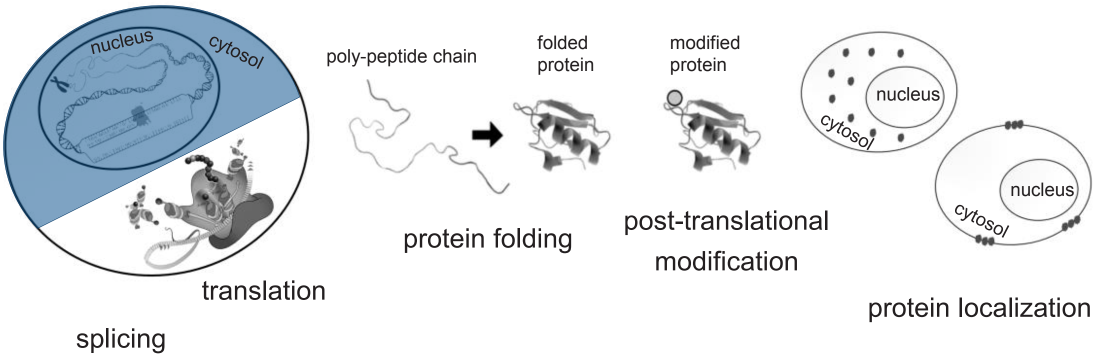
Study of biological effects

Gene expression and microarray analysis



Transcriptomic analysis using the Illumina MouseRef-8 Whole Genome Beadchip platform

High-throughput analysis of more than 19,100 unique genes and around 25,600 transcripts

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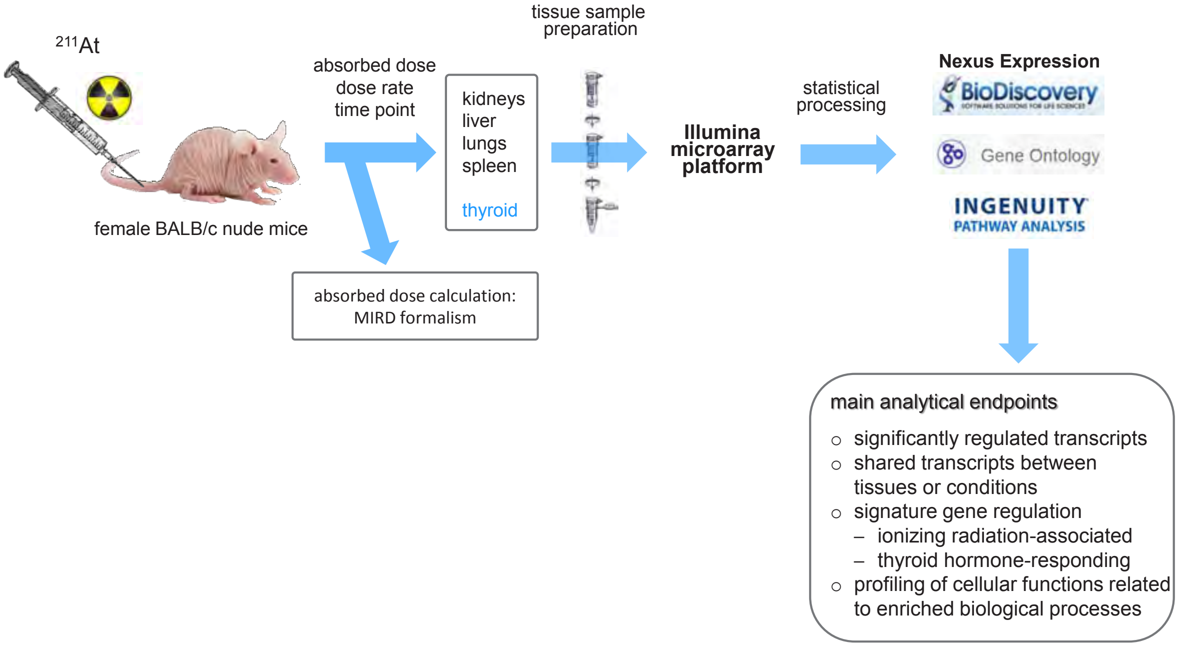
Workflow – Langen *et al.*, 2013. *JNM*. & Rudqvist *et al.*, 2012. *EJNMMI Res*.



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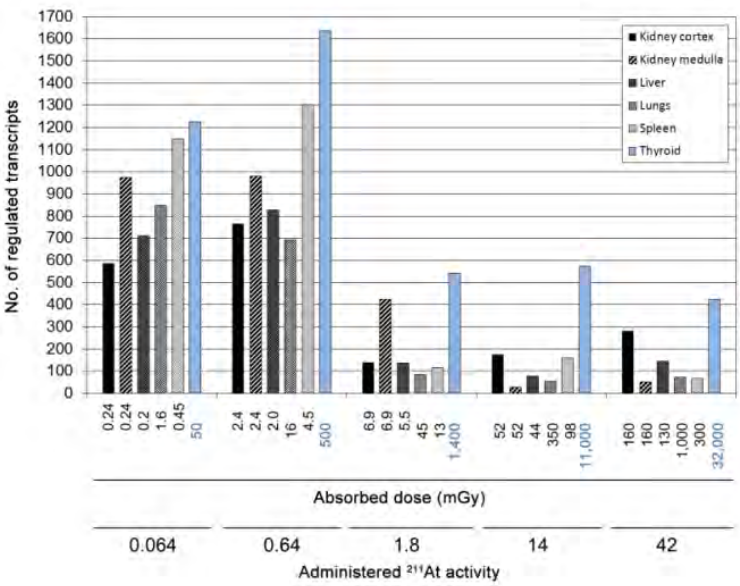
Total transcriptional regulation after 24 h



Britta Langen, PhD thesis 2015; Gothenburg, Sweden.

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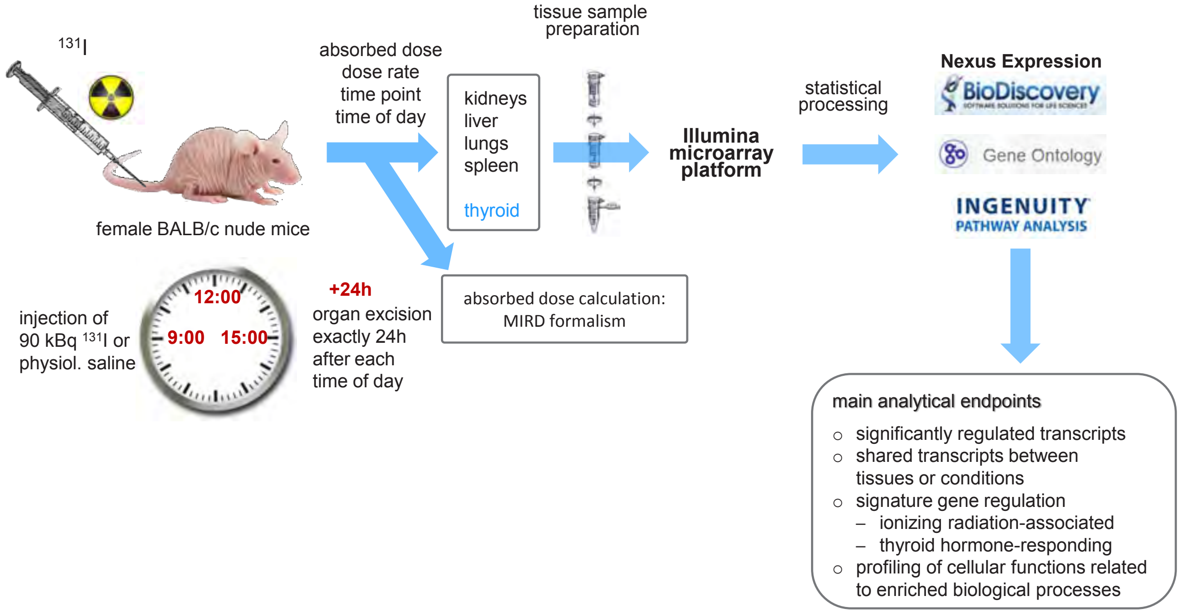
Workflow – Langen *et al.*, 2015. *EJNMMI Res.*



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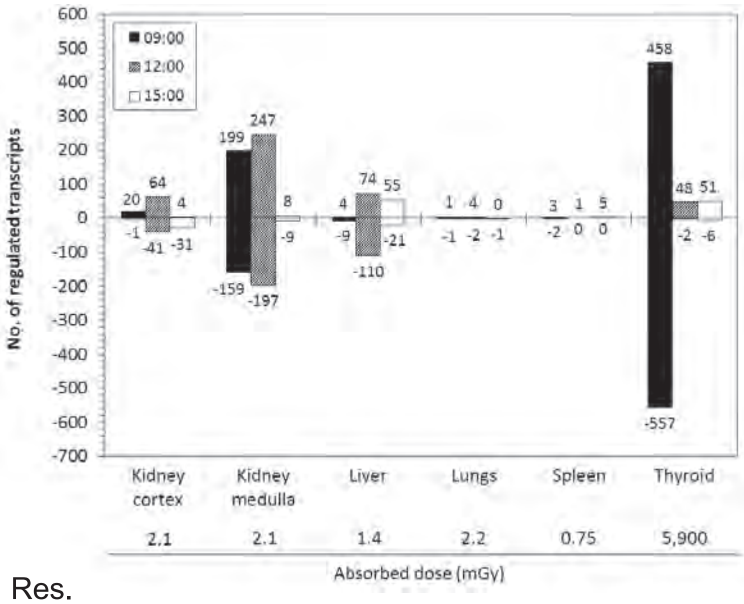
Absorbed dose

Mean absorbed dose (mGy)	
Kidney cortex	2.1
Kidney medulla	2.1
Liver	1.4
Lungs	2.2
Spleen	0.75
Thyroid	5 900

Mean absorbed dose (mGy) over 24 h from 90 kBq ^{131}I

The number of significantly regulated transcripts is dependent on the time-of-day of administration



Langen *et al.*, 2015. EJNMMI Res.

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Conclusions

- The biokinetics of radioiodine and astatine are different
- The thyroid selectively accumulates iodine and astatine
  - About five times less astatine
- Non-monotonous dose-response of transcriptional gene regulation upon radionuclide exposure
  - strong effects at (very) low absorbed dose
  - effects not directly proportional to absorbed dose level
- Circadian rhythm influences strength of biological response to absorbed dose

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Outlook

Upcoming study:

Do uptake-kinetics vary with circadian rhythm?

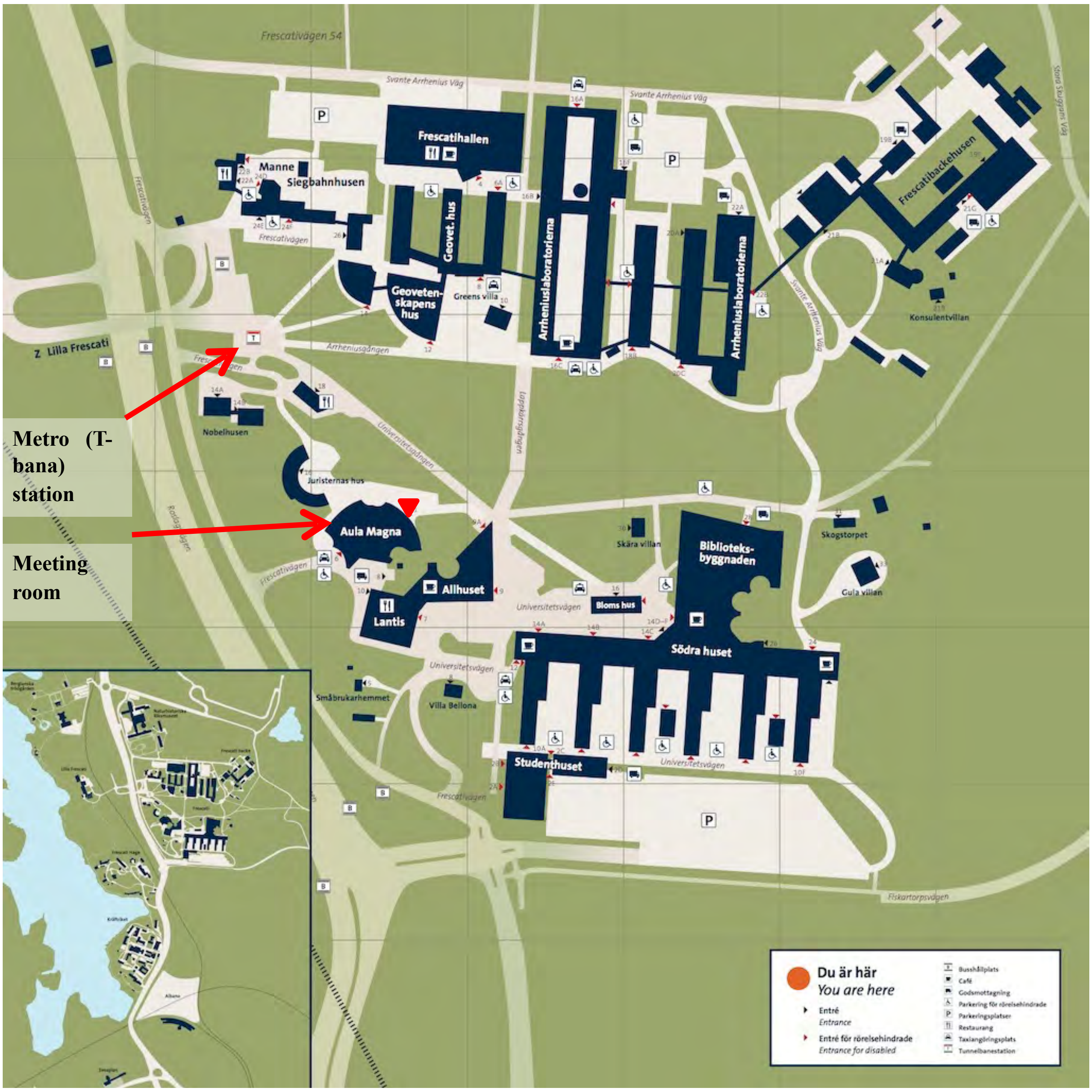
Chapter 4
Workshop at Stockholm University

Japanese-Swedish Radioecology Workshop

Stockholm University, Sweden, 3-4 September 2015

(Meeting room 'Bergsmannen' in the building 'Aula Magna')

The meeting location:



The red triangle shows the main entrance to Aula Magna – from there there will be signs to the meeting room 'Bergsmannan'. See http://tinyurl.com/obn6gu8 for a zoomable map.

Getting to Stockholm University from central Stockholm:

Take the red line on the Metro (Swedish: Tunnelbana or T-bana), final destination Mörby Centrum. Get off at ‘Universitet’. A map of the T-bana network can be found here: http://sl.se/ficktid/karta/vinter/Tub.pdf (the numbers in brackets show the number of minutes travel from the central station 'T-Centralen').

More information in English about public transport in Stockholm can be found here http://sl.se/en/

Transport to/from the airport:

If you are coming straight from the airport (Arlanda) to the meeting, taking a taxi is probably the fastest and easiest option. Make sure you use one of the larger companies such as Taxi Stockholm, Taxi 020 or Taxi Kurir all of whom have fixed prices from the airport.

If you are travelling to a central hotel, train or bus is probably better -

For those of you arriving at **Arlanda** airport (https://www.swedavia.com/arlanda/), the quickest (but most expensive) option is the Arlanda Express train: https://www.arlandaexpress.com/. It takes 20 mins to Stockholm Central station. There are also airport buses: http://www.flygbussarna.se/en which take c. 40 minutes to Cityterminalen at Stockholm Central station but are half the price.

Schedule

Time	Activity	Speakers
08:30	Welcome, round the table introductions	
09:00	The Chernobyl accident - consequences and radiation risks in Sweden nuclear accident	Leif Moberg, former Research Director of the Swedish Radiation Safety Authority
09:30	Agricultural implications of Fukushima	Keitaro Tanoi for Tomoko Nakanishi, University of Tokyo
10:00	tea/coffee break	
	Session 1: Wildlife	
10:30	Ecological measurements and monitoring of large terrestrial animals in Sweden	Robert Weimer, Swedish University of Agricultural Sciences
10:50	Radiocesium contamination in wild boar	Keitaro Tanoi, University of Tokyo
11:10	Wetland radioecology post-Chernobyl and doses to frogs from Cs-137	Karolina Stark, Stockholm University
11:30	Current conditions of fisheries, radioactive contamination of seafoods, and fish ecologies on fishing ground in Fukushima	Tomoya Hori, Kyoto University
11:50	Role of trophic transfer in benthic ecosystems off Fukushima	Clare Bradshaw, Stockholm University
12:10	Understanding of the consumer's purchase intentions on salted salmon produced in Miyagi prefecture in Japan and its determinant factors	Takashi Suzuki, University of Tokyo
12:30	Lunch	
	Session 2: Plant uptake	
13:45	Long-term desorption kinetics of Cs from soils	Kento Murota, University of Tokyo
14:05	Interception and storage of wet deposited radionuclides in crops	Stefan Bengtsson, formerly Swedish University of Agricultural Sciences and Fukushima University
14:25	Comparing Cs dynamics in two rice cultivars, Milyang23 and Akihikari, by tracer experiments	Shuto Shiomi, University of Tokyo
14:45	The analysis of characterization of cesium accumulation in wild radish	Nanami Oshima, Kyoto University
15:05	Phytoremediation - Is it possible to use plants to clean up after radioactive releases?	Maria Greger, Stockholm University
15:25	The impact of potassium fertilization: Investigation by the radioisotope tracer experiment	Natsuko I. Kobayashi, University of Tokyo

15:45	tea/coffee break	
16:15	Ecosystem modelling for a future high-level nuclear waste repository in Forsmark, Sweden	Ulrik Kautsky, Swedish Nuclear Fuel and Waste Management Company
16:35 – 17:30	General discussion	
18: 30	Evening dinner at Stockholm University	

4.1 The Chernobyl accident – consequences and radiation risks in Sweden

Leif Moberg
Presenter: Leif Moberg
Former Research Director at the Swedish Radiation Safety Authority.

The Chernobyl accident – consequences and radiation risks in Sweden

Leif Moberg*

*Former Research Director at the Swedish Radiation Safety Authority
E-mail: lcmoberg@gmail.com

Content

- The radioactive cloud and deposition in Sweden
- Initial countermeasures
- Consequences in the environment
- Dose limits for food products
- Radiation doses to the Swedish population
- Communication of decisions and radiation risks
- Experiences and lessons learned

Forsmark nuclear power plant

In the morning 28 April 1986, the Swedish authorities were informed about a possible radioactive leak at the Forsmark NPP.

Employees at Forsmark NPP were evacuated

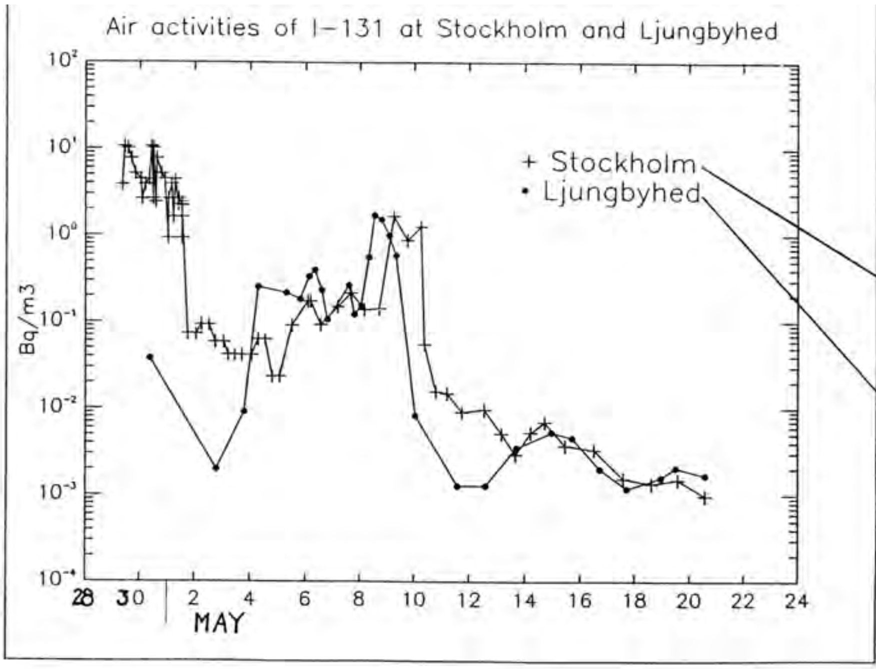
[Picture from an article by Anders Marklund in Strålskyddsnytt Nr 1, 1996]

The Soviet news agency TASS in the evening of 28 April 1986: An accident has occurred at the Chernobyl nuclear power plant, one of the reactors is damaged. Actions are taken to handle the consequences of the accident. Injured people are treated. A governmental commission has been appointed.

The origin of the radioactive contamination at Forsmark was a reactor in Ukraine.

Chernobyl – a catastrophy

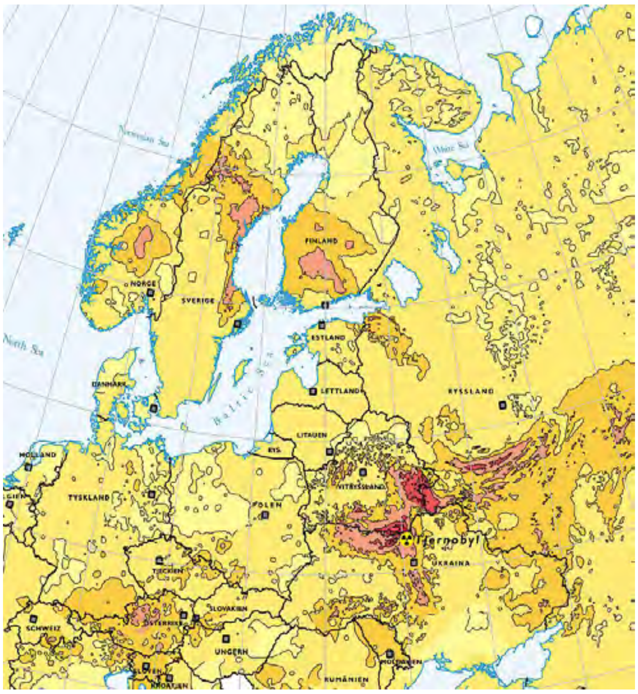
01.23 local time, 26 April 1986



FOA 215 NUCLEAR DETECTION

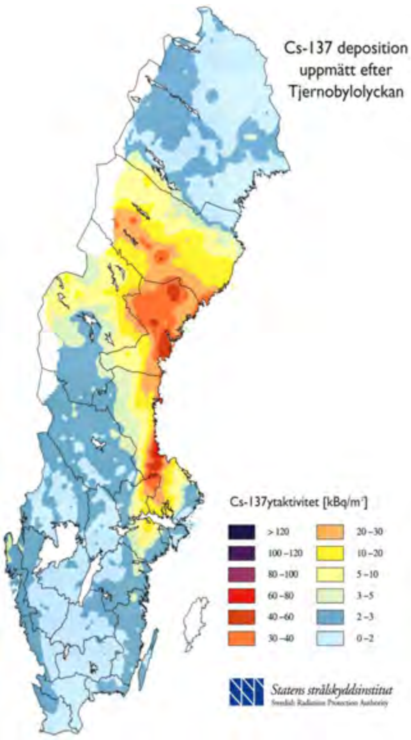
Increased I-131 activities in air occurred at two occasions, the last days of April and 8-10 May 1986.
[Chernobyl – its impact in Sweden, SSI-rapport 86-12]

Ground deposition of Cs-137



European Commission ©EU/IGCE

Deposition of Cs-137 in Sweden



- 4.25 PBq or about 5% of the Cs-137 released from Chernobyl deposited in Sweden
- About 5 % of the released Cs-137 also deposited in the Baltic sea.

Detected radionuclides

Sr-90	Cs-134
Zr-95	Cs-136
Nb-95	Cs-137
Mo-99	Ba-140
Ru-103	La-140
Ru-106	Ce-141
Rh-105	Ce-143
Sb-127	Pu-238
Te-129m	Pu-239+240
Te-131m	Pu-241
Te-132B	Am-241
I-131	Cm-242
I-133	....

Possible actions/countermeasures

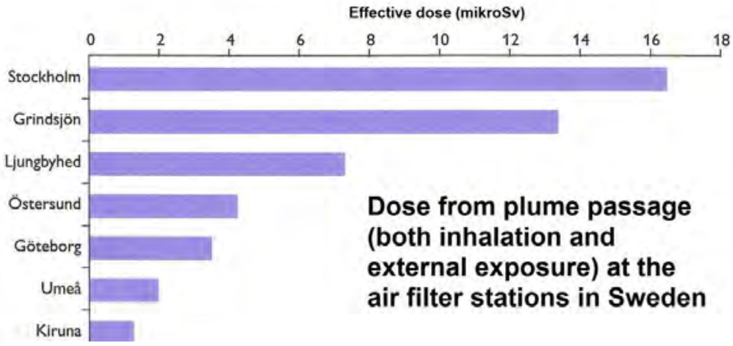
- Staying indoors/sheltering
- Evacuation/relocation
- Remediation, decontamination
- Iodine prophylaxis

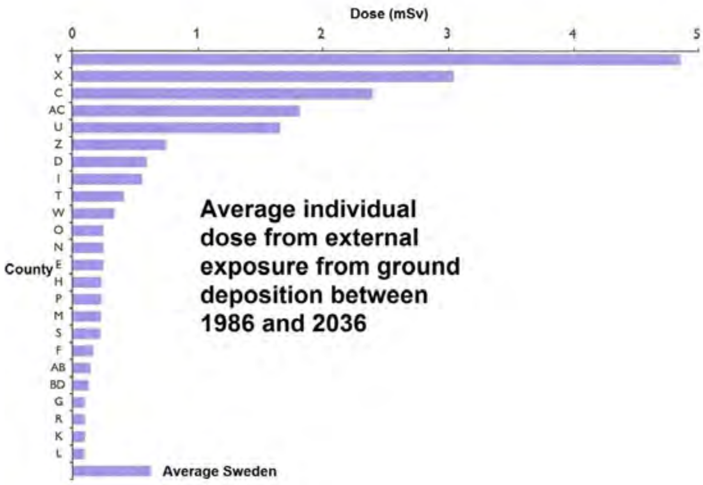
Not judged to be necessary in Sweden

- In this presentation: radiation doses and Cs in the environment

External dose

- Average dose from plume passage 0.01 mSv.
  - May have been considerably higher in certain areas.
- Average dose from ground deposition 0.6 mSv during 50 years.
- Highest dose from ground deposition 4 mSv first year and 33 mSv during 50 years.





[Graphs from an article by Robert Finck in Strålskyddsnytt Nr 1, 1996]

What is an acceptable radiation dose?

Basis for decisions in 1986:

- Highly justified to avoid long term individual doses (50 years) above 500 mSv
- Not justified to take measures with great social and economical impact for society or individuals to avoid long term doses less than 50 mSv

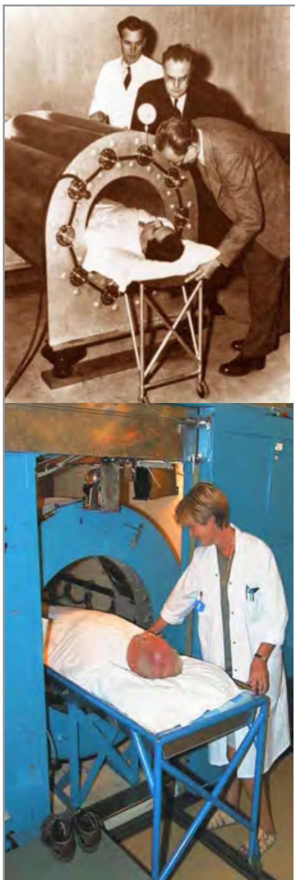
- The authority (SSI*) chose the lower end of the interval, i.e. 50 mSv in 50 years
  - The dose during the first year should be less than 5 mSv and in the following years less than 1 mSv/y in average

*The Swedish Radiation Protection Authority (SSI), since 2008 the Swedish Radiation Safety Authority (SSM)

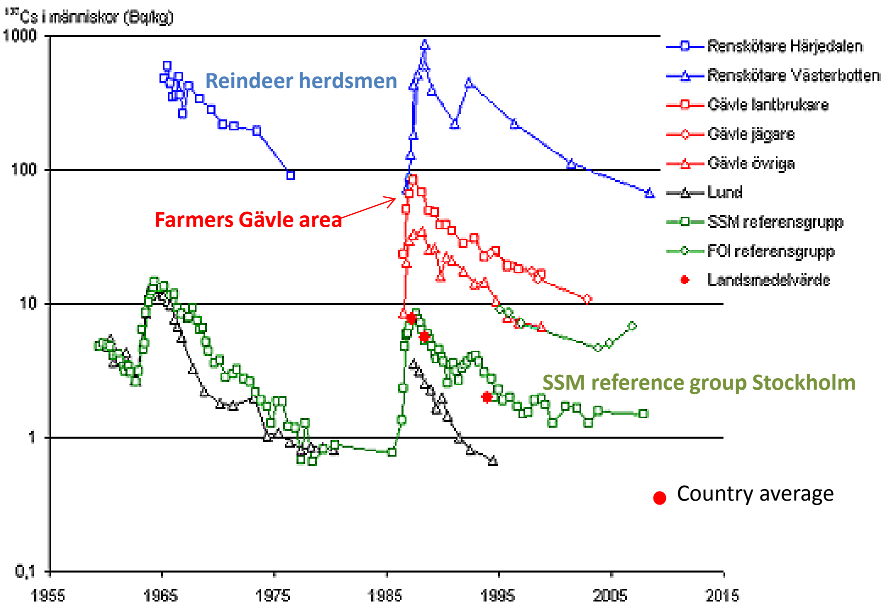
Food limits in Sweden

- In May 1986: 300 Bq/kg Cs-137
  - This should guarantee a long term average radiation dose less than 1 mSv/y
  - Annual intake less than 50 000 Bq Cs-137 incl. contribution from Cs-134
- In June 1987: the limit for reindeer meat, game meat, fish from lakes, wild berries, mushroom and nuts was increased to 1 500 Bq/kg.

Diet recommendations issued by the Swedish National Food Agency in 1987



Cs-137 (Bq/kg) in the body

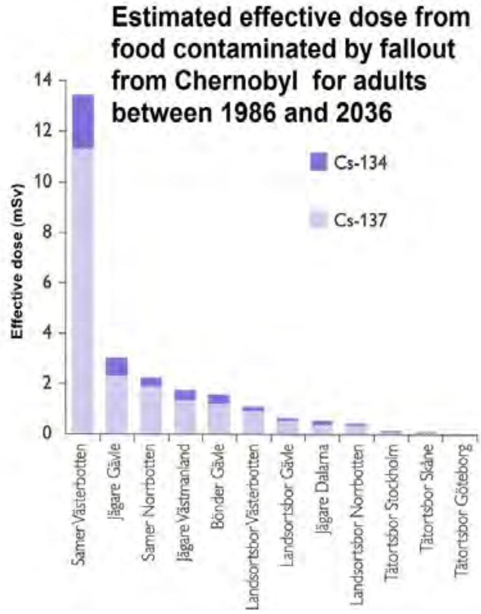


[Pictures : Swedish Radiation Safety Authority]

[Rolf Falk, Christopher Rääf, Göran Ågren et al]

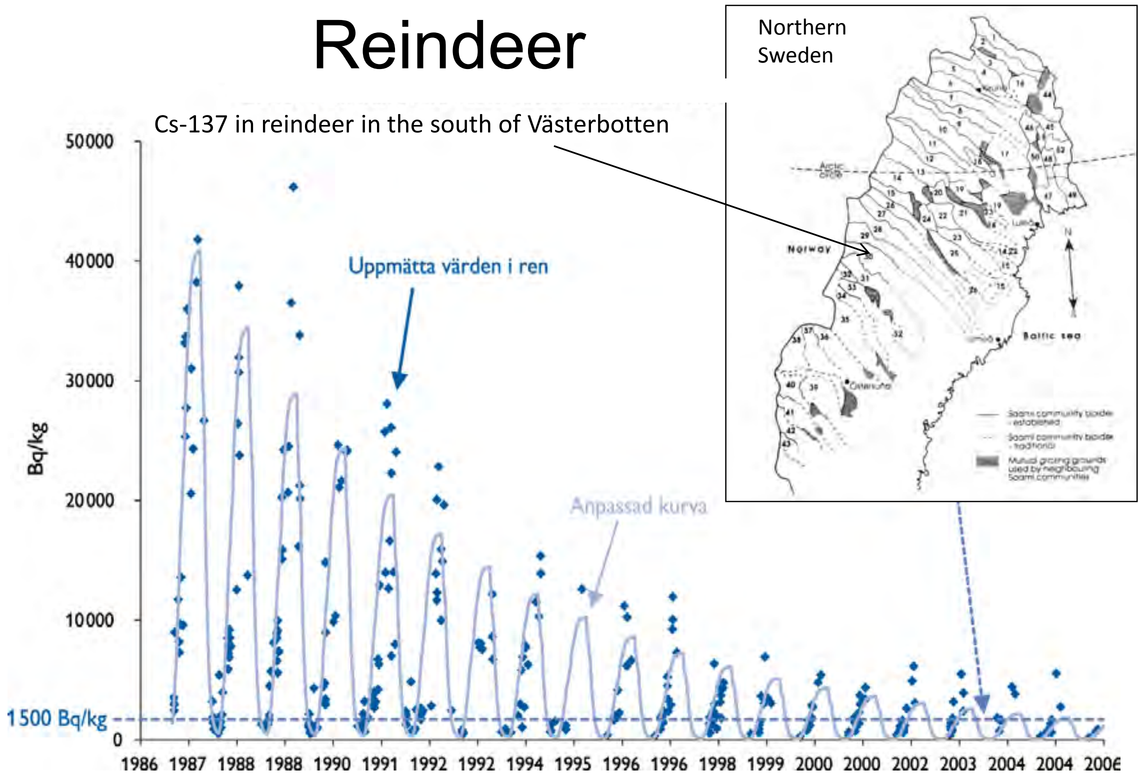
Internal doses from food

- Studies based on fallout from the atmospheric nuclear bomb tests identified reindeer farmers as the most critical group in Sweden.
- Average 50 year dose from eating food with Cs-137 and Cs-134 is 13.2 mSv in this group.



[Rääf , Strålskyddsnytt Nr 1, 2006]

Reindeer



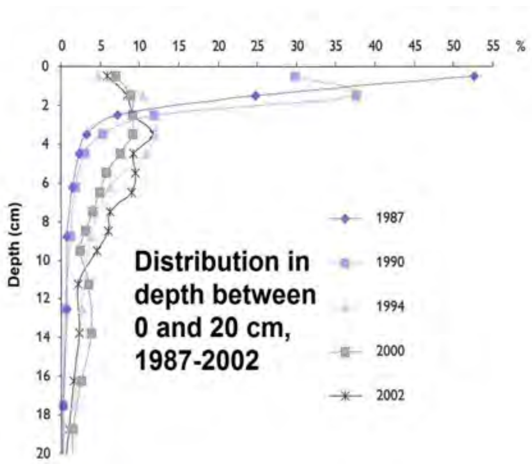
[B Åhman, Strålskyddsnytt Nr 1, 2006

Consequences for reindeer industry

- 78% of reindeer meat was destroyed the first year (>300 Bq/kg) = great cost and adverse conditions for reindeer herders
  - 0.003 mSv to average Swede (22000 reindeer between 300 – 1000 Bq per kg)
- Second year 29 % destroyed (>1500 Bq/kg); some years later less than 1% destroyed; a result of various countermeasures

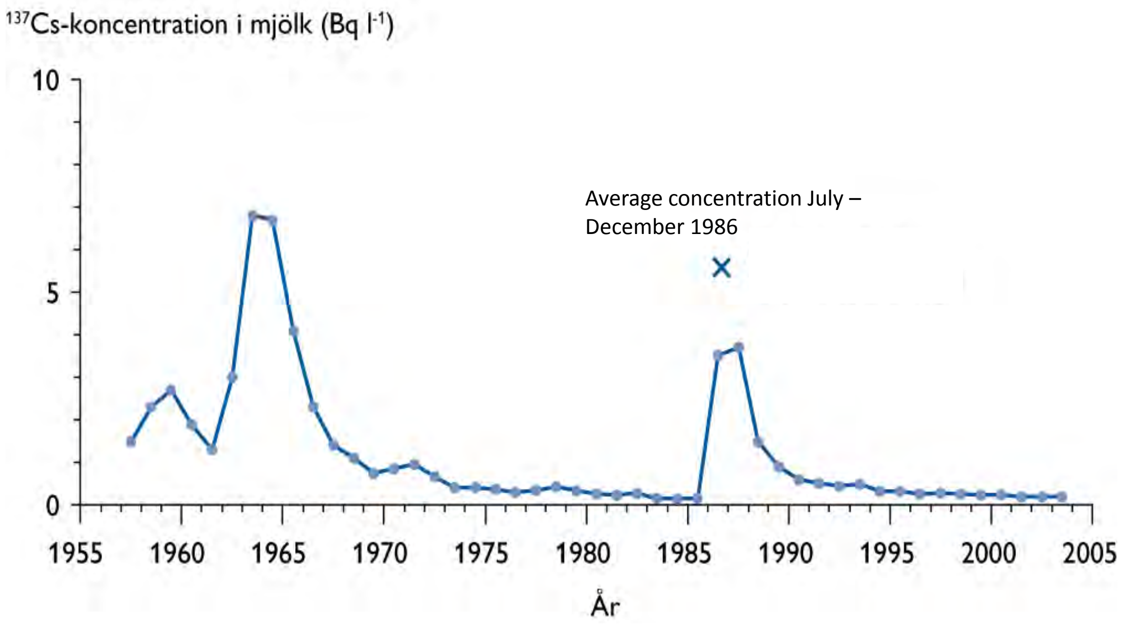
Agriculture

- Cows not allowed to graze outdoors until the area had been cleared based on grass measurements.
- The first harvest was performed by cutting the straws at an increased height.
- Increased frequency of ploughing combined with potassium fertilizer most effective countermeasure.
- Consequences mainly in 1986 and 1987



[Rosén . Strålskyddsnytt Nr 1, 2006]

Milk (Cs-137 Bq/l, country average)



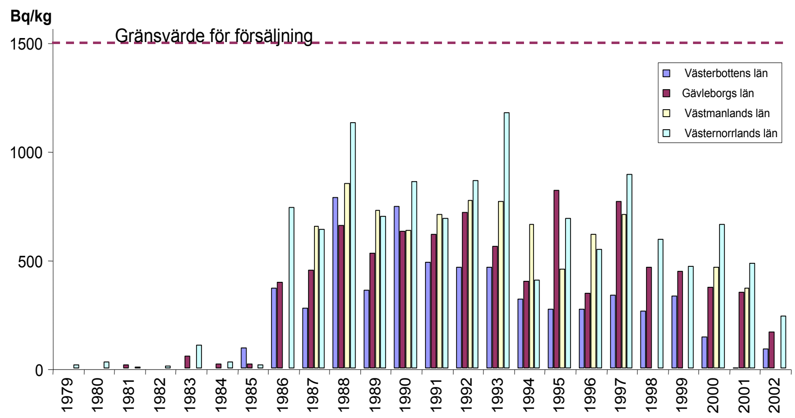
[P Andersson, Strålskyddsnytt Nr 1, 2006]

Cs-137 in forests

- The content in mushrooms can be very high (and still be above the food limit in some areas of Sweden)
- The content in wild berries is on average one tenth of that in mushrooms.
- The content in moose, which is important for hunting in Sweden, follow the Cs-137 content in wild berries.

Cs-137 in moose (Bq/kg)

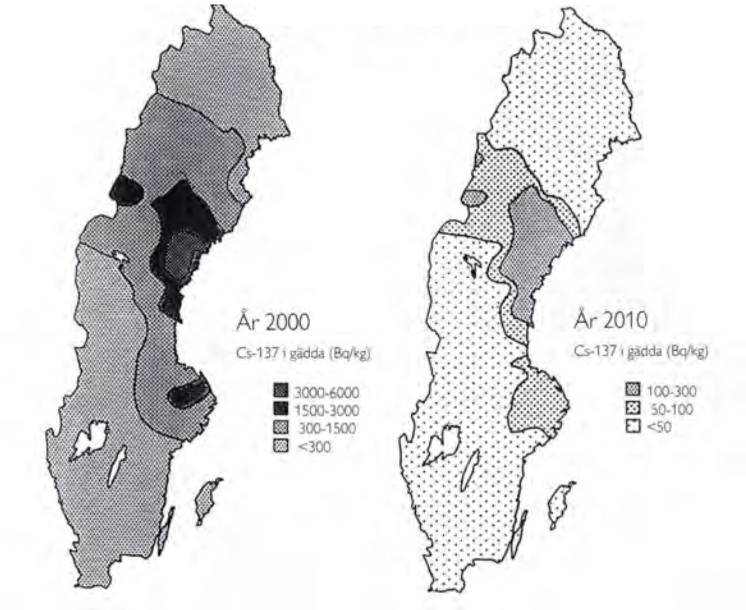
[Data from the database at SSM]



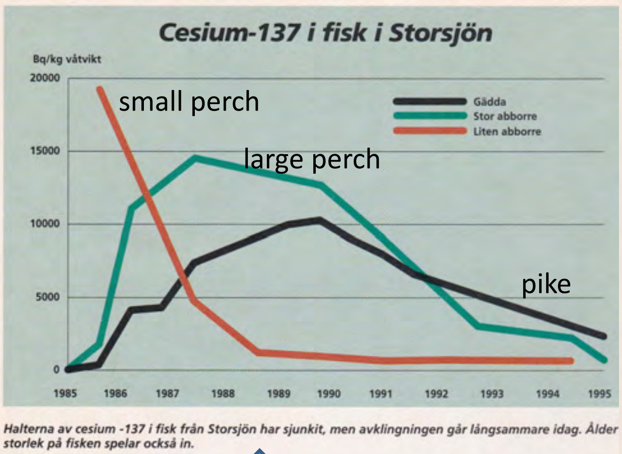
Cs-137 in lakes

- 1987 – Cs-content in fish above 1500 Bq/kg in 14000 lakes
- 2010 – Cs-content in fish *predicted* to be below 300 Bg/kg on a regional basis
- The content in fish from inland lakes can still be above 1500 Bq/kg Cs-137 in some areas.

Cs-137 in pike (Bq/kg fw)

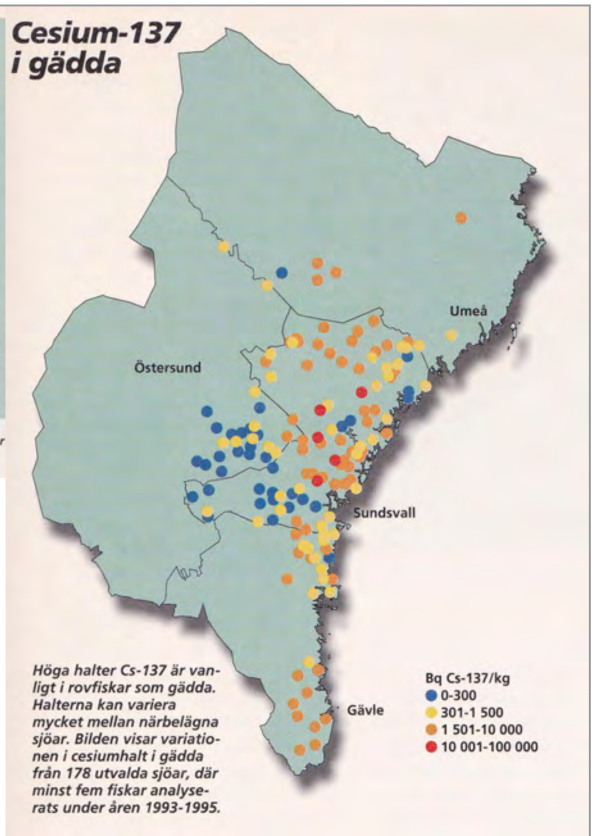


[Håkanson, Strålskyddsnytt Nr 1, 2006]



Cs-137 in pike, large and small perch in Storsjön

Cs-137 in pike in 178 lakes 1993-1995



[Vår Föda Nr 3, 1996]

Risk communication pre-internet

Information channels 1986

- Media
- Press releases
- Reports and brochures
- Public meetings
- Telephone and fax
- Via other authorities and decision-makers

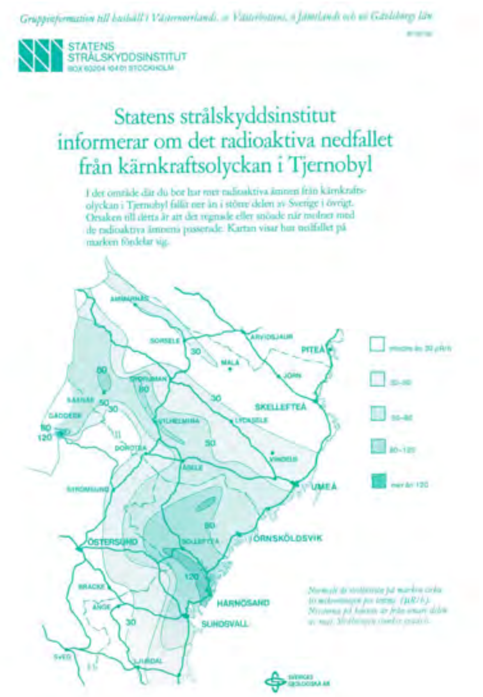
In addition today

- Internet (web pages, social media, e-mails…)

Brochure distributed to households in the counties of Uppsala, Västmanland and Gävleborg 26 May 1986

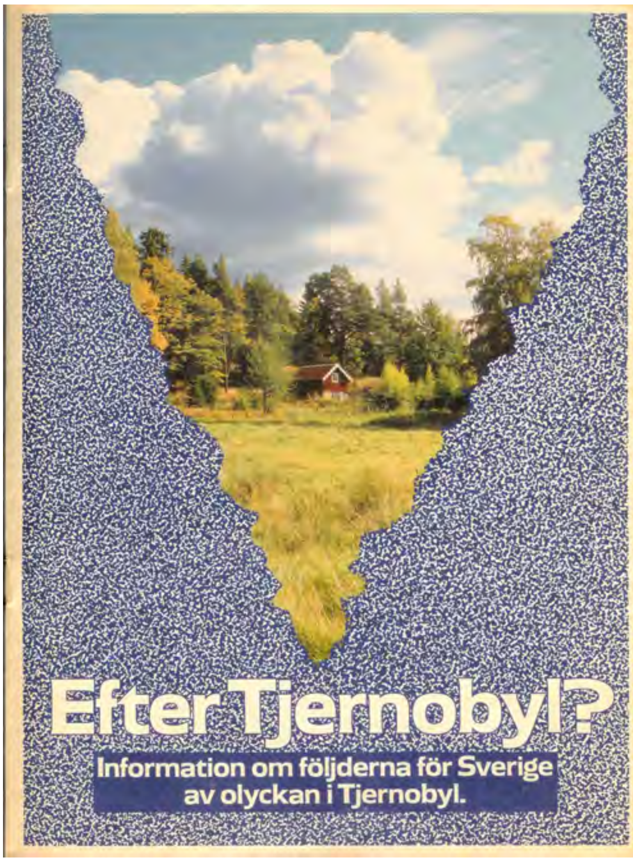
See Appendix 1 for the entire brochure.

Brochure distributed to households in the counties of Västernorrland, SW Västerbotten, E Jämtland and NE Gävleborg 4 June1986



Brochure distributed to all households in Sweden
(autumn 1986)

After Chernobyl?
Information about the consequences in Sweden of the accident in Chernobyl



See Appendix 2 for the entire brochure.

Experiences and lessons learned 1

- Comparing risks is difficult
  - Cigarette smoking, driving a car, being struck by lightning, drowning, x-ray examinations, radon in houses
- Some risks are taken voluntarily others not, some risks (may) cause health effects later in life, other can cause death instantaneously
  - Individuals interpret similar risks in different ways
- Differences in how laymen and experts interpret risks associated with radiation
  - ”small radiation doses are harmless”, i.e. harmless in a more everyday terminology and in comparison with many other risks we subject ourselves to on a daily basis
- ”Ionising radiation” itself evokes a sense of danger

Experiences and lessons learned 2

- Confidence
  - Complete openness in providing information and assessment of the situation as it becomes available is necessary
- Measurements of radiation levels (ground, foodstuffs)
  - Important to communicate rapidly

Experiences and lessons learned 3

Finally,

- Society must guarantee a certain minimum protection level but in the end it is the individual who decides what protection he/she wants
- Therefore, authorities are responsible for both the societal protection level <u>and</u> for providing the individual with adequate information for making his/her own assessments.

Summary Sweden

- Larger consequences than expected from a nuclear accident abroad
- 5 % of released cesium-137 deposited in Sweden (4,25 PBq)
- Only cesium-137 today, in forests and lakes
- No observable radiation induced health effects expected
- Many people have felt a lower quality of life

- A major radioecological research program was initiated

- Substantial improvements in nuclear emergency preparedness after 1986

4.2 Agricultural implications of Fukushima nuclear accident

Tomoko M. Nakanishi†,[1]
† Presenter: atomoko@mail.ecc.u-tokyo.ac.jp
1 Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1, Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan

More than 4 years have passed since the Fukushima Daiichi nuclear power plant accident. More than 110,000 people who were evacuated from the area remain at locations different from where they used to live. Immediately after the accident, the Graduate School of Agricultural and Life Sciences at Tokyo University created an independent team from a wide variety of research specialties including soil, vegetation, animal life, fishing, and forestry. This team entered sites in the affected areas immediately after the accident and initiated research studies. They are continuing their research to determine the effects of the accident on agricultural fields. Our Graduate School includes many research areas, and many facilities such as meadows, experimental forests, and farming fields are associated with the school. Employing these facilities, many on-site research studies have been conducted in Fukushima Prefecture.

It was important to the Graduate School of Agricultural and Life Sciences that the results of these research studies contribute to the recovery of the affected area; therefore, we have endeavoured to officially publish the results. For example, 11 meetings have been held since November 2011 to report research results. The objective of these meetings was to provide a simple explanation of the results of the research studies so that the general public could understand them. We published two books about the research on Fukushima, one through Springer Publishing Company and the other as an easy-to-understand book written in Japanese. The books were published to allow a wide range of ordinary people to have a correct understanding of the impact of radioactive material on agricultural, forestry, and fishing products and the countermeasures taken against radiation exposure.

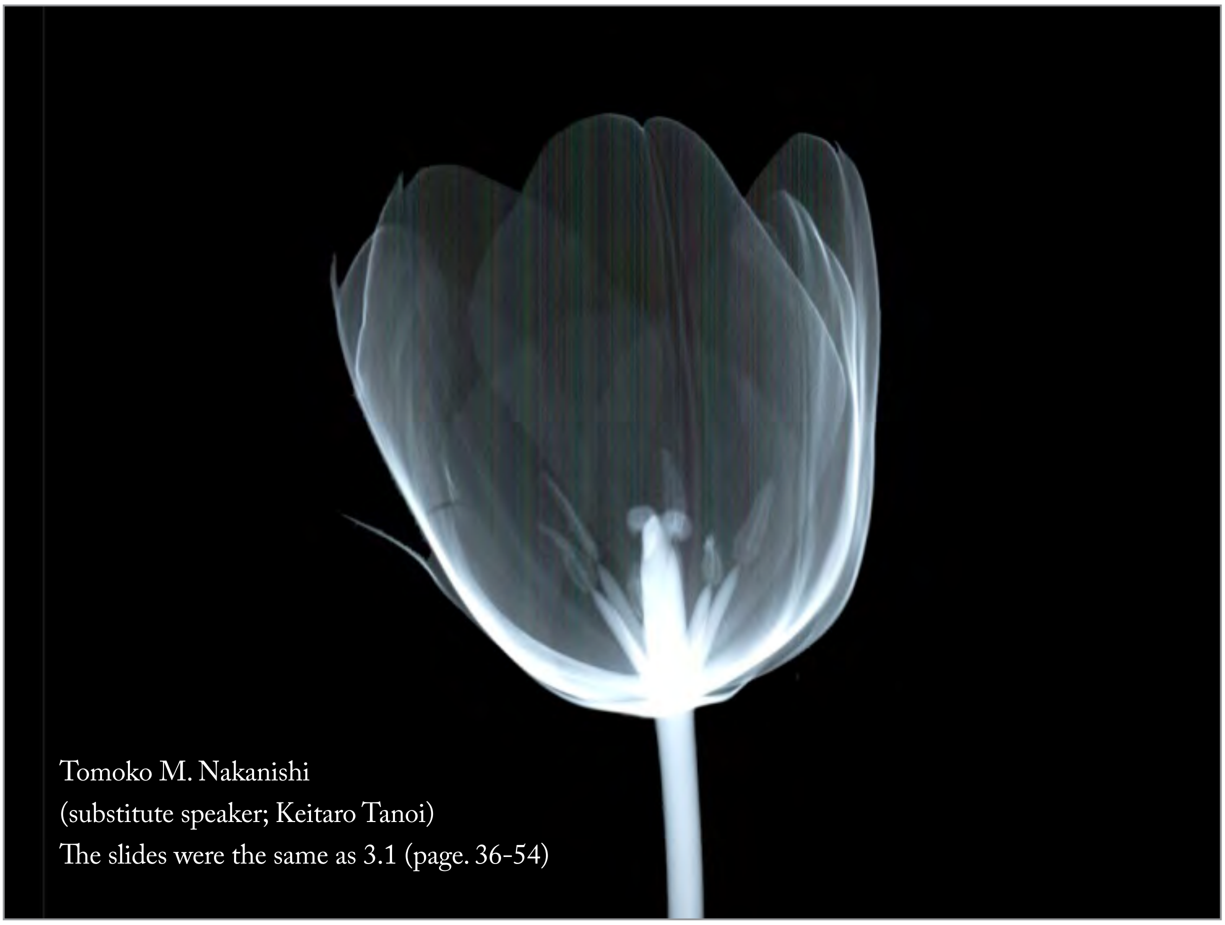
Based on the scientific data from these studies, we initiated lecture classes for students and for the general public to explain the behaviour and movement of radioactivity in the environment and to provide basic knowledge about radioactivity. To provide firsthand experience of radio-ecology in the environment for students, we periodically hold open lectures in the contaminated fields or mountains.

A major feature of the radioactive fallout is that radioactive caesium (Cs) has remained at the initial contact sites and has moved very little since the initial event. In animals, metabolic activity has reduced the radioactivity level over time at a much faster rate than the physical half-life. The biological half-life in animals was estimated to be less than 100 days. Soil plays a major role in immobilising fallout. When fallout nuclides are absorbed into the soil, little of the radioactive Cs is taken up by plants growing there. In the mountains, radioactive Cs was transferred gradually from vegetative litter to soil and subsequently moved very little, even when the soil was washed with heavy rain. The mechanism of contamination by radioactive nuclides is completely different from that of heavy metals.

Similar to the agricultural environments of other Asian countries, Japan is located in a monsoon area, with many paddy fields used to grow rice. However, the climate and agricultural environment in Japan differ from those near Chernobyl; therefore, it is important to gather information regarding the movement and features of fallout that are specific to Japan from an agricultural point of view.

It appears that the recovery of the agricultural, forestry, and fishing industries in Fukushima Prefecture will take quite some time, but the Graduate School of Agricultural and Life Sciences at Tokyo University will continue to support the recovery of these industries in the future.

Keywords: Fukushima Daiichi nuclear power plant accident, radiation contamination, agriculture, radio-ecology



4.3 Monitoring of ^{137}Cs in large terrestrial animals in Sweden

Robert N. Weimer

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Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences (SLU)

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Monitoring of ^{137}Cs in large terrestrial animals in Sweden

Robert N. Weimer (MSc in Biology)
Licentiate-student at the Department of Aquatic Sciences and Assessment, Uppsala

E-mail robert.weimer@slu.se

Forest or Mixed Ecosystems:

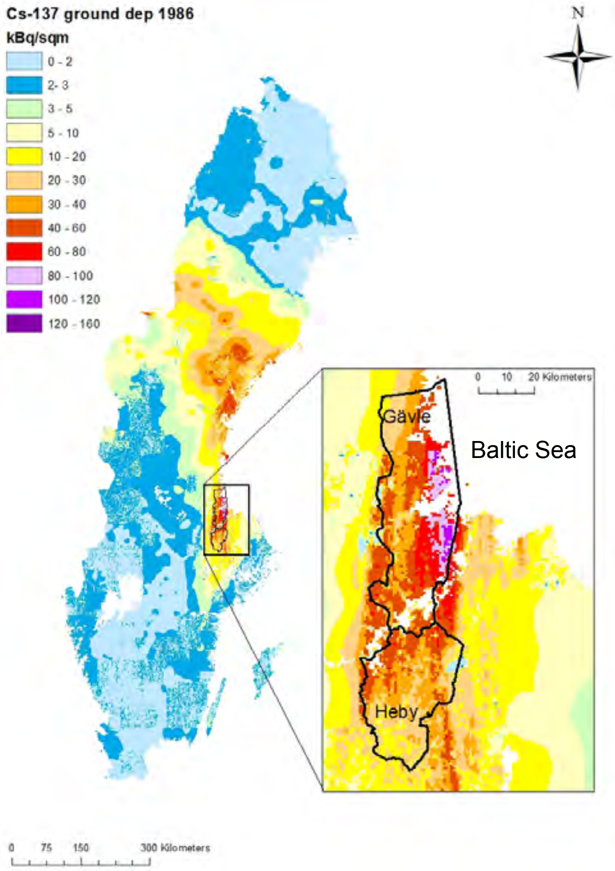
Monitoring or investigations of ^{137}Cs in animals, such as:

Species	When	Purpose
Moose (Eurasian elk) (*Alces alces*)	- autumn	meat
Wild boar (*Sus scrofa*)	- all year	meat
Brown bear (*Ursus arctos*)	- autumn	meat
Lynx (*Lynx lynx*)	- spring	mgmt

Monitoring of Cs-137 in Moose

Heby municipality
Start in 1986
~3700 samples

Gävle municipality
Start in 1986
~ 12 000 samples



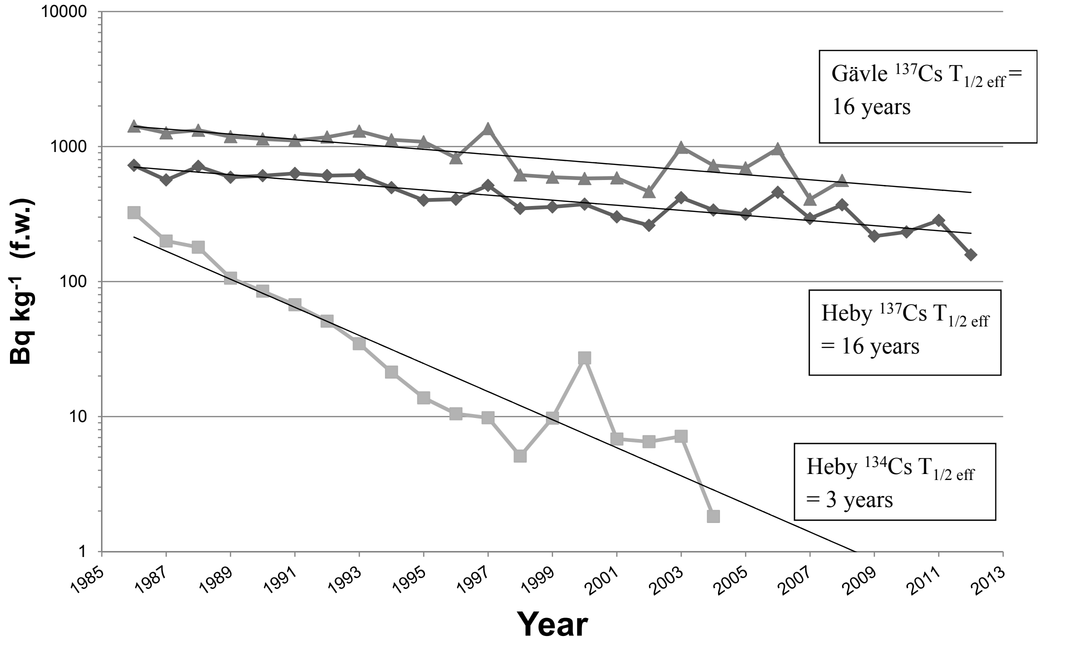
<u>My thesis</u>

Two data sets on ^{137}Cs concentrations in moose from Heby (1986-2012) and Gävle (1986-2008).

Paper 1:
descriptive

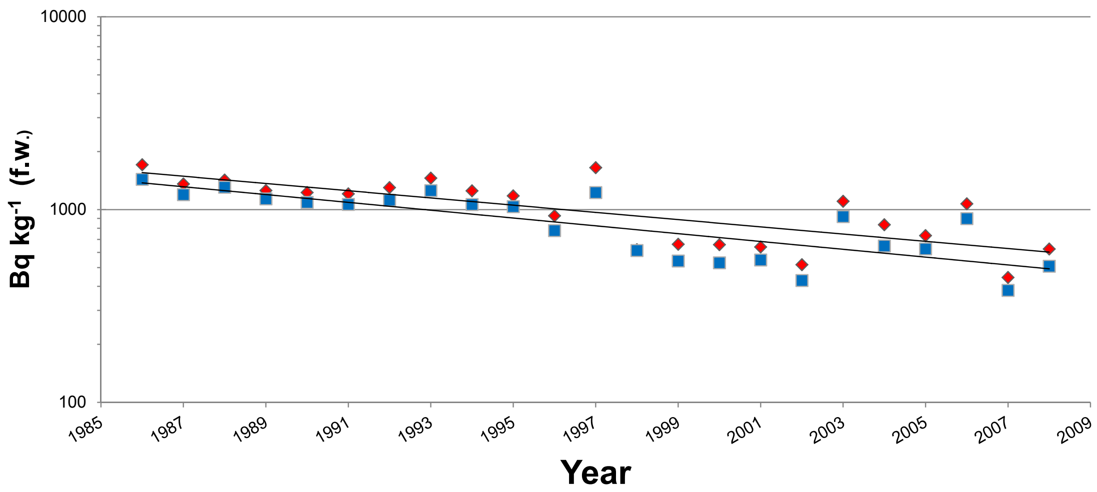
Paper 2:
modelling with multivariate statistics. (PLS)

Long-term Decline of Radiocaesium in Moose (Paper 1)



Weimer et al., unpublished data

^{137}Cs on average 18% higher in calves compared to adults (Gävle)



Weimer et al., unpublished data

Model influence of various parameters* on ^{137}Cs concentrations in moose by PLS (Paper 2)

(* Environmental variables and physical characteristics)

- Heby annual mean variation in 1986-2012 was 68% (49-98%)
- Gävle annual mean variation in 1986-2008 was 53% (46-61%)

Weimer et al., unpublished data

Explanatory variables in PLS-models

1, Information from data set on:

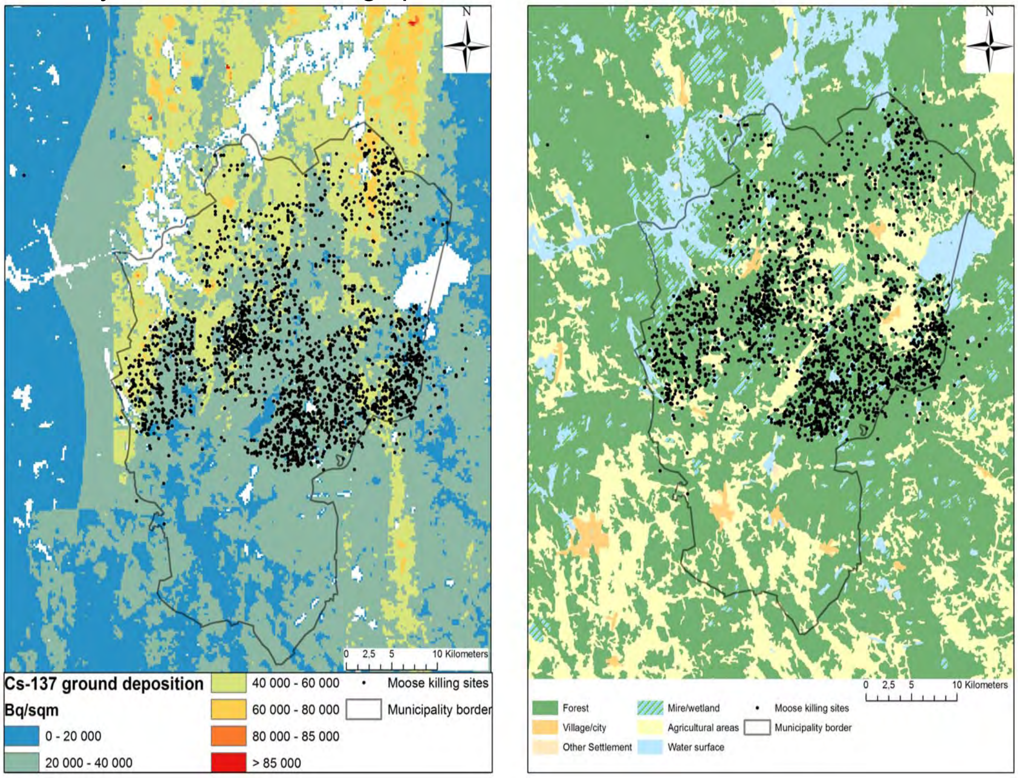
age, weight, sex, killing spot and date

2, Supplementary information on:

Rainfall (mm) and temperature (°C) in June - September

Deposition (Bq m^{-2}) and habitat (%) around killing spots (Heby)

Heby area – 2 700 killing spots



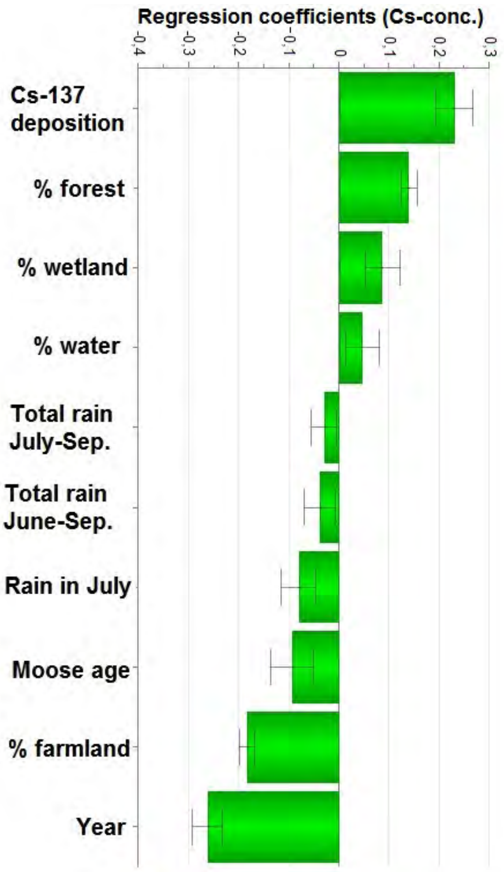
PLS-model on Heby data set

Deposition and time since deposition

Habitat type

Moose age

Weather conditions prior to hunting seson



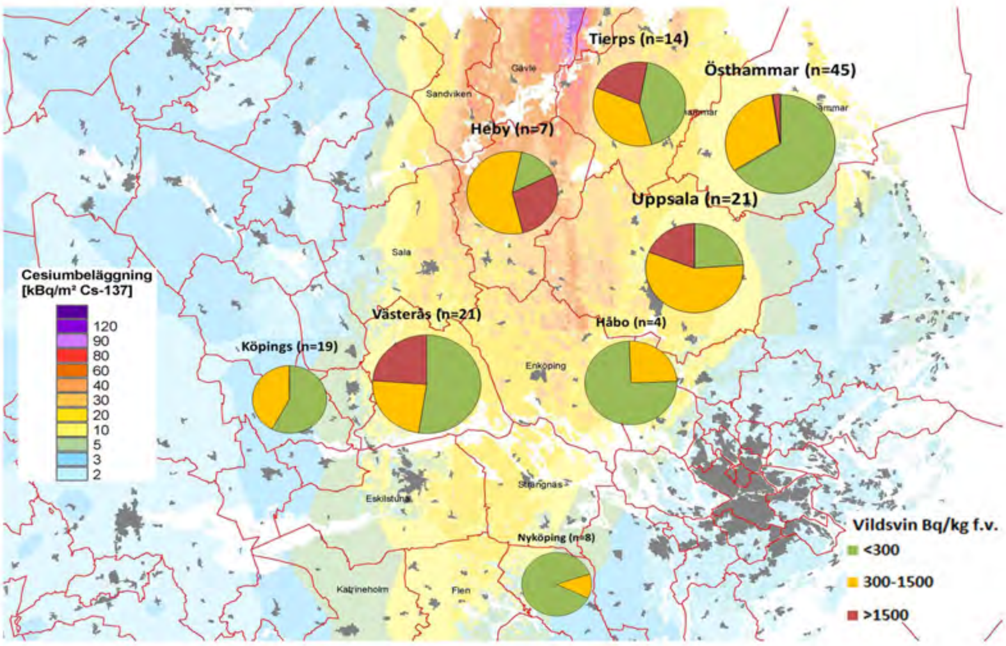
Weimer et al., unpublished data

^{137}Cs in Wild Boars in East-central Sweden, 2010-2014

- ~170 muscle samples
- High variation CV=162%
- ex, 100 and 4900 Bq kg^{-1} ,same date and place
- Lowest levels in autumn

2 x BSc-thesis, Hallqvist, E. 2013 and Frtitzon, K. 2013

^{137}Cs in Wild Boars 2010-2014

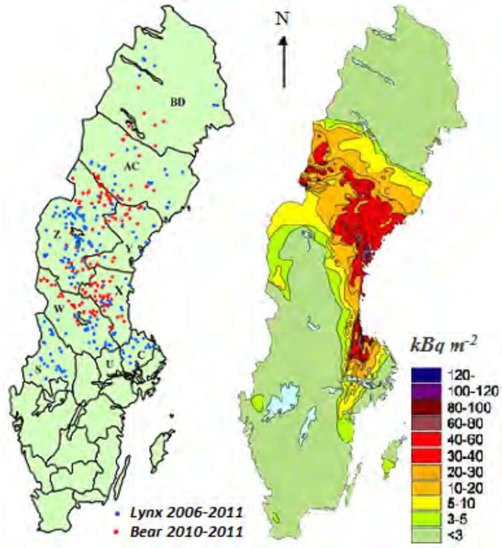


^{137}Cs in Bear and Lynx

An example from county of Västerbotten (Y)

Year	Bear (n)	Range	Lynx (n)	Range
2010	695±571 (9)	90-2020	1369±1147 (2)	558-2180
2011	553±423 (17)	48-1280	910±1943 (11)	90-6750

MSc-thesis Chaiko, Y. 2012



Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Thanks for listening!

Questions ?

4.4 Radiocaesium contamination in wild boars

Keitaro Tanoi†, [1]
† Presenter: uktanoi@mail.ecc.u-tokyo.ac.jp
1Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1, Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan

I present the distribution of radiocaesium in wild boars, as well as the official monitoring data of wild boars inspected in Fukushima Prefecture. After the Fukushima Daiichi nuclear power plant accident in 2011, the radiocaesium contamination levels in wild boars in most of Fukushima Prefecture exceeded 100 Bq/kg, which has been the limit for radioactivity in meat since April 2012 in Japan. The most contaminated wild boars were observed in Soso District, where the radiocaesium concentration in the soil was the highest in the whole prefecture. To obtain detailed information on radiocaesium contamination in wild boars, we measured radiocaesium concentrations in different organs and tissues from wild boars inhabiting Iitate Village in Soso District in 2012 and 2013. After capturing the wild boars, we collected 24 organs and tissues and placed them into vials. Using a NaI(Tl) scintillation counter, we determined the concentrations of radiocaesium (^{134}Cs and ^{137}Cs) and found that the levels were highest in the muscles (approximately 15,000 Bq/kg) and lowest in the ovaries (approximately 600 Bq/kg) in 2012, indicating large variation among the organs and tissues. The trends were similar in 2012 and 2013. Observations of the contamination levels in wild boars revealed the radiocaesium availability in the forest and village ecosystems.

Keywords: radioactive materials, radiocaesium, wild boars, Fukushima Daiichi nuclear power

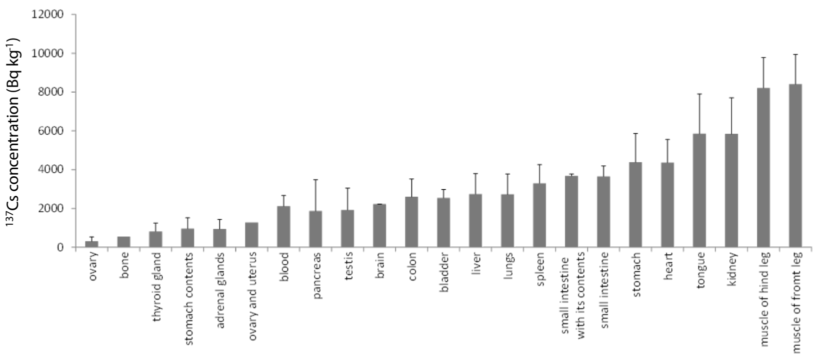
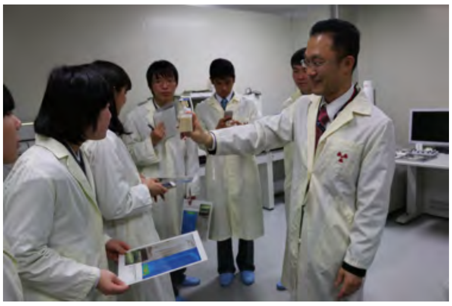


Fig.1 Radiocaesium concentration in wild boar organs in November 2012.

Radiocesium contamination in wild boars after the Fukushima daiichi NPP accident

Keitaro Tanoi



Wild boars in Fukushima

1. Introduction - Why wild boars?
2. Inspection data from Fukushima
3. Distribution of radiocesium in wild boars in 2012 and 2013
4. Summary

2

Introduction

- Significant quantities of radiocesium were released from Fukushima Daiichi NPP in March 2011
- **70-80 %** of Fukushima prefecture is Forest.

Forest in Fukushima

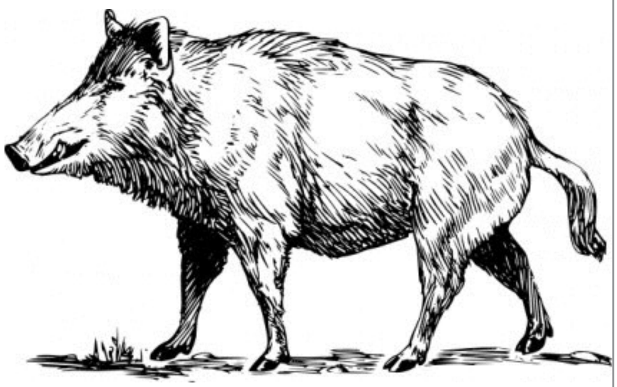
3

Introduction

- The dominant radionuclides in soil are radiocesium - ^{134}Cs and ^{137}Cs.
- Very small amount of radiostrontium (Steinhauser et al 2013) and plutonium (Zheng et al .2012) were deposited in soil.

4

Introduction



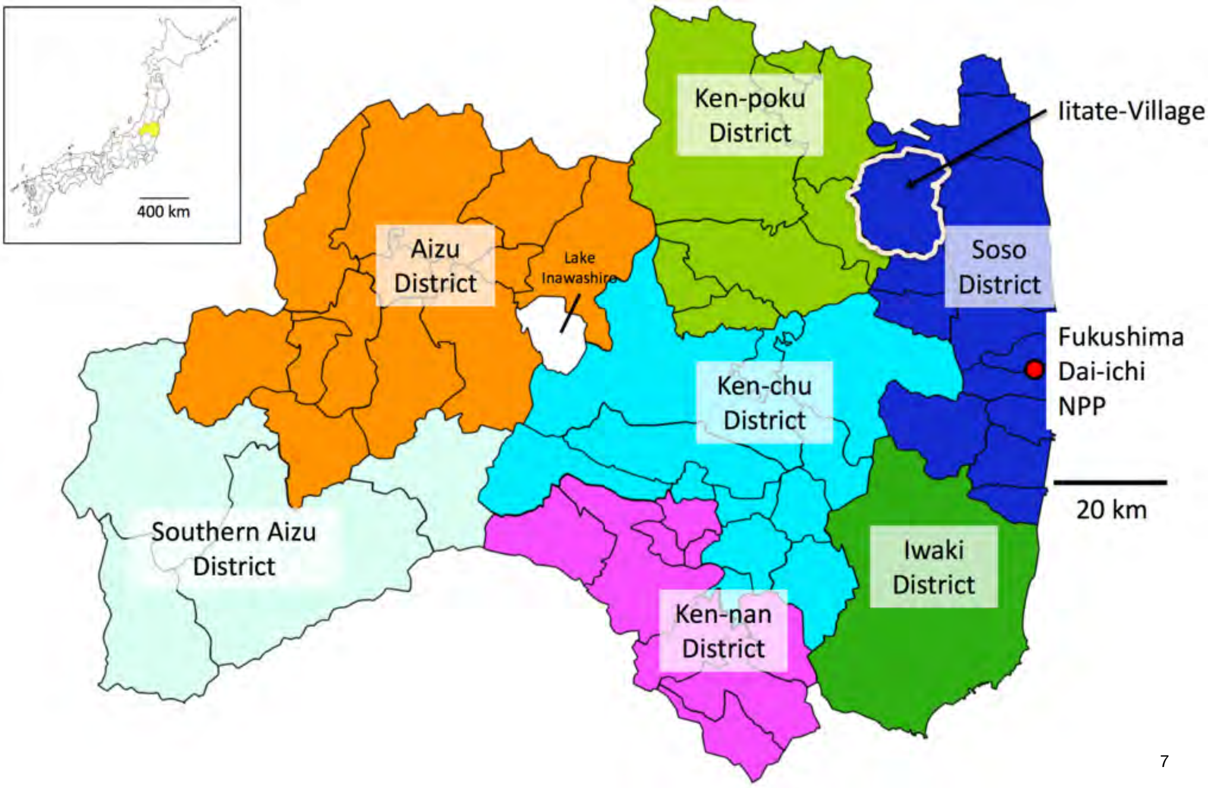
- Wild boars are…
  - wild animals.
  - vermin
  - omnivorous feeders.
  - increasing in evacuated area
  - need to be controlled by hunting in evacuated area.

5

2. Inspection data in Fukushima

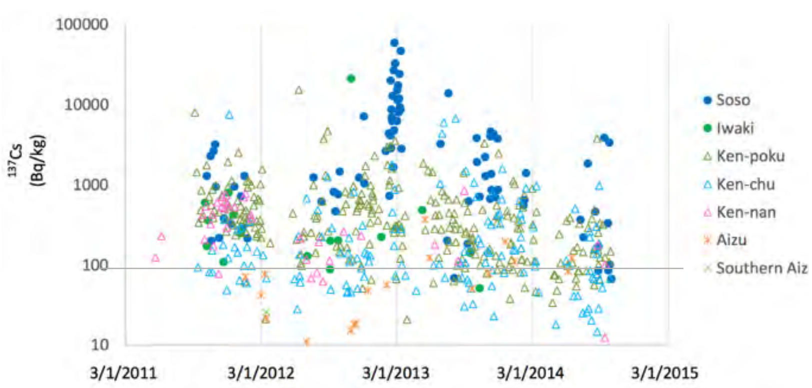
6

Location of Fukushima prefecture



7

2. Inspection data in Fukushima



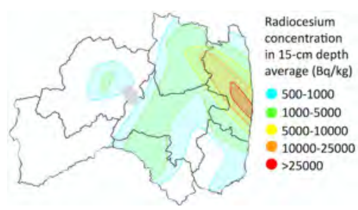


Figure. Inspection data of ^{137}Cs performed in Fukushima prefecture.

- Correlated with soil contamination
- Highest: more than 50,000 bq/kg
- Most of the samples have >100 Bq/kg

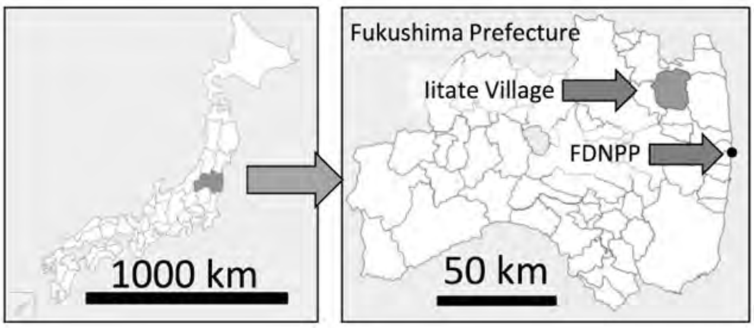
8

3. Distribution of radiocesium in wild boars in 2012 and 2013

9

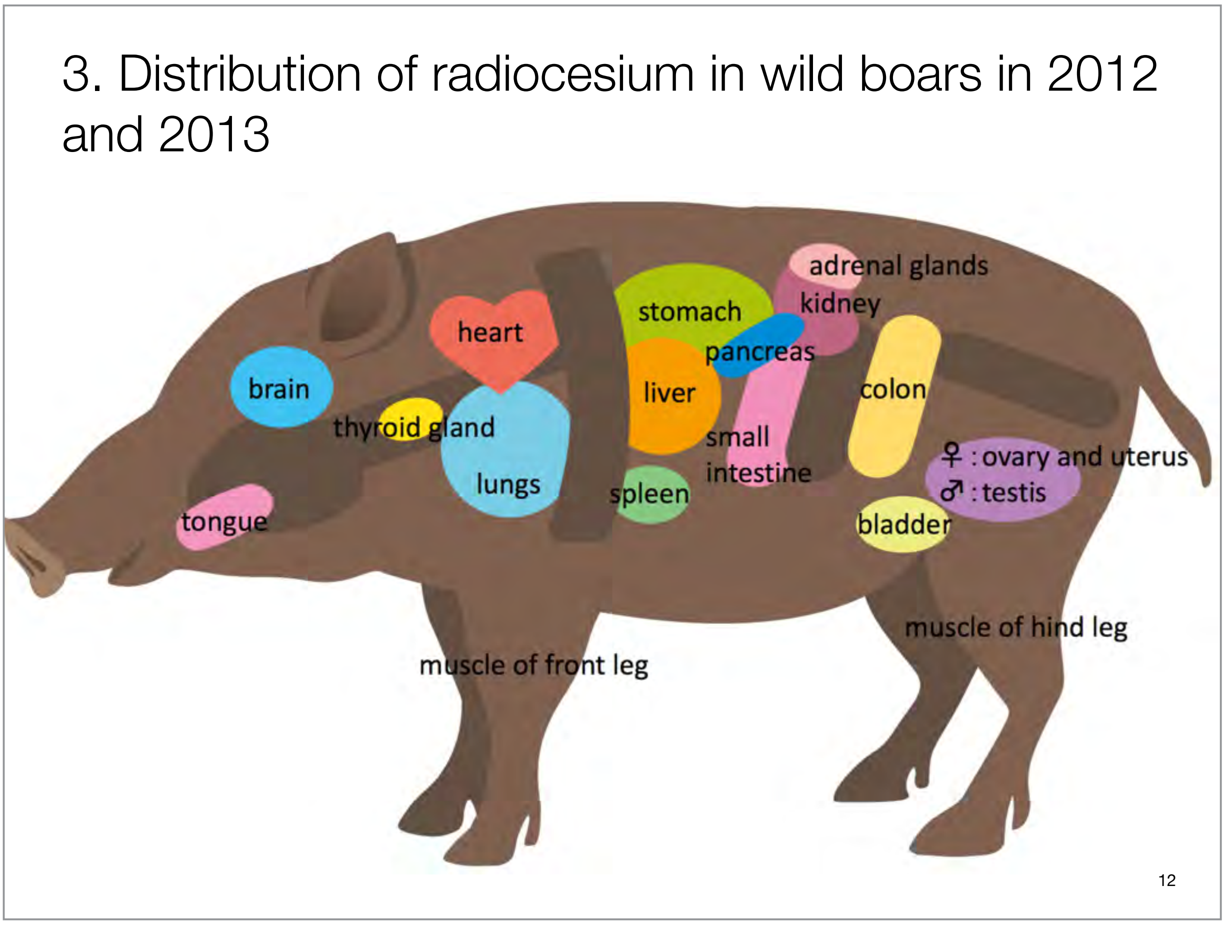
3. Distribution of radiocesium in wild boars in 2012 and 2013

- Iitate-village
  - highly contaminated by the NPP accident.



- all the inhabitant evacuate even after 4 years.
- need to reduce wild boars.

10


3. Distribution of radiocesium in wild boars in 2012 and 2013
adrenal glands
kidney
stomach
heart
pancreas
brain
liver
colon
thyroid gland
small intestine
♀ : ovary and uterus
♂ : testis
lungs
spleen
tongue
bladder
muscle of hind leg
muscle of front leg
12

3. Distribution of radiocesium in wild boars in 2012

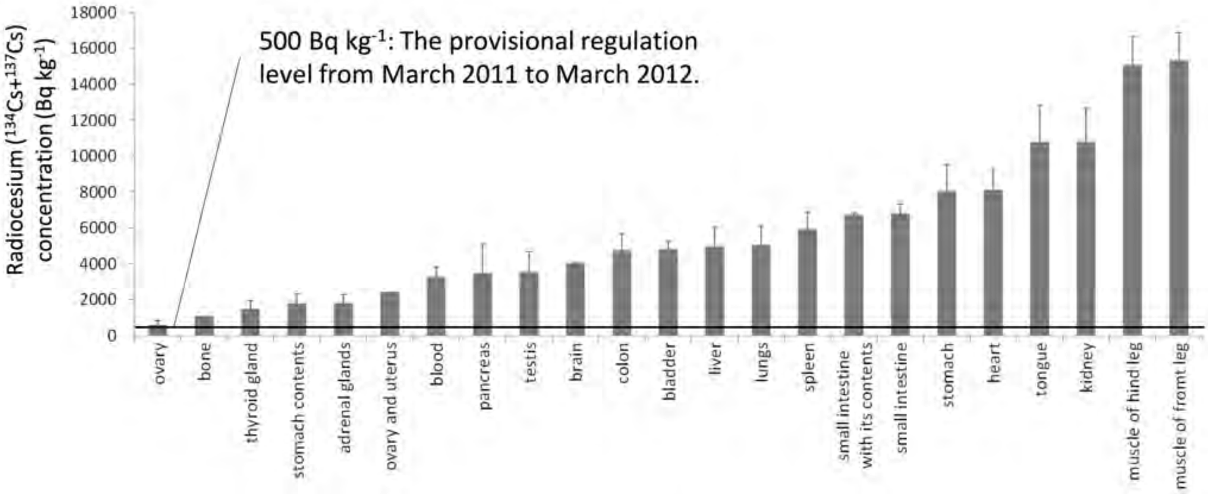
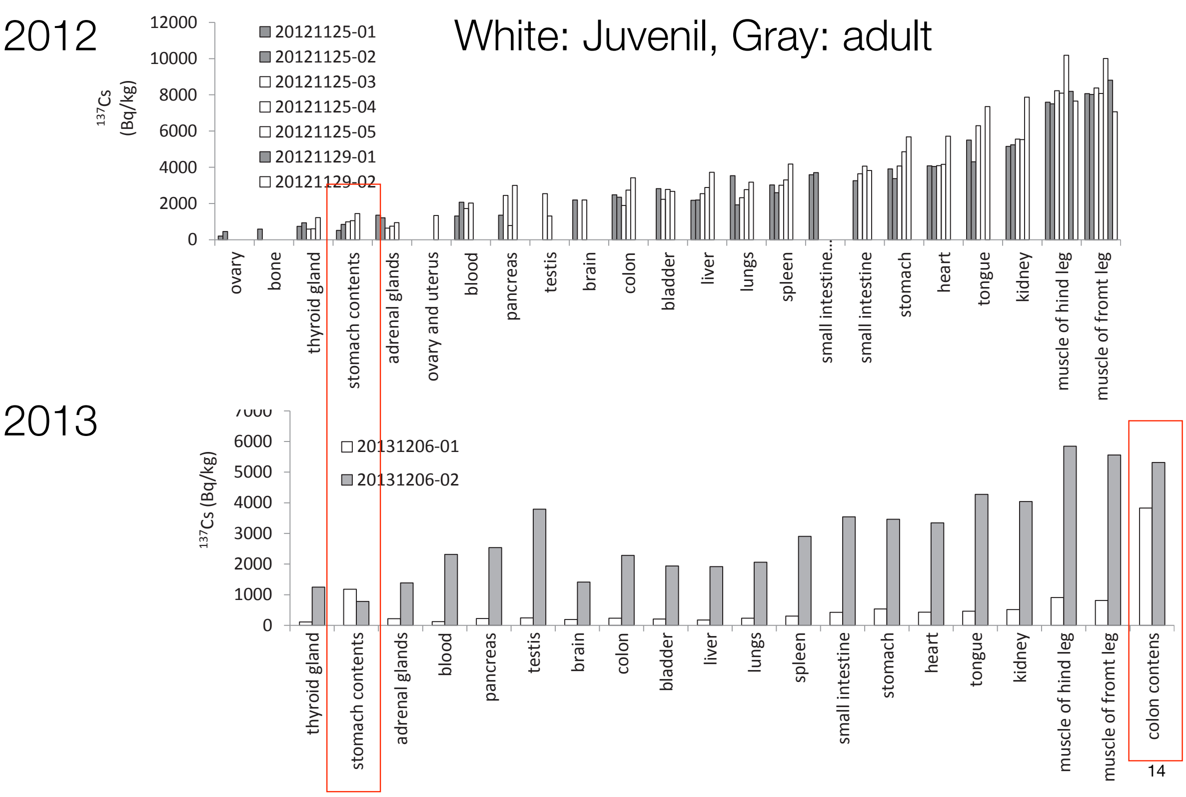


Figure: Radiocesium concentration of organs of wild boars in November 2012. Data is shown as average of 5-7 wild boars captured in November of 2012.

13

3. Distribution of radiocesium in wild boars in 2012 and 2013



14

3. Distribution of radiocesium in wild boars in 2012 and 2013

Table The ratios of blood to muscle in ^{137}Cs

Animals	Year	description	^{137}Cs Ratio of blood to muscle	Reference
wild boar	2012	average of 2 juvenils	0.22	Tanoi et al. 2015
wild boar	2012	average of 2 adults	0.23	Tanoi et al. 2015
wild boar	2013	juvenil	0.14	Tanoi et al. 2015
wild boar	2013	adult	0.41	Tanoi et al. 2015
pig	1960s		0.10	Green et al. 1961
calf	1960s		0.01	Green et al. 1961
cattle	2011	average of 79 cattles (63 of adults and 13 of calves)	0.04	Fukuda et al. 2013

ave.0.24

15

4. Summary

- Monitoring the wild boars revealed that..
  - The muscle, or meat, is highly contaminated.
  - The change of the radiocesium situation in forest ecosystem.
  - We need to have more data for years.

16

References

J Radioanal Nucl Chem
DOI 10.1007/s10967-015-4233-z

CrossMark

Investigation of radiocesium distribution in organs of wild boar grown in Iitate, Fukushima after the Fukushima Daiichi nuclear power plant accident

Keitaro Tanoi[1] · Kazuyuki Uchida[1] · Chiyo Doi[1,2] · Naoto Nihei[1] · Atsushi Hirose[1] · Natsuko I. Kobayashi[1] · Ryohei Sugita[1] · Tatsuya Nobori[1] · Tomoko M. Nakanishi[1] · Muneo Kanno[2] · Ippei Wakabayashi[2] · Miicha Ogawa[2] · Yoichi Tao[2]

Received: 5 January 2015

Abstract The concentrations of radiocesium in different organs of wild boar inhabiting Iitate, Fukushima were measured, after the Fukushima Daiichi nuclear power plant accident. After dissection, about 24 parts were collected

and the others [7], has been detected in the land of Fukushima prefecture. The dominant radionuclides in the environment are radiocesium because of its half-life: ^{134}Cs (half-life: 2 years) and ^{137}Cs (half-life: 30 years) as well as

17

References

Coming soon !!

Agricultural Implications of the Fukushima Nuclear Accident: The First Three Years

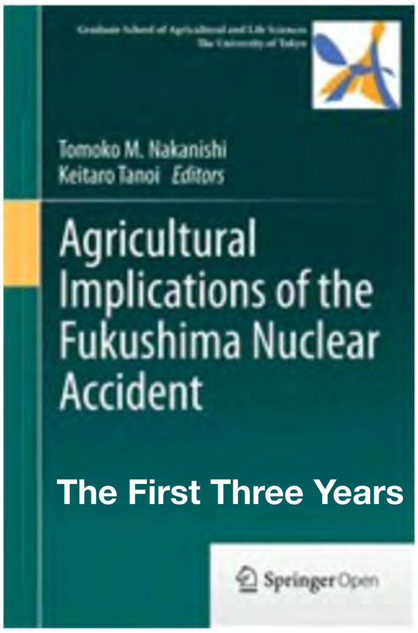
Chapter 8

Wild boars in Fukushima after the nuclear power plant accident: Distribution of radiocesium

Keitaro Tanoi

Abstract

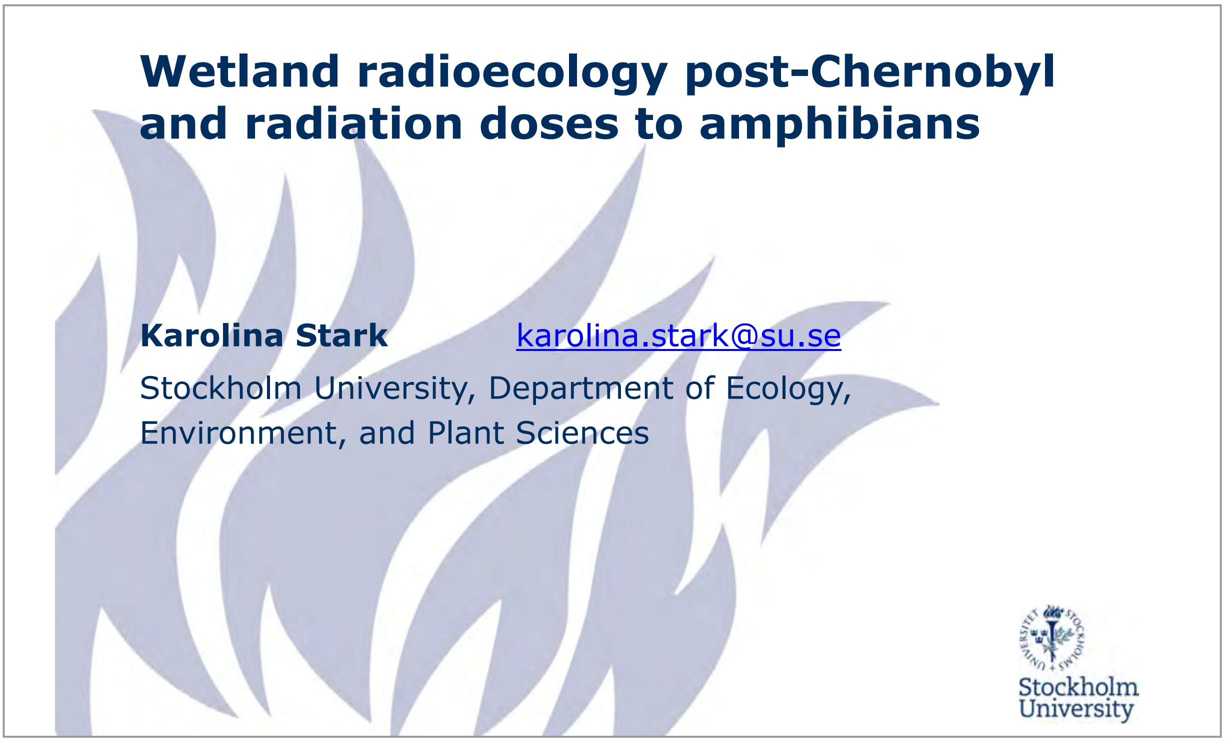
In the present chapter, I present the distribution of radiocesium in wild boars as well as the official monitoring data of wild boars from Fukushima. After the nuclear accident in 2011, the radiocesium contamination levels in wild boars from most places in Fukushima Prefecture exceeded 100 Bq/kg. The most contaminated wild boars were observed in Soso district where the radiocesium

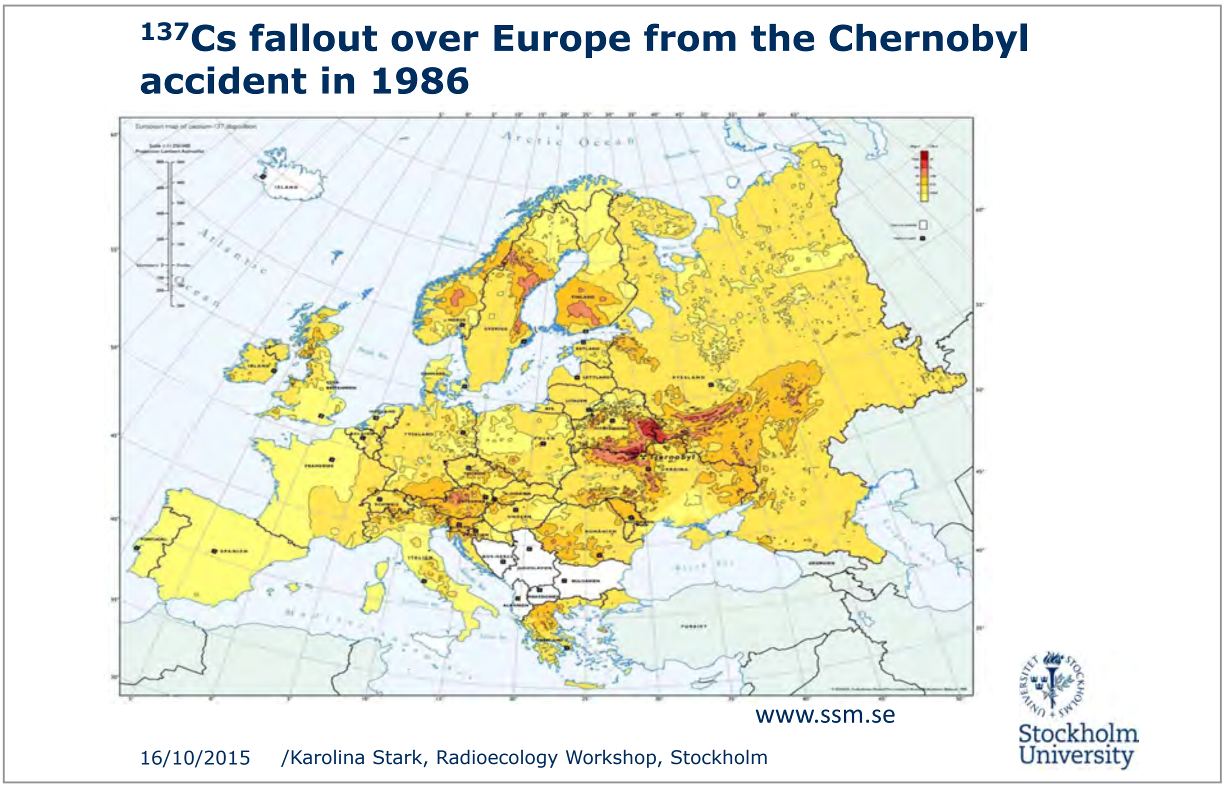


18

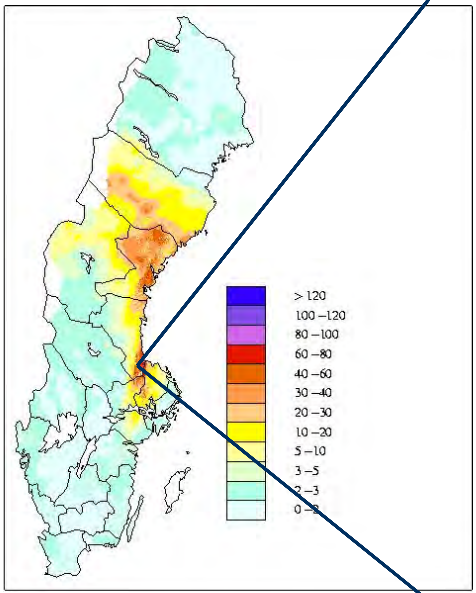
4.5 Wetland radioecology post-Chernobyl and radiation doses to amphibians

Karolina Stark
Presenter: karolina.stark@su.se
Department of Ecology, Environment and Plant Sciences, Stockholm University

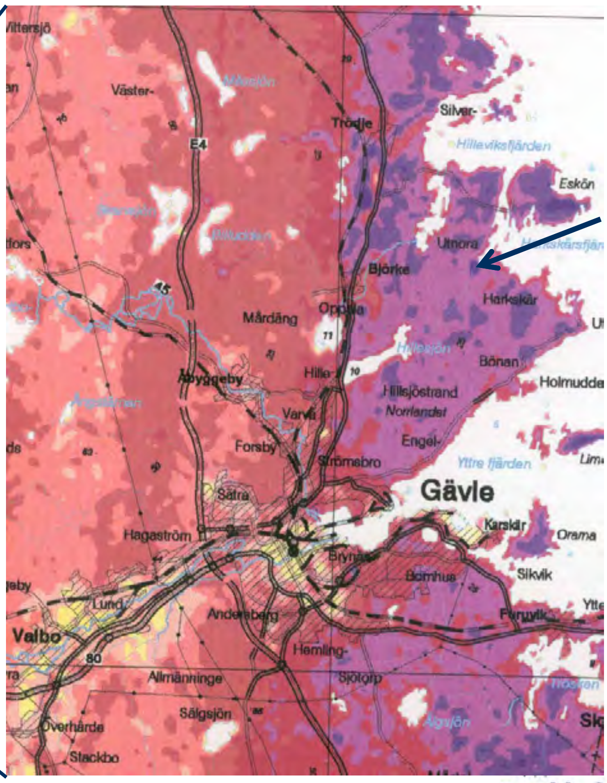




Study sites



^{137}Cs deposition (kBq/m^2) in Sweden. Air gammaspectrometry measurements from SSM



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Wetland ecosystems

- ”Kidneys of the landscape”

- Bogs = peat accumulating, no inflow/outflow
- Fens = peat accumulating, inflow
- Swamps = mineral soil, with trees/shrubs
- Marshes = mineral soil, emergent plants

mires

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Factors influencing ^{137}Cs accumulation in wetlands

Factor	Example	Mechanism of retention	Reference
Type of soil	Peat or mineral soil	^{137}Cs high affinity to clay minerals	Sawhney, 1972; Broberg & Andersson, 1991; Avery, 1996
Degree of salinity	Marine or freshwater	Low salinity (saline waters makes Cs+ more mobile)	Horrill, 1984
Level of pH	High, neutral, low	High or neutral pH (H+ releases Cs+ from soil particles)	Munthe et al., 2001
Duration of saturation	Permanent or temporary	Dry periods (constantly saturated area loose ^{137}Cs faster)	Nylén & Grip, 1991; Hilton et al., 1993; Saxén, 1994
Topography	Elevated or low areas	Hollows/depression enhance sediment deposition	Jeffries et al., 2002; Van der Perk et al., 2002
Type of vegetation	Tall or short, thick or scarce	Tall and thick vegetation filter particles	Horrill, 1984; Mungur et al., 1995
Level of nutrients in soil	High or low	High uptake of ^{137}Cs by plants if low K+ and high NH_4+	Camps et al., 2003

Modified from Stark et al., 2006. J of Environ Radioact 87: 175-187

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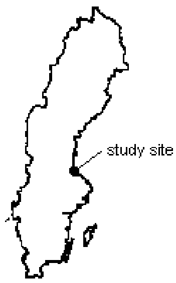
Available online at www.sciencedirect.com
SCIENCE DIRECT
Journal of Environmental Radioactivity 87 (2006) 175–187
JOURNAL OF ENVIRONMENTAL RADIOACTIVITY
www.elsevier.com/locate/jenvrad

Post-depositional redistribution and gradual accumulation of ^{137}Cs in a riparian wetland ecosystem in Sweden

K. Stark [a,*], P. Wallberg [b], T. Nylén [c]



- Wetland area in Utnora, Sweden
- Alder forest swamp and a marsh dominated by reed
- Depositon >100 kBq/m²
- Average inventory 1 MBq/m² in wetland

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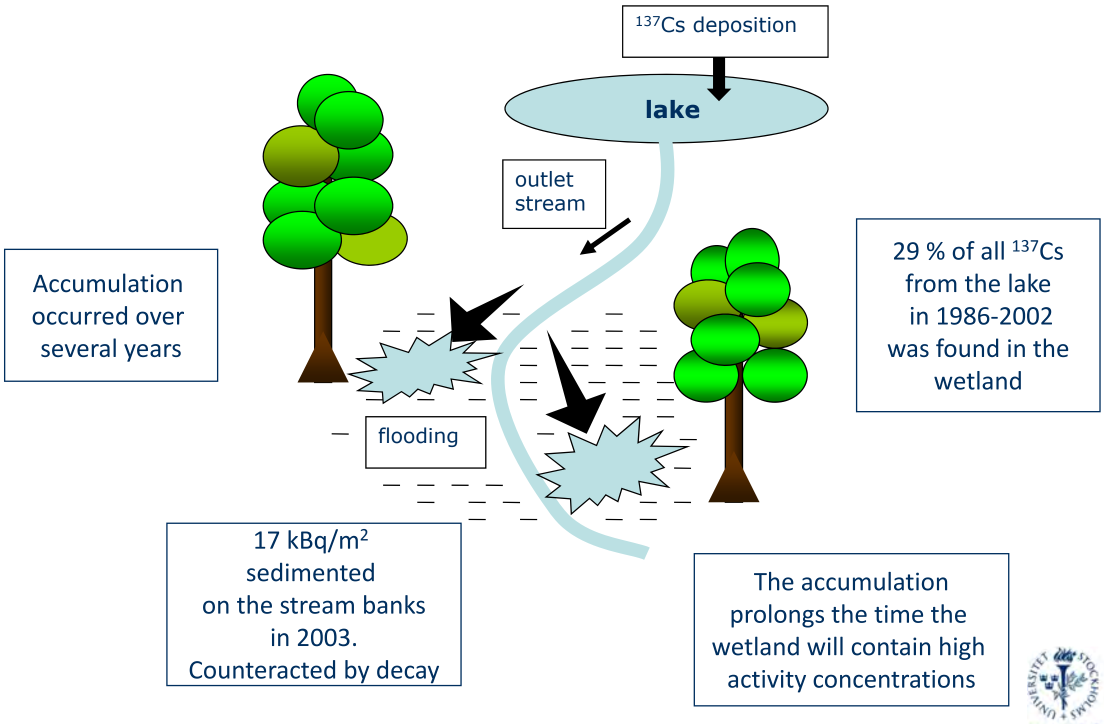
Results from ^{137}Cs budget calculations



From Stark et al., 2006. J of Environ Radioact 87: 175-187

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Radiation exposure assessment

- New recommendations for radiation protection of the environment (animals and plants) increase the need to measure and estimate doses to biota in their specific environment.
- Estimating doses to biota has proved to be challenging (e.g. IAEA EMRAS I, II and IAEA MODARIA, STAR Network)
- Assumptions in current biota dose models (e.g. ERICA tool, RESRAD-BIOTA) needs to be validated by field studies taking biota ecology and physiology in to consideration.

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Amphibians

- Amphibians can influence the energy and contaminant dynamics within ecosystems (Seale, 1980; Beard et al., 2002)
- Key species in many wetlands, often having the greatest abundance among vertebrates
- Amphibians are threatened world-wide
- Protected in national legislation
- Amphibians may need special attention in many environmental risk assessments for releases of contaminants such as radionuclides

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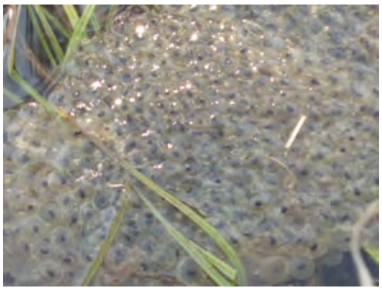
A frog's physiology & ecology

- Both aquatic & terrestrial stages
- Complex life-cycle
- Thin skin
- Hibernate where ^{137}Cs accumulates
- Small home range



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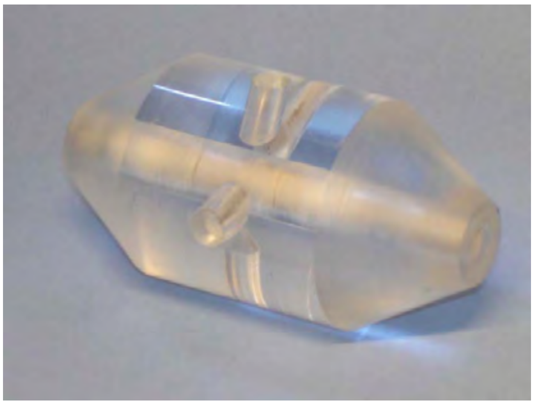
Radiat Environ Biophys (2008) 47:481–489
DOI 10.1007/s00411-008-0185-9

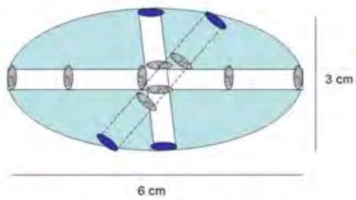
ORIGINAL PAPER

External radiation doses from ^{137}Cs to frog phantoms in a wetland area: in situ measurements and dose model calculations

K. Stark · H. B. L. Pettersson

- Constructed frog phantoms of PMMA containing thermoluminescence (TL) chips





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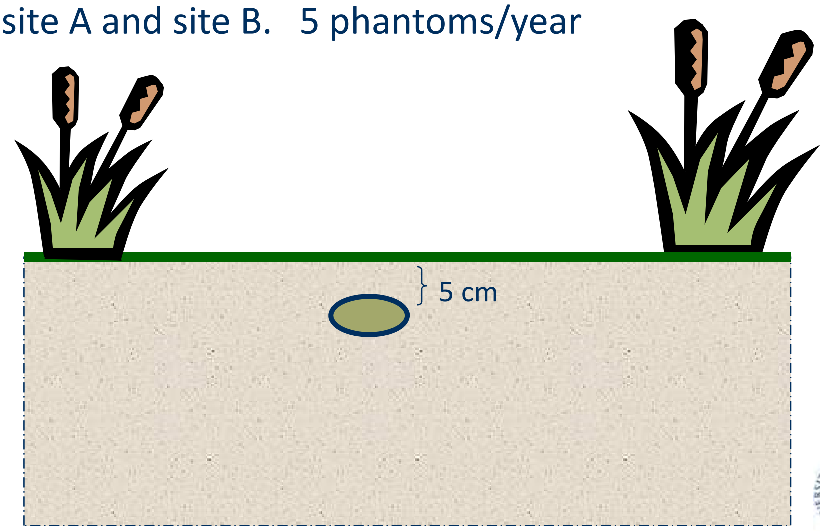
Measurement of dose to frog phantom

Measured dose for 90 days in 2003 and 2004 at site A and site B.   5 phantoms/year



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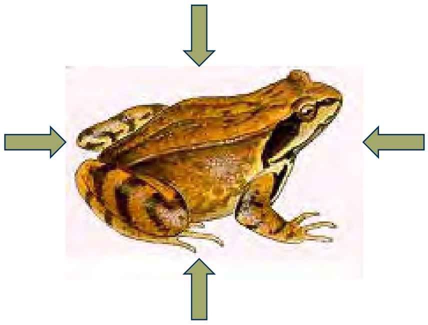
Results:
External dose



- The measured doses were lower than the calculated doses

- Measured doses: 0.026 ± 0.003 mGy/d
- Modelled dose range: 0.017-0.128 mGy/d

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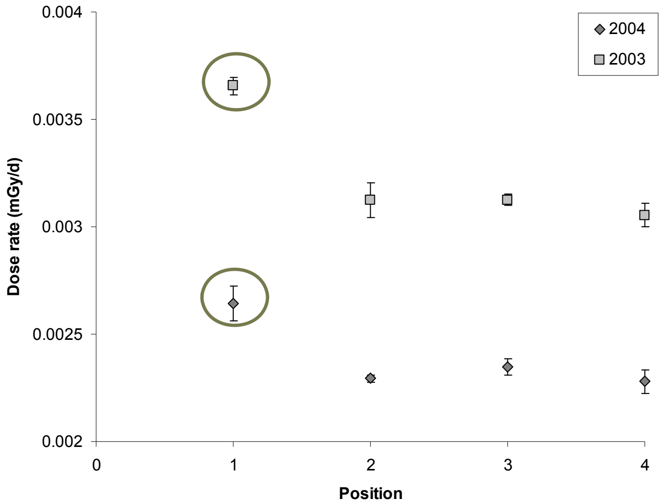
Measured external dose



Higher dose measured to the phantom surface = frog skin

- Phantoms provide valuable dose information for improvement and verification of dose models and in site-specific assessments

Stockholm University


Environmental Pollution 196 (2015) 201–213
Contents lists available at ScienceDirect
Environmental Pollution
journal homepage: www.elsevier.com/locate/envpol

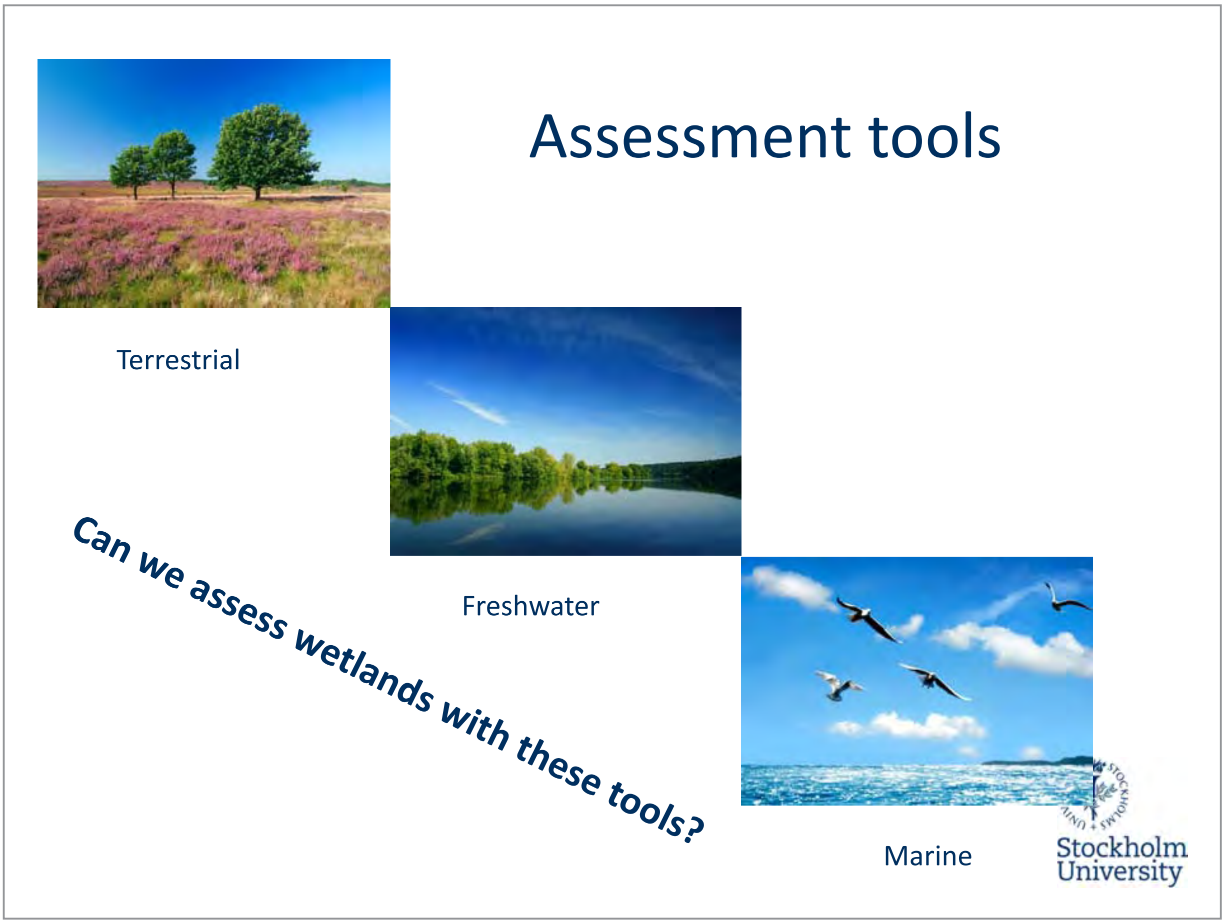
Predicting exposure of wildlife in radionuclide contaminated wetland ecosystems

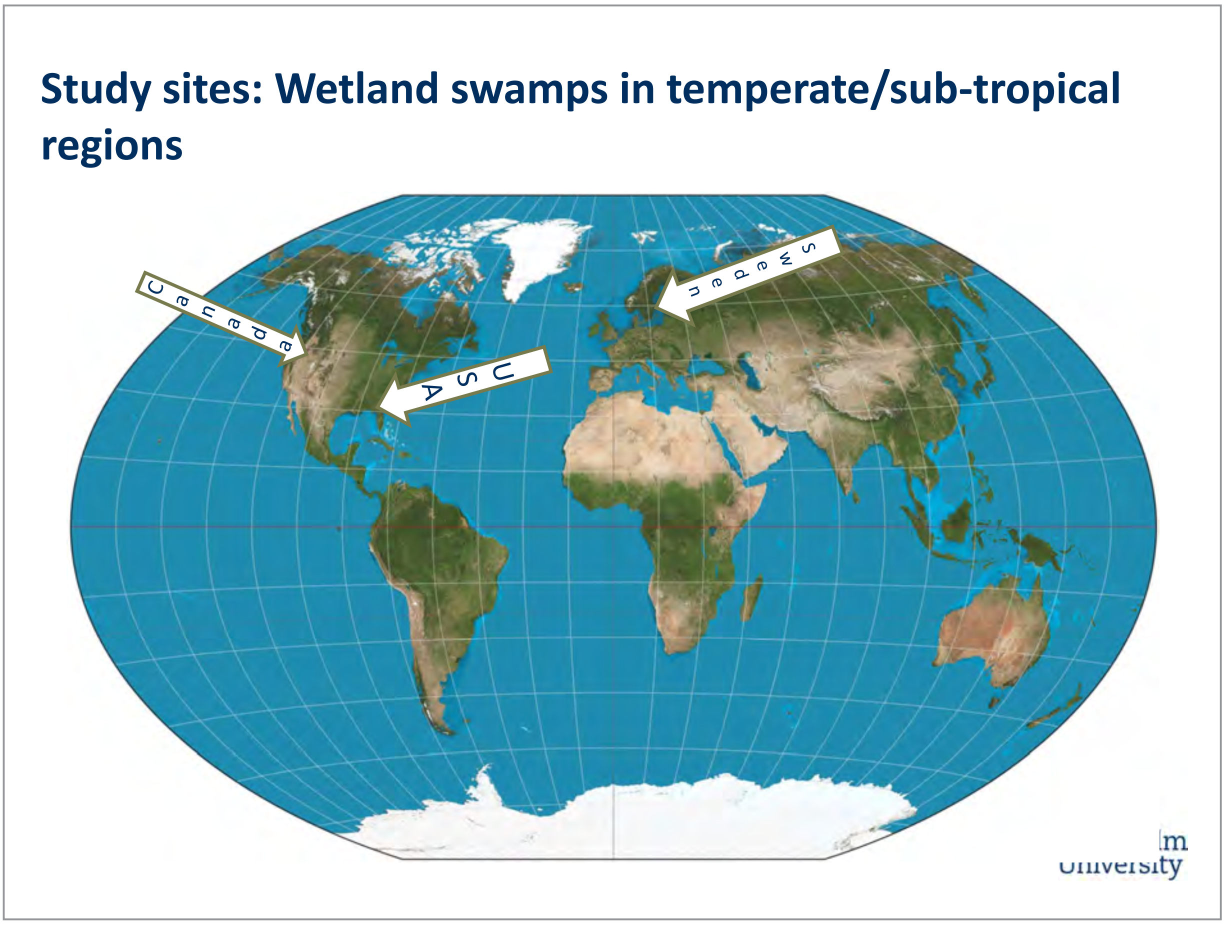
K. Stark [a,*], P. Andersson [b], N.A. Beresford [c], T.L. Yankovich [d], M.D. Wood [e], M.P. Johansen [f], J. Vives i Batlle [g], J. Twining [f,l], D.-K. Keum [h], A. Bollhöfer [i], C. Doering [i], B. Ryan [j], M. Grzechnik [k], H. Vandenhove [g]

- Workgroup exercise within IAEA's Environmental Modelling for Radiation Safety (EMRAS) II Programme

16/10/2015 /Karolina Stark, Radioecology Workshop, Stockholm

Stockholm University


Assessment tools
Terrestrial
Freshwater
Marine
Can we assess wetlands with these tools?
Stockholm University


Study sites: Wetland swamps in temperate/sub-tropical regions
Canada
USA
Sweden

Results

Terrestrial parameters

Stockholm University

Results

Occupancy assumptions

Food choice

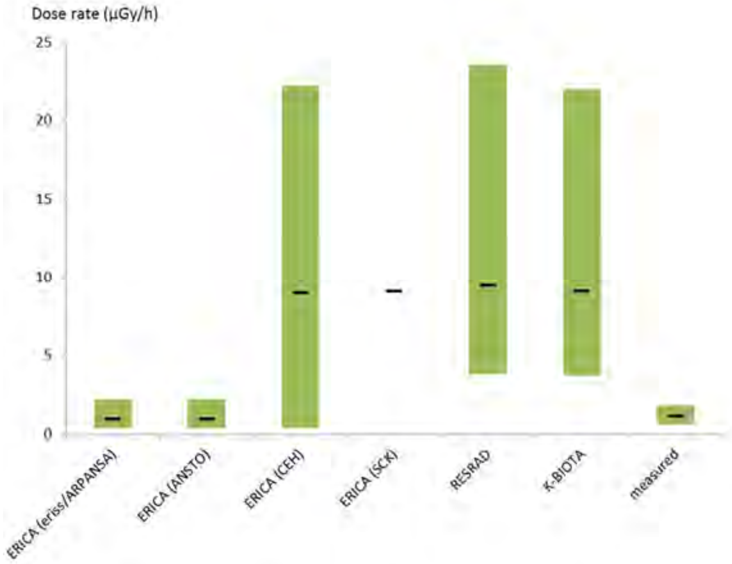
Stockholm University

Results

Assumed soil moisture

Stockholm University

IAEA's EMRAS II programme: Radiation doses to hibernating frog in soil



Estimated and measured external radiation dose rates (µGy/h) from ^{137}Cs to moor frog in Utnora Swamp assuming 100% occupancy in soil. Measurements were done using frog phantoms (Stark and Pettersson, 2008).

16/10/2015 / Karolina Stark, Radioecology workshop, Stockholm

Stockholm University


Thank you for your attention!

4.6 Current conditions of the fisheries, radioactive contamination of seafood, and fish ecology on the fishing grounds of Fukushima

Tomoya Hori†,[1], Takuji Noda[1], Toshihiro Wada[2], Takashi Iwasaki[3], Hiromichi Mitamura[1, 5], Nobuaki Arai [4, 5]

† Presenter: t-hori@bre.soc.i.kyoto-u.ac.jp

1 Graduate School of Informatics, Kyoto University, 606-8501 Kyoto, Japan

2 Institute of Environmental Radioactivity at Fukushima University, Fukushima, Fukushima 960-1296, Japan

3 Soma Branch, Fukushima Prefectural Fisheries Experimental Station, Soma, 976-0022 Fukushima, Japan

4 Field Science and Education and Research Center, Kyoto University, 606-8502 Kyoto, Japan

5 CREST, Japan Science and Technology Agency,332-0012 Saitama, Japan

After the Fukushima Daiichi Nuclear Power Plant accident, vast amounts of radionuclides were released into the ocean. In April 2011, Fukushima prefecture began monitoring radioactive Cs concentrations in Fukushima's marine products at the instruction of the Fukushima Prefectural Government (MAFF, 2015). The radionuclide (^{134}Cs and ^{137}Cs) concentrations in marine species collected off the coast of Fukushima Prefecture were inspected. For three months after the accident, more than 50% of the specimens exceeded the Japanese regulatory limit for radioactive Cs (100 Bq/kg-wet). Subsequently, the overall radioactive Cs concentrations in marine products have decreased significantly. In the most recent tests, only 1% of the specimens exceeded the limit, and no Cs was detected in more than 80% of the specimens (MAFF, 2015). Radioactive Cs concentrations also differ greatly among taxa, habitats, and spatial distributions (Wada et al. 2013). This report presents an example of fish ecology on fishing grounds contaminated by Cs. Since September 2013, annual acoustic telemetry monitoring of the white spotted conger (Conger myriaster) has been conducted at Matsukawa-ura, a brackish lagoon, in Fukushima, Japan, to elucidate their spatiotemporal distribution and activities. The study showed that congers mainly inhabited areas with low Cs concentrations but that they sometimes spent time in other areas in which the sediments contained high levels of Cs contamination (106 to 3,773 Bq/kg dry, Fukushima Pref., 2014).

Keywords: Acoustic telemetry, Activity, Conger myriaster, radioactive contamination, fish ecology

4.7 Role of trophic transfer in benthic ecosystems off Fukushima

Clare Bradshaw

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Department of Ecology, Environment and Plant Sciences Stockholm University

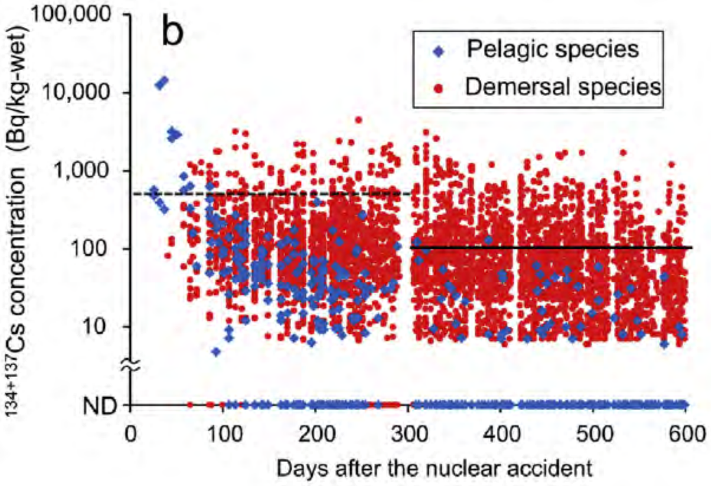
Stockholm University

Role of trophic transfer in benthic ecosystems off Fukushima

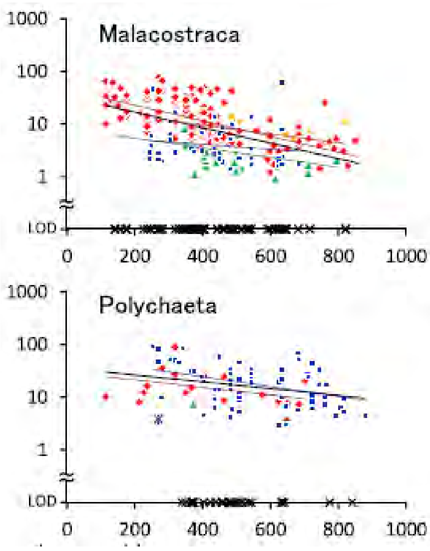
Clare Bradshaw

Dept. of Ecology, Environment and Plant Sciences
Stockholm University

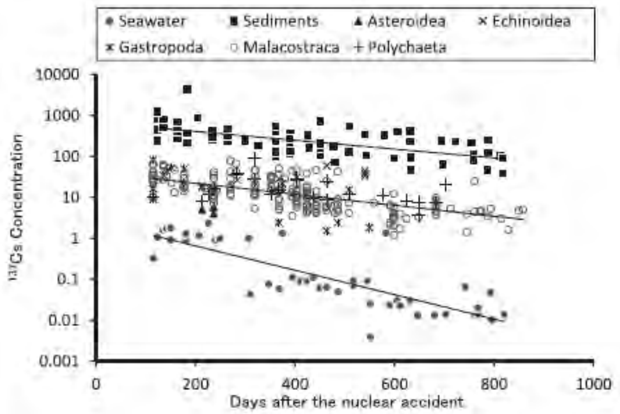
- Dose rates from $^{134+137}Cs$ are highest in demersal fish with sediment-associated food chains and feeding behaviours (Johansen et al 2015)
- Demersal fish have consistently have higher ^{137}Cs concentrations of than pelagic ones
- Some species still have high concentrations even 4 years after the accident
- Why?!



Wada et al (2013) JER 124: 246-254



- Some benthic invertebrates also have a slow decrease in Cs-137 concentrations

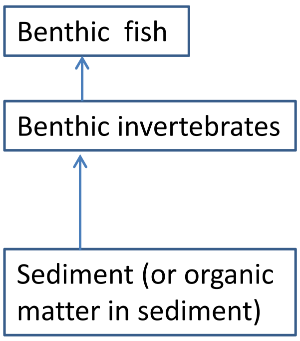


- Is transfer to fish through the benthic food chain important?

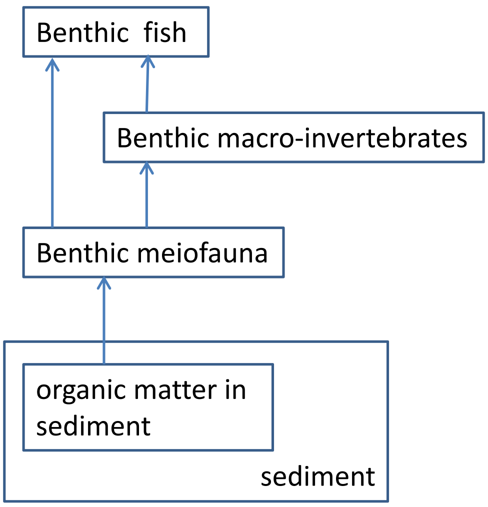
Sohtome et al (2014) JER 138: 106-115

Benthic foodweb structure

Most foodweb studies:



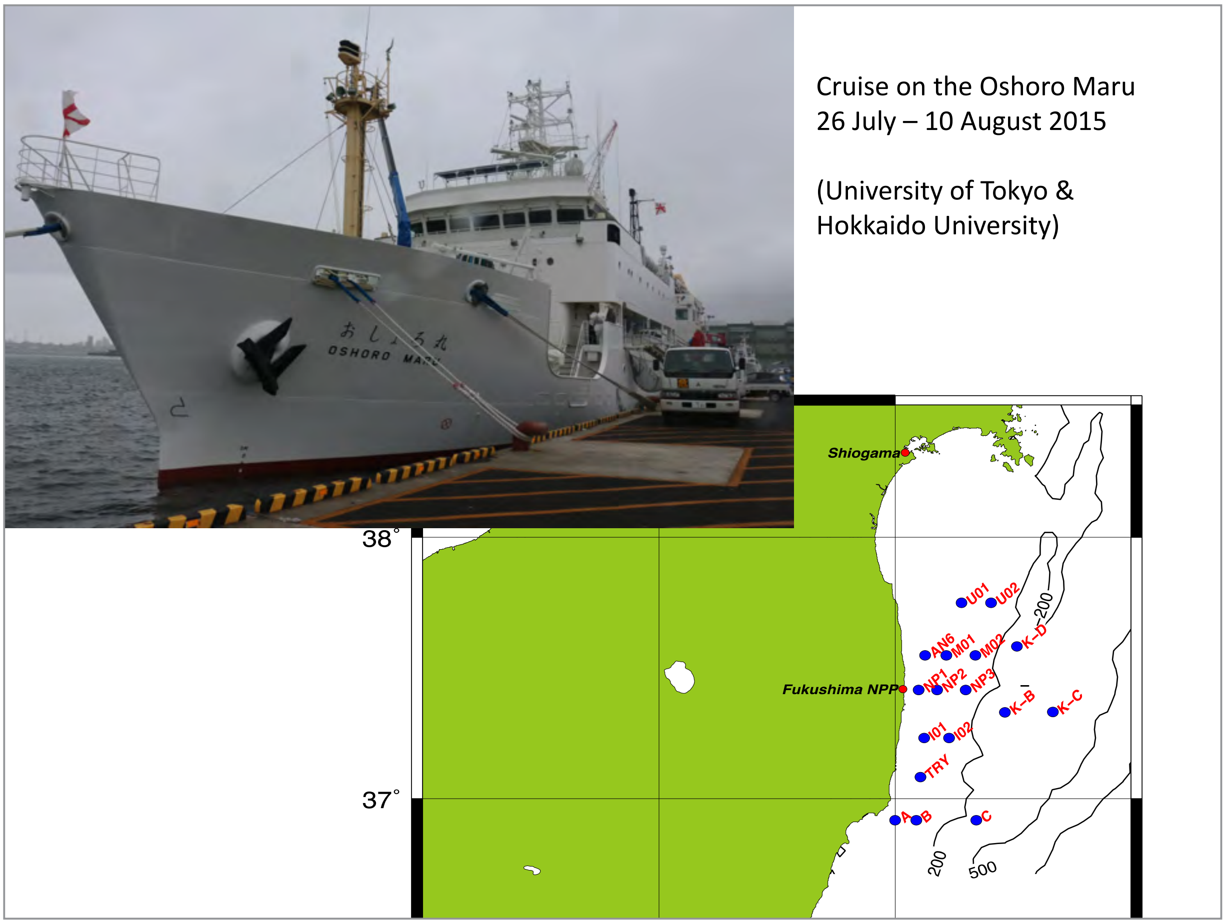
But what about meiofauna?

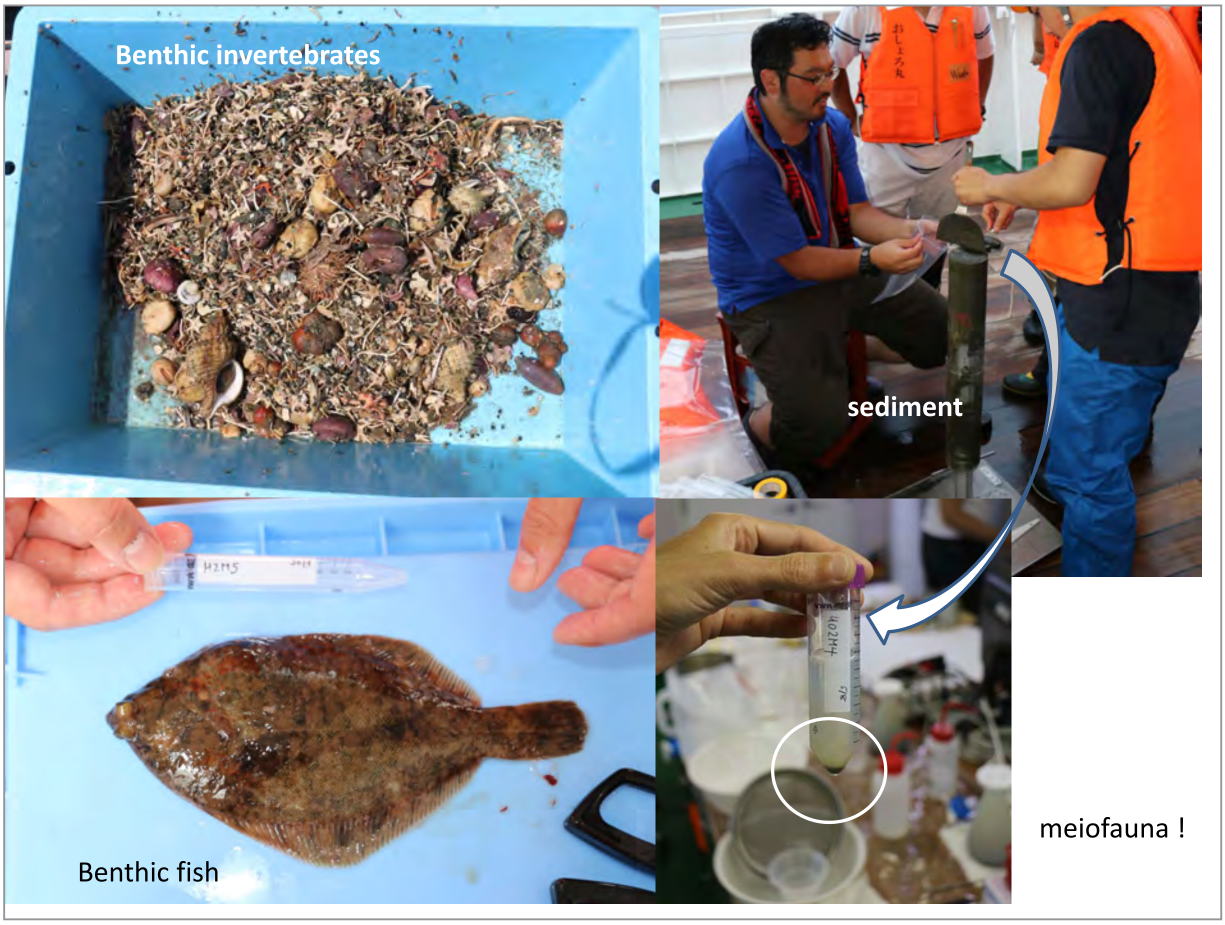


New project started July 2015!

Goals:

to understand how ^{137}Cs is accumulated in marine benthic meiofauna, and the role of this group of organisms as a source of food and Cs to higher trophic levels.


Cruise on the Oshoro Maru
26 July – 10 August 2015
(University of Tokyo &
Hokkaido University)
Shiogama
38°
37°
Fukushima NPP
U01
U02
AN6
M01
M02
K-D
NP1
NP2
NP3
K-B
K-C
I01
I02
TRY
A
B
C
200
500


Benthic invertebrates
sediment
Benthic fish
meiofauna !

We will:

- Analyse ^{137}Cs concentrations in as many components of the food web as possible
- Evaluate fish diet using gut content analysis (visual and with DNA sequencing)
- Evaluate meiofauna community composition using DNA sequencing
- Analyse stable isotope ratios ($\delta 13C$ and $\delta 15N$) in as many components of the food web as possible

This will:

- Give us more detailed information about benthic food web structure, particularly the role of meiofauna
- Allow us to better link food web structure to ^{137}Cs concentrations

4.8 Understanding consumer purchasing intentions towards salted salmon produced in Miyagi prefecture, Japan

Takashi Suzuki†, [1], Taro Oishi [2], Hisashi Kurokura[1], Nobuyuki Yagi[1]

† Presenter: takashi-suzu1182@kss.biglobe.ne.jp

1 Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1, Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan

2 Faculty of Socio-Environmental Studies, Fukuoka Institute of Technology, Higashi, Fukuoka, 811-0295 Japan.

After the Great East Japan Earthquake and Fukushima nuclear power plant accident in 2011, some newspapers said that consumers avoided purchasing fish products produced in the affected area because of concerns about radioactive contamination. However, consumers also bought fish products to contribute to the reconstruction of the affected area. Some previous research on agricultural products mentioned that consumers prefer to purchase products that have not only private dimensions but also public dimensions (e.g. environmental conservation, animal welfare, sustainable resource management, fair trade, and helping the local economy). Thus, it is clear that consumer evaluations of a product differ according to the product's dimensions. However, as there is limited research concerning fish products, the extent to which consumers' concerns about the radioactive contamination of fish products has had a negative on their purchasing intentions remains unclear. Thus, we sought to clarify the degree to which concerns about radioactive contamination had negative effects on purchasing intentions by focusing on the salted salmon produced in Miyagi prefecture. A factor analysis was conducted on data collected through an online survey targeted at consumers living in Tokyo and Osaka in August 2012. Then, we clarified the effects of factors by applying structural equation modelling based on the results of the factor analysis. The results of the factor analysis revealed four factors (F1: value of food, F2: concern about radioactive contamination, F3: purchasing intention along the private dimension, F4: purchasing intention along the public dimension) related to consumer attitudes towards Miyagi's salted salmon, which we incorporated into a structural study (Fig. 1). The results of structural equation modelling indicated that the path coefficient between F1 and F3 and F4 was higher than that between F2 and F3 and F4. Additionally, there was a significant difference between F2 and F3 by area. In Osaka, the negative effect between F2 and F3 was significantly higher than the effect between F2 and F4. These results indicate that advertising the public dimensions of fish products may be an effective way to reduce the negative effects between purchasing intentions and concern about radioactive contamination.

Keywords: consumer behavior, public dimension, Miyagi's salted salmon, Great East Japan Earthquake, radioactive contamination of fish products

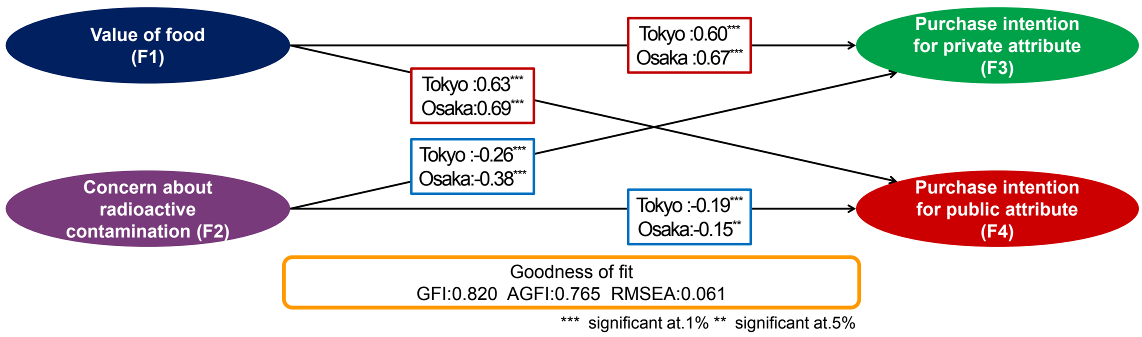


Fig.1 Result of structural equation modeling by using SPSS Amos 20

Understanding of the consumer's consciousness for public aspects on salted salmon produced in Miyagi prefecture in Japan

Takashi Suzuki[1], Taro Oishi[2],
Hisashi kurokura[1] and Nobuyuki Yagi[1]

[1]The University of Tokyo, [2]Fukuoka Institute of Technology

Background : Great east Japan earthquake

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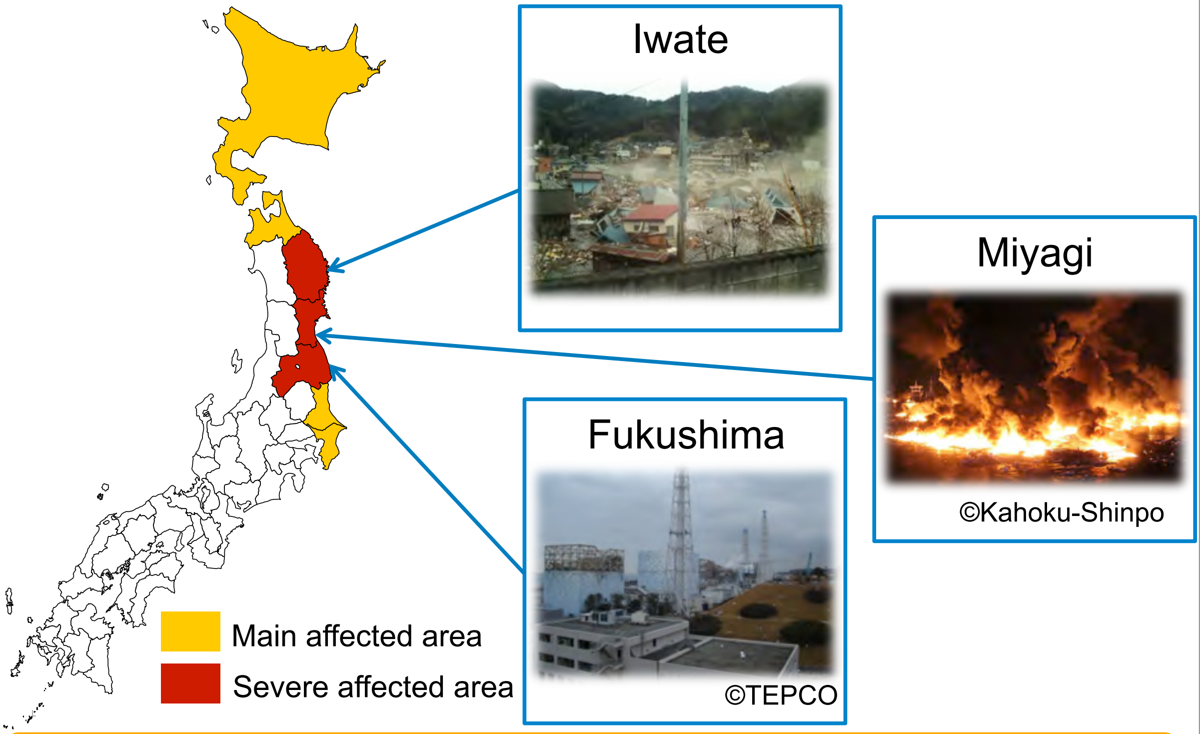


Huge damage for coastal area of north-east Japan

Damage on fishery by nuclear disaster

3

Fukushima daiichi nuclear power plant accident

©Yomiuri news paper (May 2012)

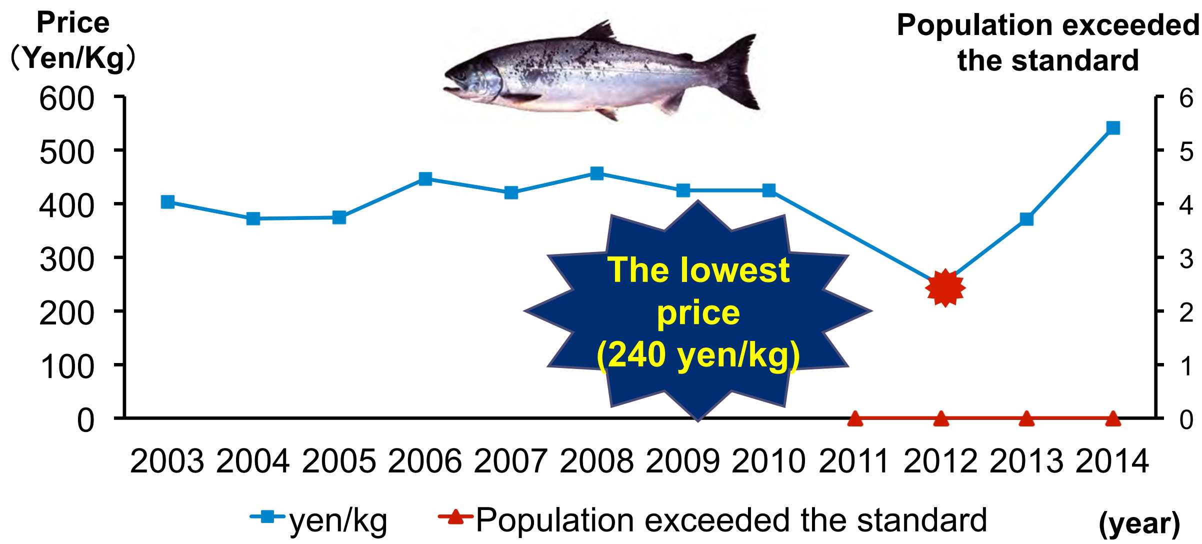
- Contaminated water with radio cesium was leaked to the sea
  →Fishery activity was suspended
- Consumers avoid purchasing fish produced in affected areas
  →Damage by bad image

Recovery of fishery activities are delayed
by nuclear power plant accident and bad image

Damage on fishery by bad image

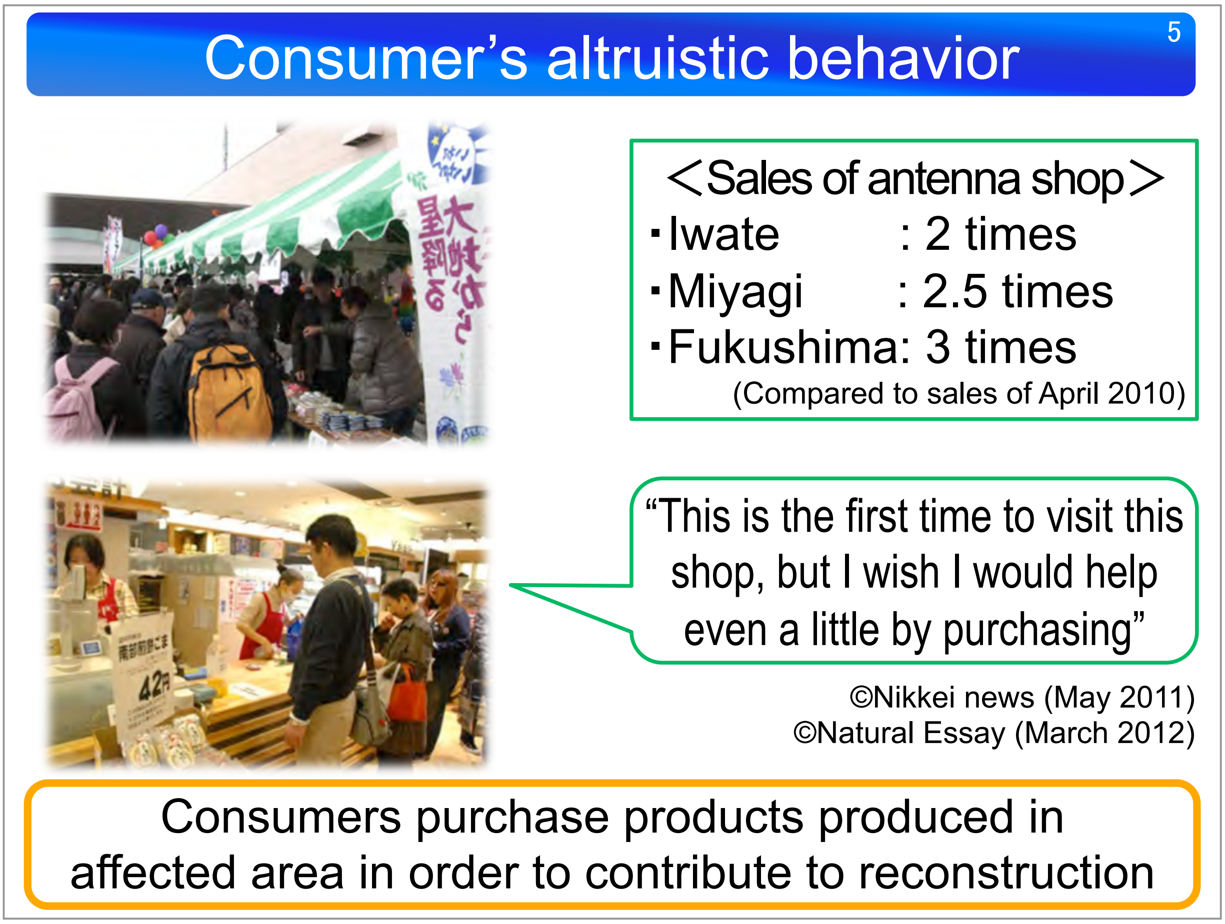
4

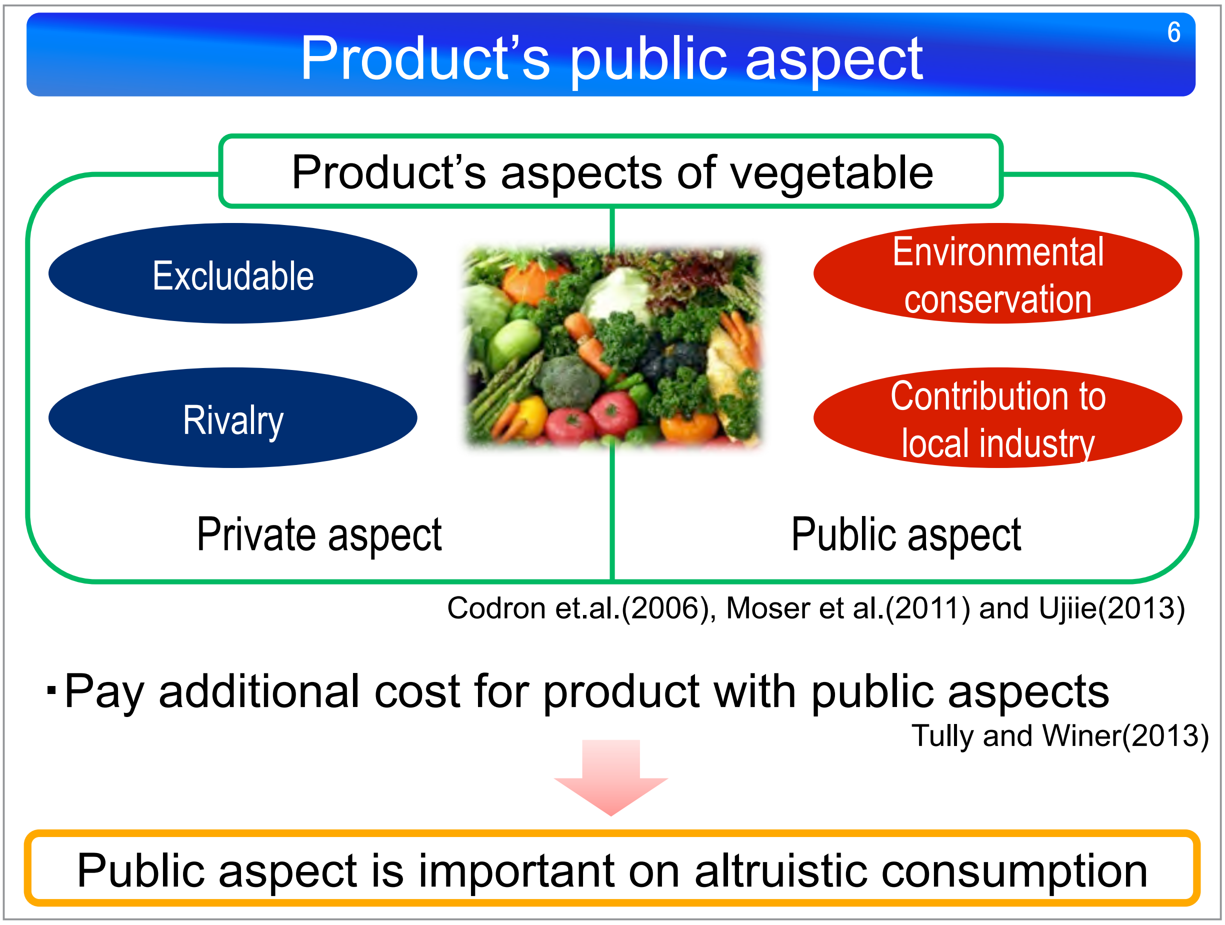
Price decreasing of Miyagi's farmed silver salmon

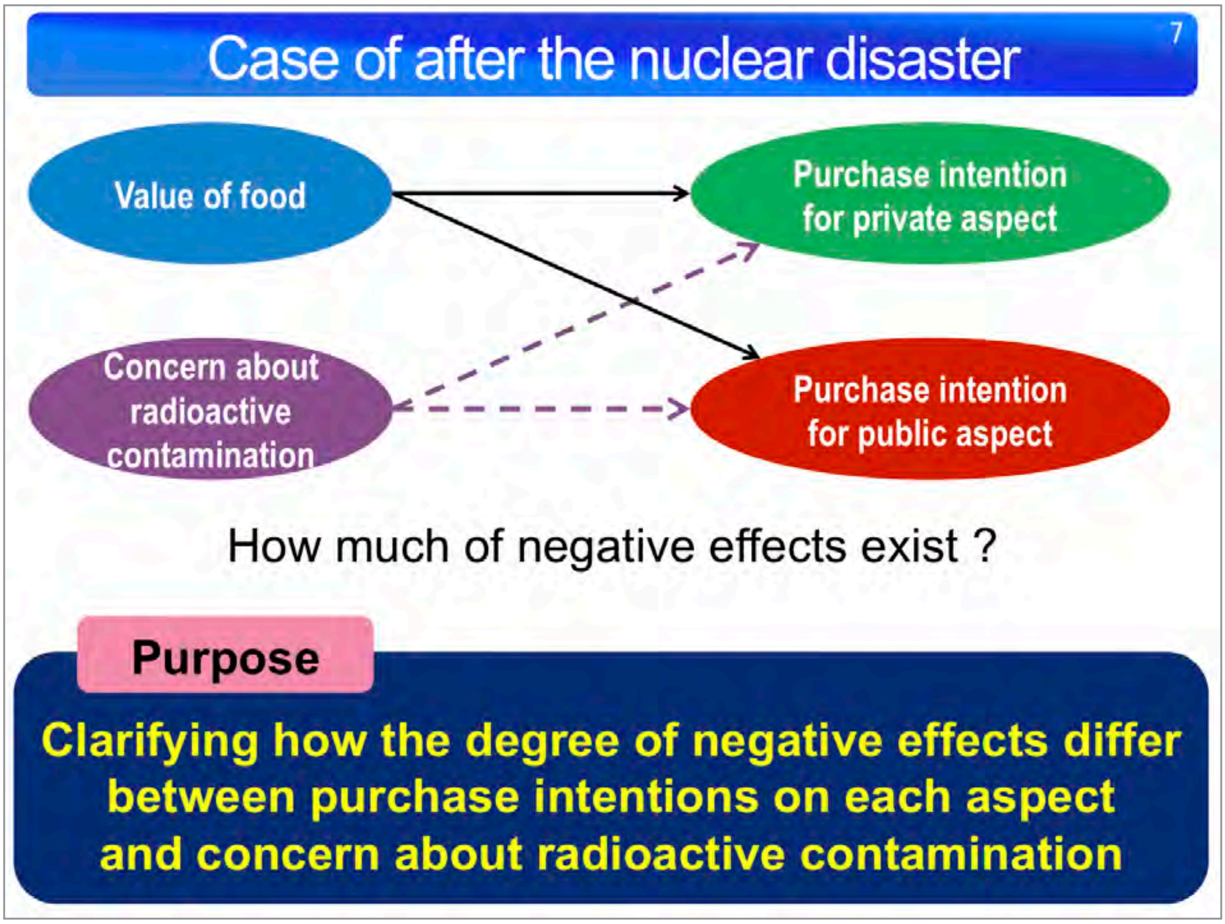


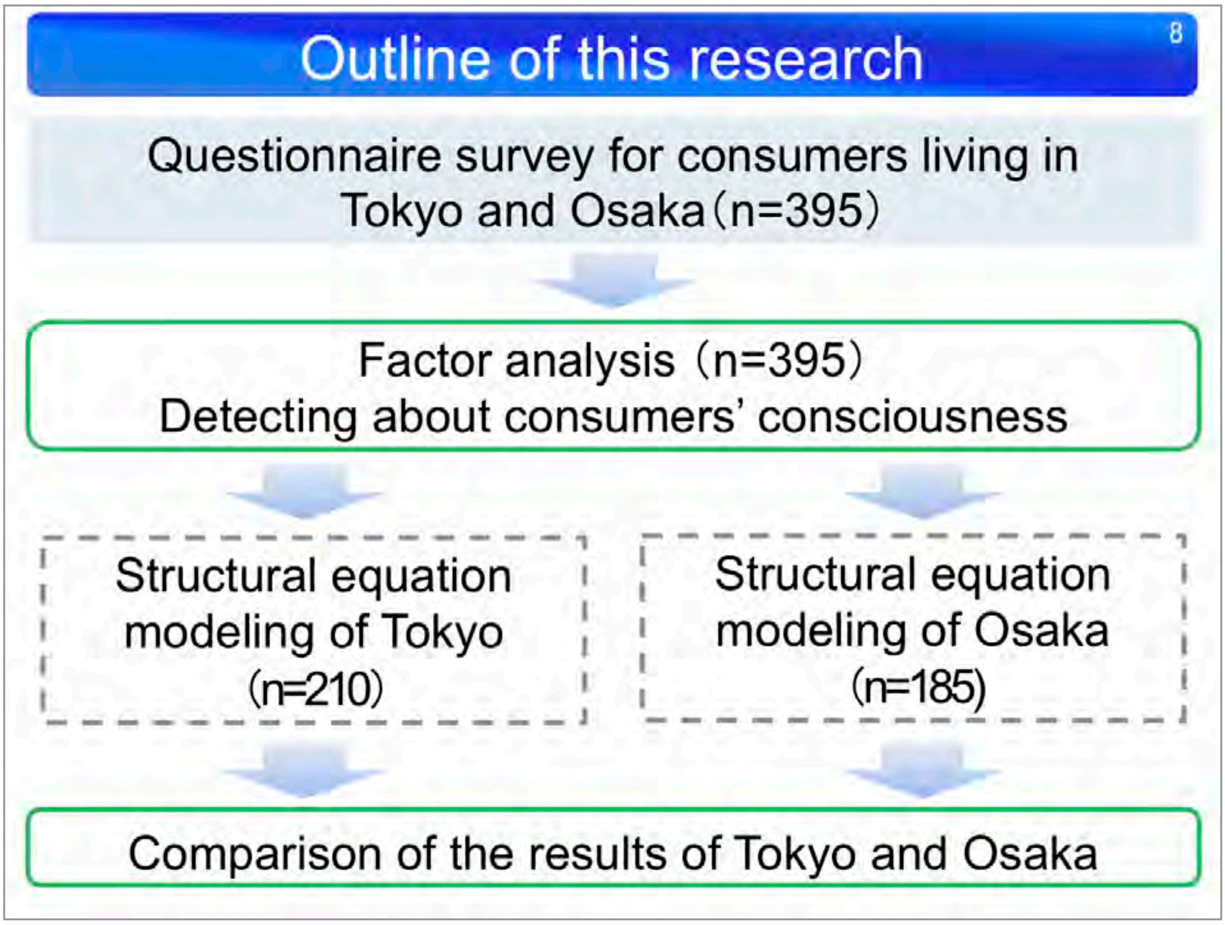
Even though silver salmon didn't exceeded,
price decreased about 130 yen/kg by bad image

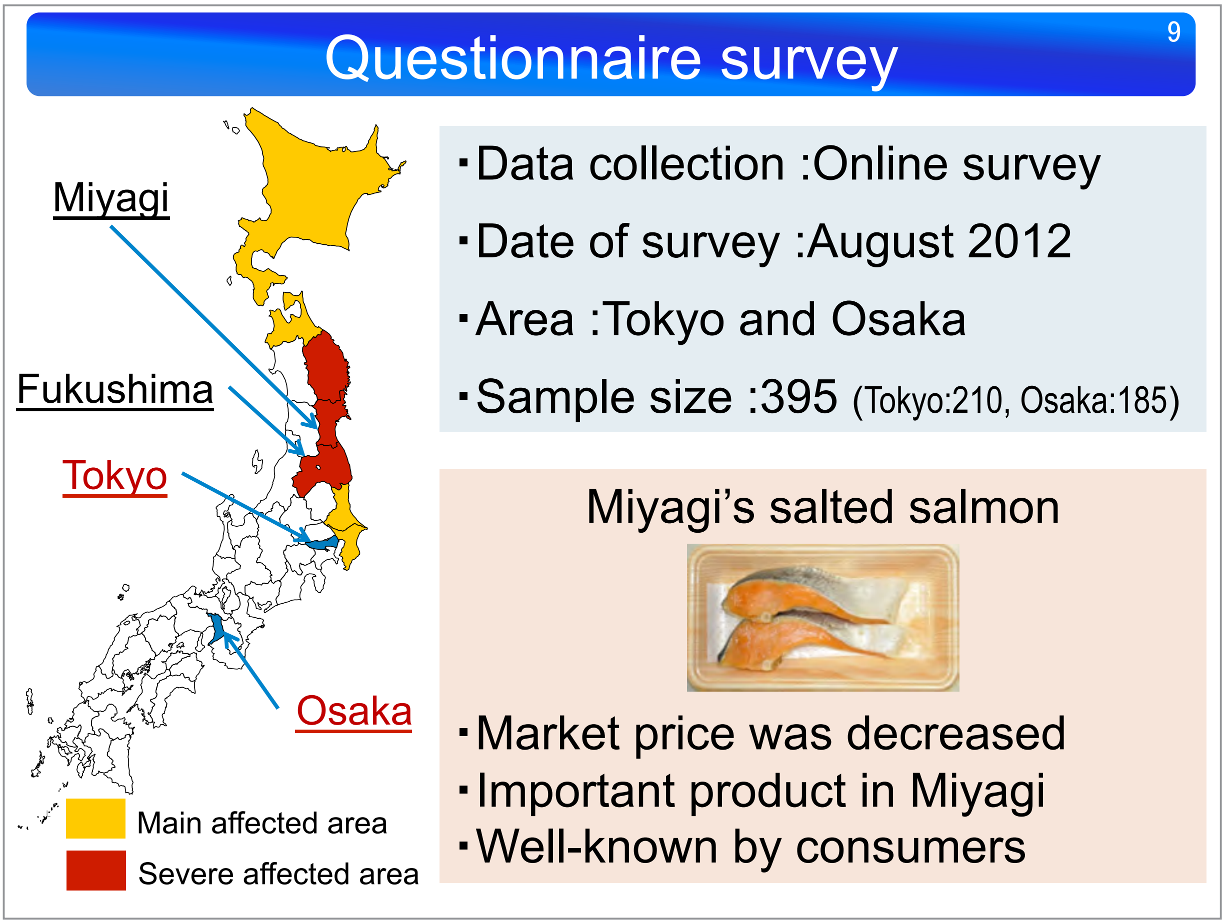
©The Suisan-Keizai (August 2012)　　※No Production in

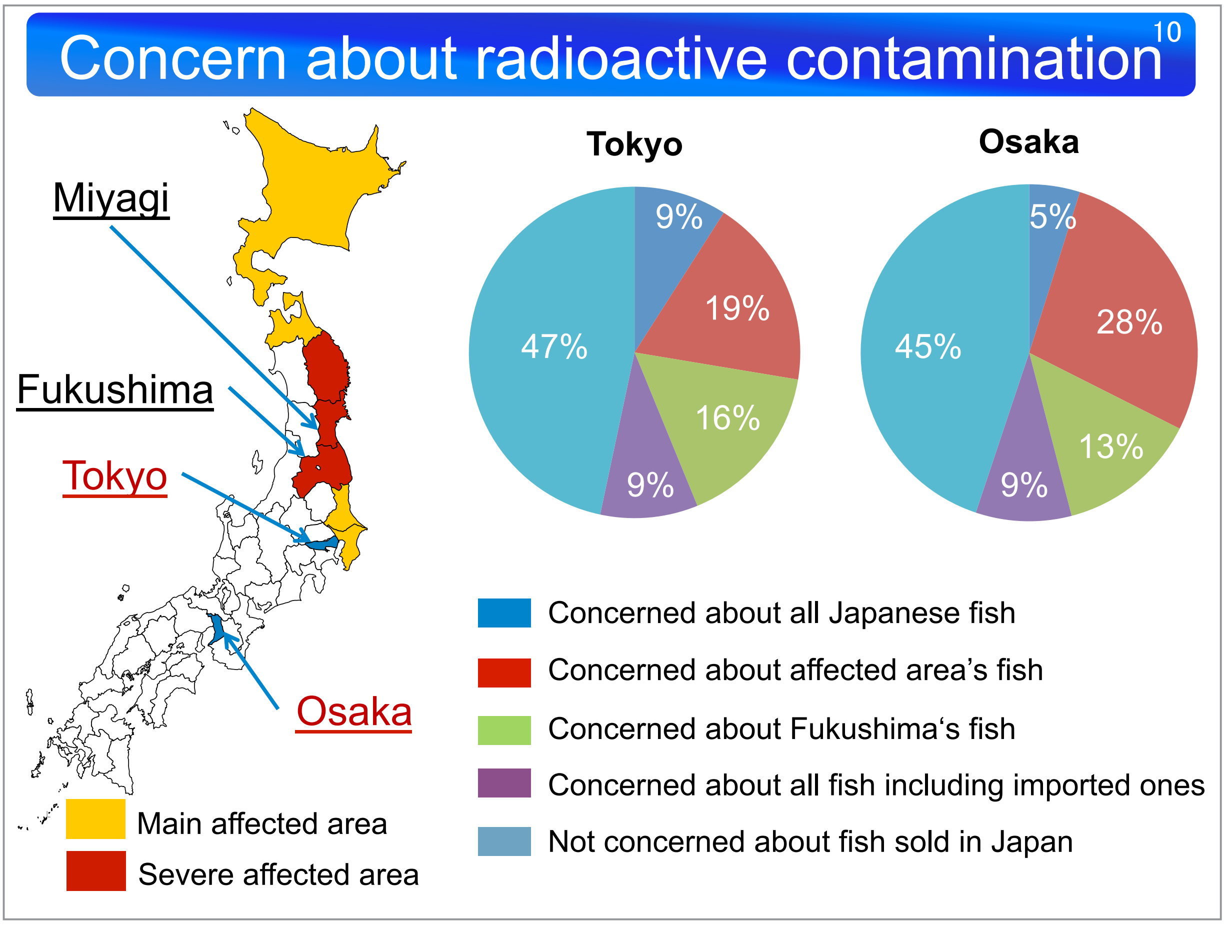

Consumer's altruistic behavior
5
＜Sales of antenna shop＞
・Iwate : 2 times
・Miyagi : 2.5 times
・Fukushima: 3 times
(Compared to sales of April 2010)
"This is the first time to visit this shop, but I wish I would help even a little by purchasing"
©Nikkei news (May 2011)
©Natural Essay (March 2012)
Consumers purchase products produced in affected area in order to contribute to reconstruction


Product's public aspect
6
Product's aspects of vegetable
Excludable
Rivalry
Environmental conservation
Contribution to local industry
Private aspect
Public aspect
Codron et.al.(2006), Moser et al.(2011) and Ujiie(2013)
・Pay additional cost for product with public aspects
Tully and Winer(2013)
Public aspect is important on altruistic consumption


Case of after the nuclear disaster
7
Value of food
Purchase intention for private aspect
Concern about radioactive contamination
Purchase intention for public aspect
How much of negative effects exist ?
Purpose
Clarifying how the degree of negative effects differ between purchase intentions on each aspect and concern about radioactive contamination


Outline of this research
8
Questionnaire survey for consumers living in Tokyo and Osaka (n=395)
Factor analysis (n=395)
Detecting about consumers' consciousness
Structural equation modeling of Tokyo (n=210)
Structural equation modeling of Osaka (n=185)
Comparison of the results of Tokyo and Osaka


Questionnaire survey
9
Miyagi
Fukushima
Tokyo
Osaka
Main affected area
Severe affected area
▪Data collection :Online survey
▪Date of survey :August 2012
▪Area :Tokyo and Osaka
▪Sample size :395 (Tokyo:210, Osaka:185)
Miyagi's salted salmon
▪Market price was decreased
▪Important product in Miyagi
▪Well-known by consumers


Concern about radioactive contamination
10
Miyagi
Fukushima
Tokyo
Osaka
Main affected area
Severe affected area
Tokyo
9%
19%
16%
9%
47%
Osaka
5%
28%
13%
9%
45%
Concerned about all Japanese fish
Concerned about affected area's fish
Concerned about Fukushima's fish
Concerned about all fish including imported ones
Not concerned about fish sold in Japan

Example of Questions

11

Example of questions（18 questions）
・Miyagi's salted salmon tastes good
・It seems that Miyagi's salted salmon can be preserved for a longtime because it is salted
・By purchasing Miyagi's salted salmon, we contribute for the reconstruction of the affected areas
・Having concerns about the inspective institutions on radioactivity of Miyagi's salmon
・I want to buy Miyagi's salted salmon to consume at home

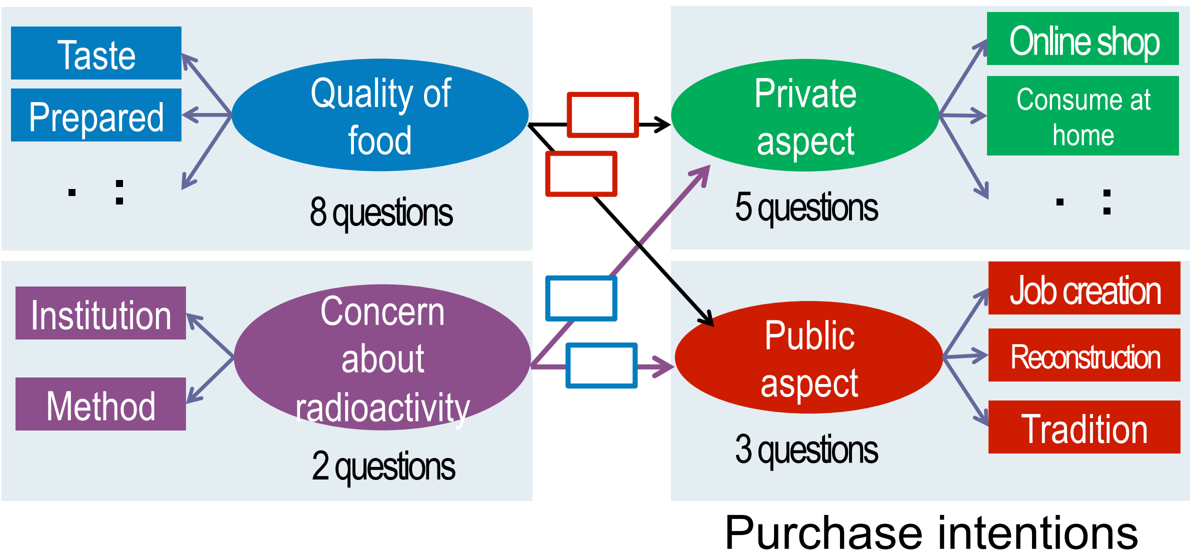
Using five-point scale

1	2	3	4	5
Strongly Agree	Agree	Indifferent	Disagree	Strongly Disagree

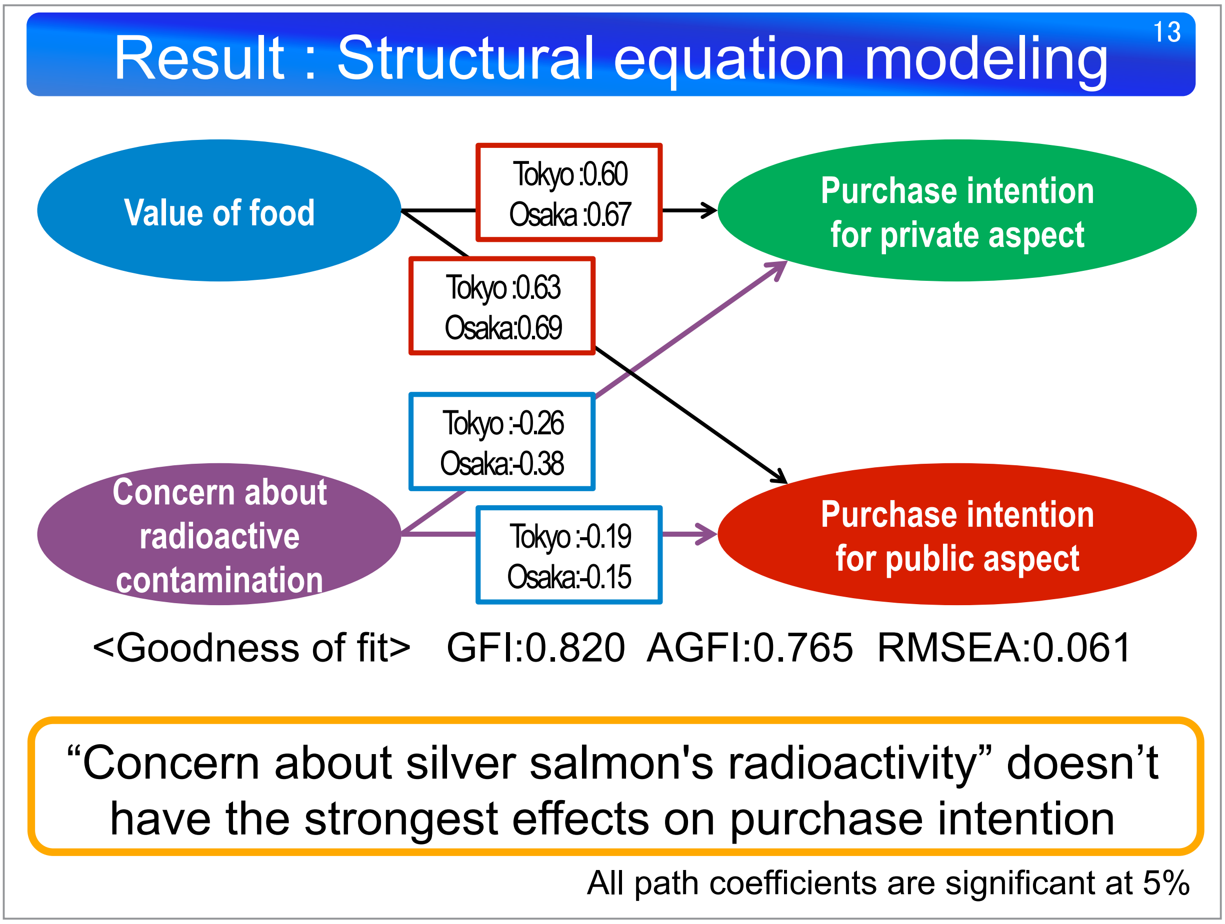
Result：Factor analysis

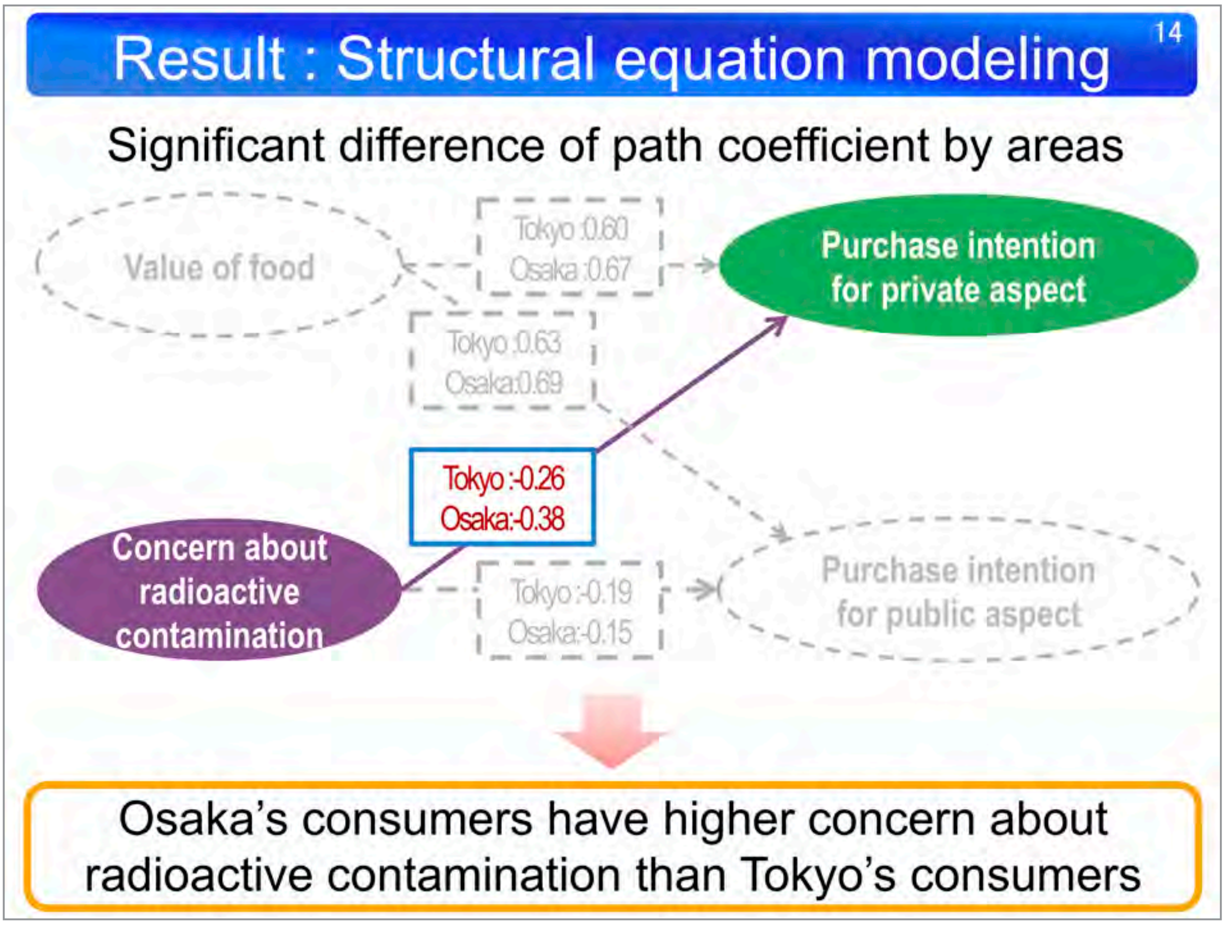
12

Detecting about consumers' latent consciousness



4 factors on consumer consciousness
can be applied to structural equation modeling

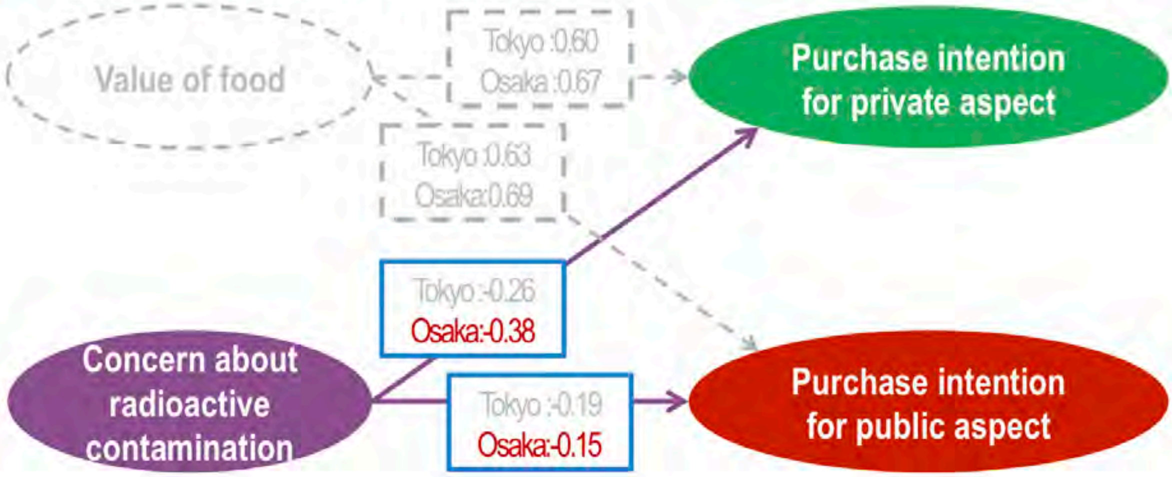

13
Result : Structural equation modeling
Value of food
Tokyo :0.60
Osaka :0.67
Purchase intention
for private aspect
Tokyo :0.63
Osaka:0.69
Tokyo :-0.26
Osaka:-0.38
Concern about
radioactive
contamination
Tokyo :-0.19
Osaka:-0.15
Purchase intention
for public aspect
<Goodness of fit> GFI:0.820 AGFI:0.765 RMSEA:0.061
“Concern about silver salmon's radioactivity” doesn’t have the strongest effects on purchase intention
All path coefficients are significant at 5%


14
Result : Structural equation modeling
Significant difference of path coefficient by areas
Value of food
Tokyo :0.60
Osaka :0.67
Purchase intention
for private aspect
Tokyo :0.63
Osaka:0.69
Tokyo :-0.26
Osaka:-0.38
Concern about
radioactive
contamination
Tokyo :-0.19
Osaka:-0.15
Purchase intention
for public aspect
Osaka’s consumers have higher concern about radioactive contamination than Tokyo’s consumers

Result : Structural equation modeling

15

Significant difference of path coefficient within Osaka



Negative effect of "Concern about radioactive contamination" differs by product's aspects in Osaka

Discussion

16

- Consumers place more importance on the values of food than concern on radioactivity

  → Consumer's rejection isn't the main reason of price decreasing of salmon

- Negative effect differs by product's aspects

  → Advertising public aspect of fish products can be an effective way to reduce the negative effect of radioactive contamination

Japanese consumers opted altruistic behavior purchasing products with public aspects

Thank you for listening

4.9 Long-term desorption kinetics of Cs from contaminated soil

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Understanding the behaviour of caesium (Cs) in soils is crucial in the disposal of soil that is contaminated by radiocaesium (^{137}Cs). Cs is known to selectively adsorb to clay minerals in soils, and desorption of Cs from soils and clay minerals has received much research interest in recent decades. However, the Cs desorption has typically been underestimated, which is particularly important for long-term management of contaminated soil. We investigated the long-term desorption kinetics of Cs from soil in the Fukushima prefecture via batch desorption experiments in the presence of an adsorbent. The adsorbent can maintain a low concentration of Cs in solution, and prevent re-adsorption of the desorbed Cs.

Up to 50% of ^{137}Cs was desorbed after 139 days in 1-mM KCl, which was more than that desorbed via ordinary short-term extraction using 1-M ammonium acetate. Furthermore, desorption of ^{137}Cs continued after this period. We also found that high concentrations of K^+ prevented desorption of Cs in the initial stages of desorption, but that the effect decreased with time. The desorbed fraction of stable Cs (^{133}Cs) was less than that of ^{137}Cs, which indicates that ^{137}Cs can gradually move to more stable sites in the soil.

Keywords: Radiocaesium, stable caesium, soil, desorption, adsorbent, decontamination.

Long-term desorption kinetics of Cs from cotaminated soil

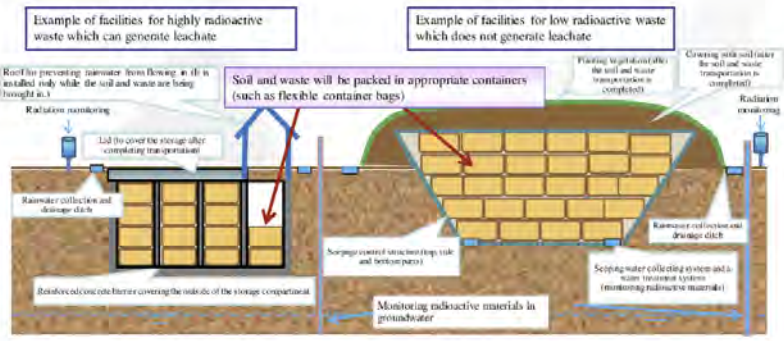
Kento Murota[†,1], Takumi Saito[1, 2]

[1] School of Engineering, The University of Tokyo
[2]Advanced Science Research Center, Japan Atomic Energy Agency

Background - 1

Soils contaminated with radioactive Cs

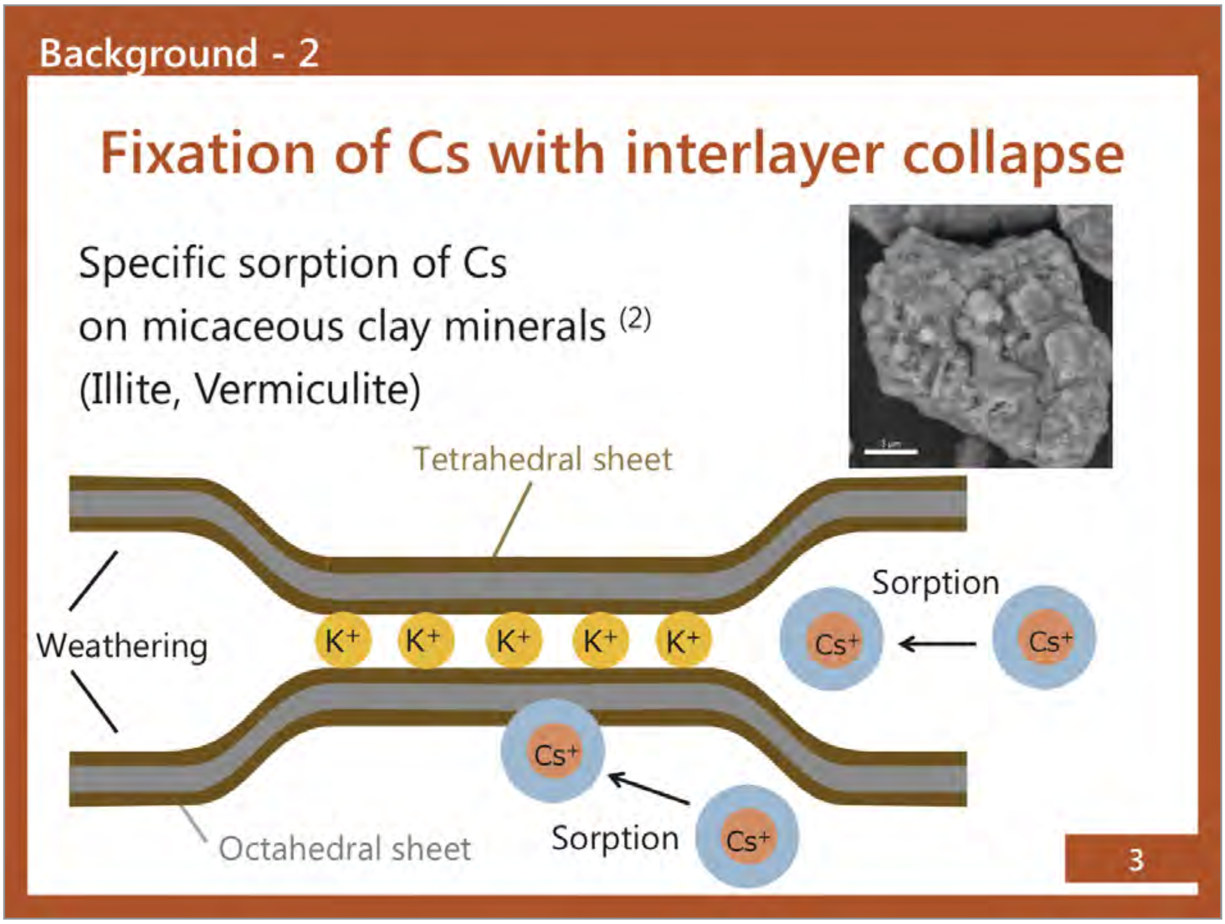
- ^{137}Cs: long half life (30 y), fixation to soils
- Construction of <u>interim storage facilities</u> and <u>final disposal sites</u>

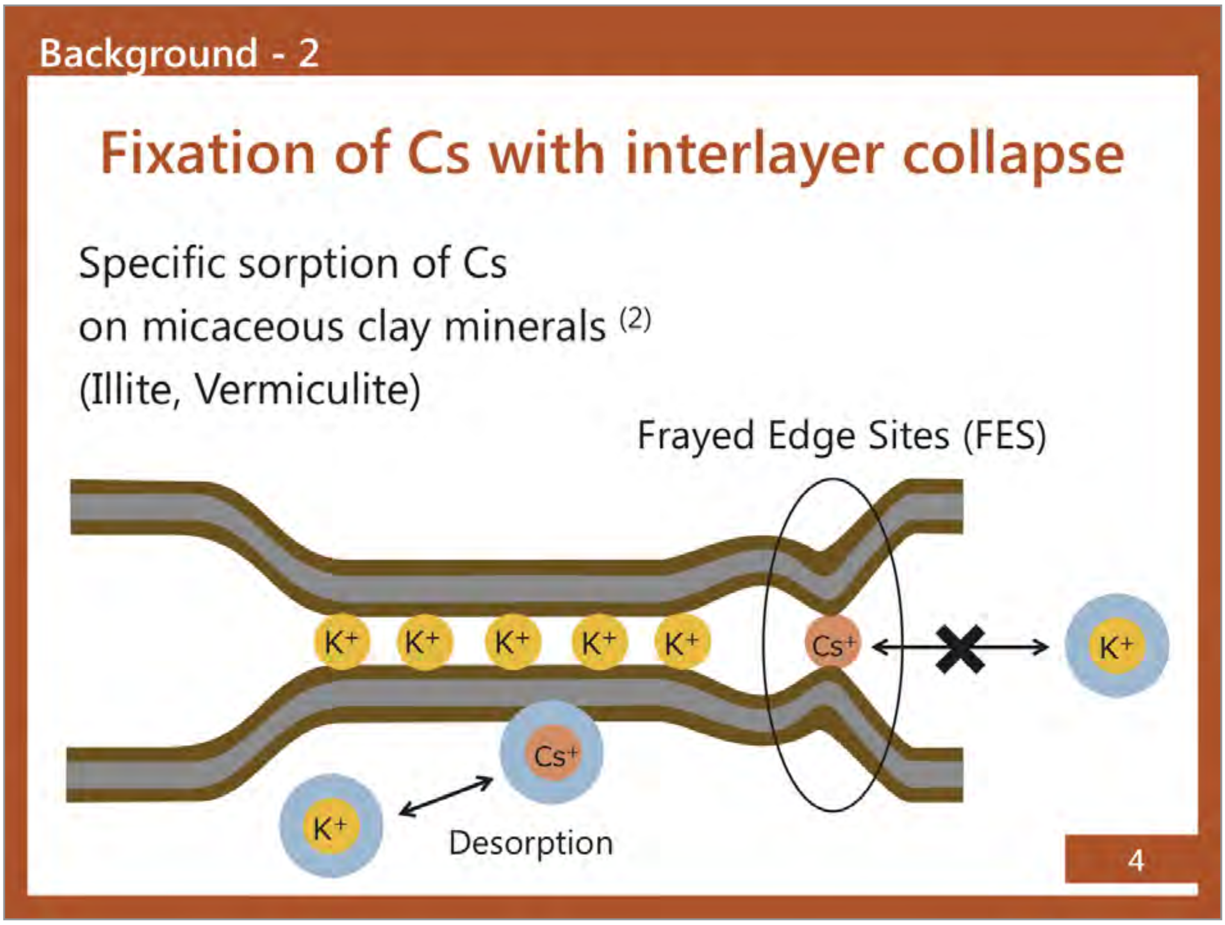


(1)

⇒Need to understand long-term mobility of Cs

2


Background - 2
Fixation of Cs with interlayer collapse
Specific sorption of Cs
on micaceous clay minerals (2)
(Illite, Vermiculite)
Tetrahedral sheet
Weathering
Sorption
K+
Cs+
Octahedral sheet
Sorption
3


Background - 2
Fixation of Cs with interlayer collapse
Specific sorption of Cs
on micaceous clay minerals (2)
(Illite, Vermiculite)
Frayed Edge Sites (FES)
K+
Cs+
Desorption
4

Background - 3

Underestimation of the desorption of Cs

1. **Short (~two weeks) period of the experiment**

   Sorption time ↑ → desorbed fraction ↓ [3]

   ⇒slow sorption process

2. **High concentrations of competitive cations**

   Increasing the concentrations of K^+ ⇒

   facilitation of ion exchange

   ⇔ inhibition due to interlayer collapse [4]

3. **The effect of re-sorption of Cs on soils** [5]

5

Objective

Evaluation of the long term desorption kinetics of Cs from contaminated soil with an adsorbent

- Desorption by the different concentrations of K^+
  - Evaluation of the effect of competing cation
- Comparison of the desorption of ^{137}Cs and stable Cs
  - Evaluation of the effect of contact time with soil

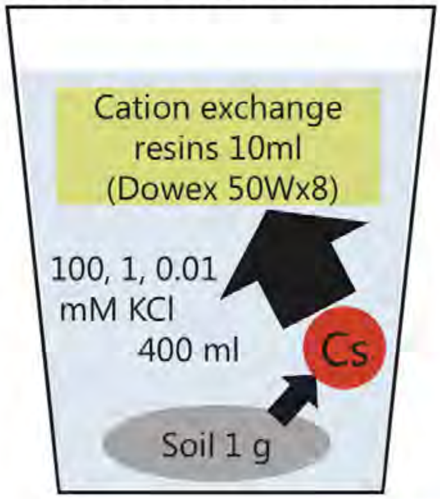
6

Method

Experimental procedures

1. A soil sample (collected in Fukushima prefecture on April 20, 2011) was agitated in the presence of the resins in a dialysis bag.
2. After **0.5, 1.5, 3, 7, 14, 28, 42, 56, 93, 139 days**, the adsorbents were replaced with new ones.
3. ^{137}Cs: **Ge detector**
   ^{133}Cs: **ICP-MS**
   (after extraction by HNO_3)

"Infinite bath scenario" (6)



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Result - 1

Strongly sorbed Cs can be desorbed

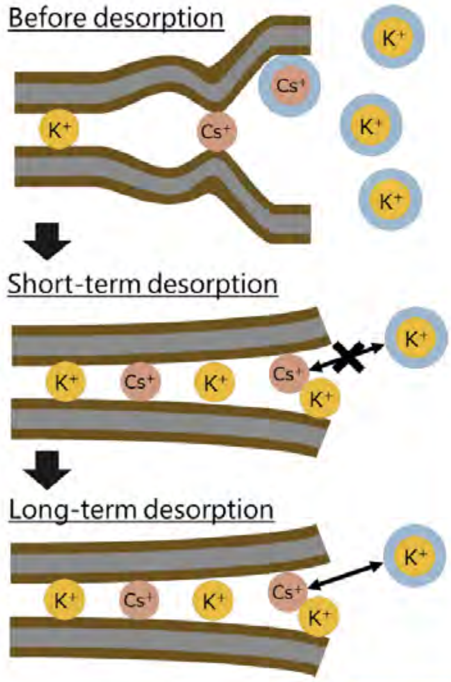
the desorption of ^{137}Cs still continued even after the 139-day desorption period.

The desorbed fraction of ^{137}Cs was more than that by the ordinal extraction method (7)
(by 1 M NH_4Ac for 1 day).

8

Result - 2

Fixation by high concentration of K^+ is effective only in the initial stage



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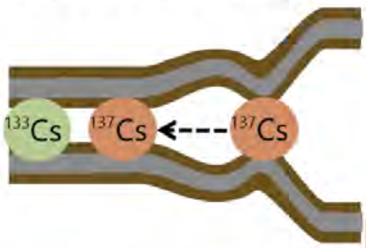
Result - 3

Different desorption of ^{133}Cs and ^{137}Cs derived from residence time

Desorbed fraction:
^{137}Cs > ^{133}Cs

⇐ difference of residence time in soil

→ <u>the desorbed Cs decreases with time</u>



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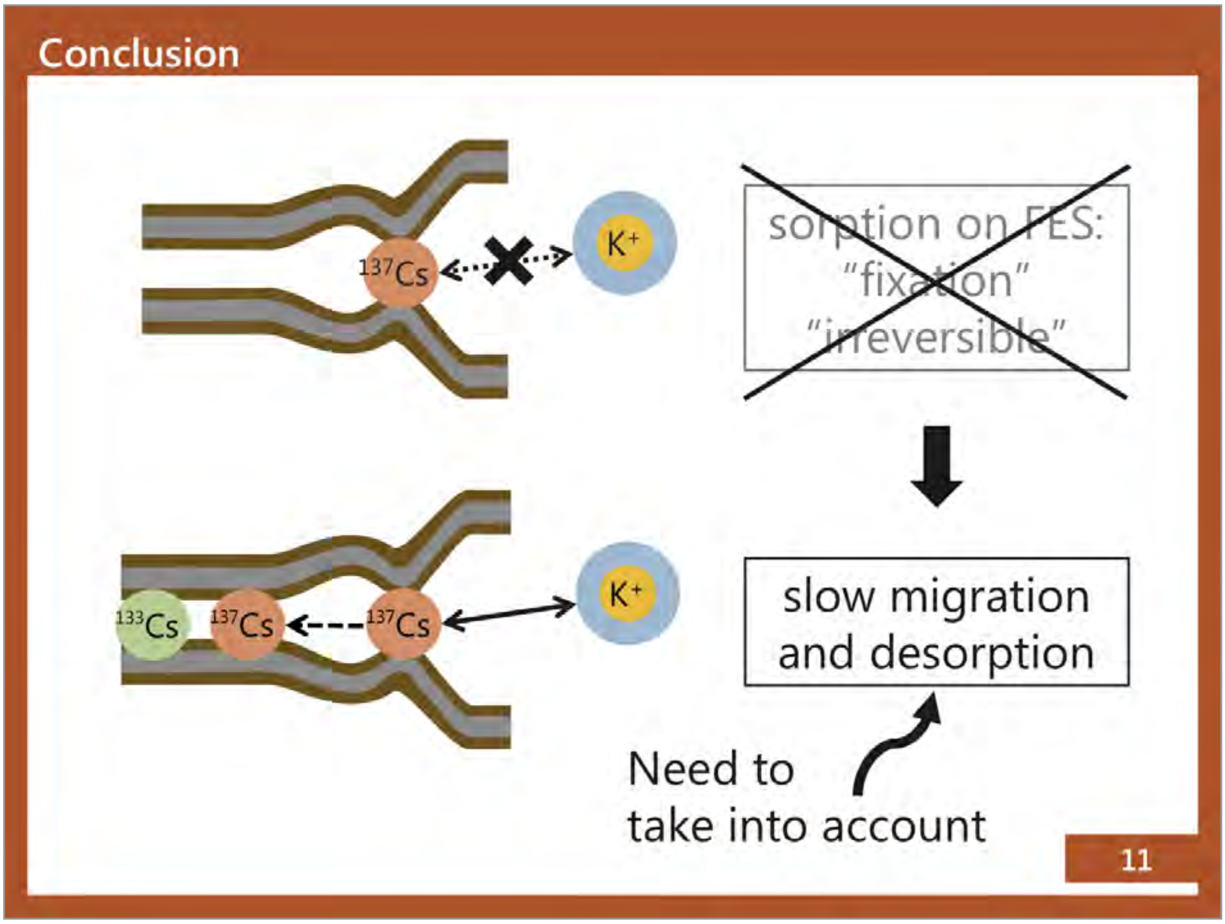

Summary

- In the presence of the adsorbent, The desorption of ^{137}Cs continued after 20 weeks. The part of **^{137}Cs not extracted by an conventional ion exchange procedure** can be desorbed.
- The high concentrations of competitive ions interrupt the desorption of ^{137}Cs initially but **^{137}Cs fixed by it can be gradually desorbed**.
- The desorbed fraction of ^{137}Cs was more than that of ^{133}Cs. It is possible that **^{137}Cs would shift to more stable forms** as ^{133}Cs.

12

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13

4.10 Interception and Storage of Wet Deposited Radionuclides in Crops

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Swedish University of Agricultural Sciences

Interception and Storage of Wet Deposited Radionuclides in Crops

Dissertation by Stefan B. Bengtsson
09:00 15th November 2013

SLU

Contents

- Introduction
- Background
- Aim
- Materials and Methods
- Results and Discussion
- Conclusions

Introduction

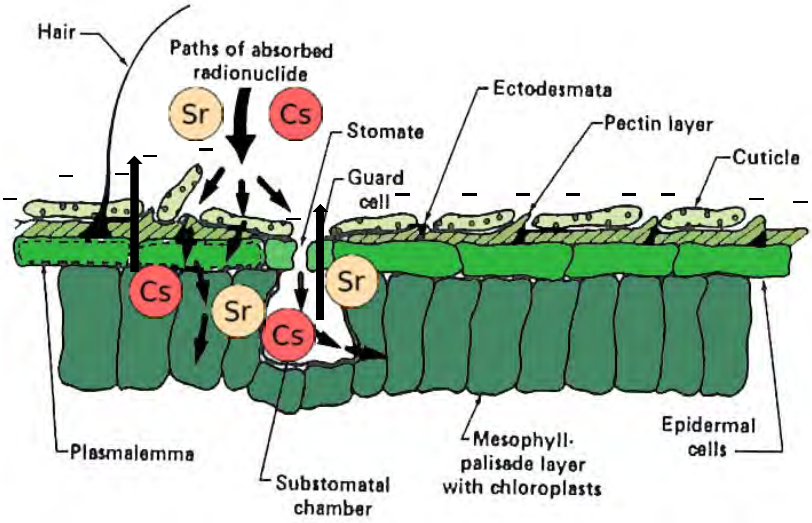
- Release of radionuclides from accidents can result in deposition onto food crops.
- Main harmful radionuclides → radiocaesium (Cs), iodine (I) and radiostrontium (Sr)
- Level of interception is dependent on; 1) morphology, 2) angle of leaves, 3) plant biomass, and 4) water storage capacity.
- Redistribution to edible plant parts depends on uptake.
- Information is essential for the risk assessment for food chain.

Background

- Entrance of radionuclides into plants
  - Two main types of deposition: *dry deposition* and *wet deposition*
  - Uptake of radionuclides differs depending on: growth stage → well-developed stage, a majority are taken up.
- Interception of radionuclides
  - Complicated process → negatively charged leaves: weaker retention of monovalent ions than for divalent ions
  - Related to plant morphology

Background

Cs+

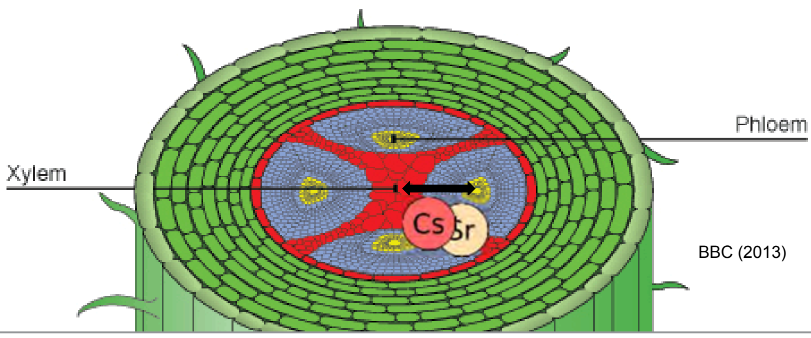


Sr^{2+}

Illustration with permission from Koranda & Robison (1978)

Background

- Uptake of radionuclides
  - Radionuclide entrance depends on: plant species, precipitation, temperature, light, pH, carrier of the radionuclides, and valence of the radionuclides.
  - Radionuclides are actively transported by the symplastic pathways and by exchange mechanisms between phloem and xylem.



BBC (2013)

Background

- Distribution of radionuclides in plants
  - Radiostrontium, lower redistribution than radiocaesium
  - Epidermis retain more radiostrontium (divalent)
  - Caesium analog to potassium and strontium analog to calcium
- Transfer of radionuclides
  - Transfer is regulated by rate of foliar uptake and root uptake by plant parts.
  - Concentration of radionuclides in plant is linearly related to the concentration of radionuclides in the root zone of the soil.
  - Described by a transfer factor (TF, $m^2\ kg^{-1}$) or translocation factor (TLF, $m^2\ kg^{-1}$), is explained later.

Aim

- Overall aim → to determine the amount of radionuclides intercepted, taken up and redistributed to different plant parts during wet deposition at different growth stages of oilseed rape, wheat and ley.

Aim

- The specific aims were:

1) Measure **interception** of ^{134}Cs and ^{85}Sr by oilseed rape, wheat, and ley at different growth stages and clarify the relation to plant biomass, leaf area, type of radionuclide and type of crop (Papers I and III).
2) Investigate **accumulation** of ^{134}Cs and ^{85}Sr between plant parts of oilseed rape, wheat and ley at different growth stages and describe transfer to seeds and other plant parts through calculation of transfer factors (Papers II and III) and translocation factors (Paper III).
3) Calculate **distribution** of ^{134}Cs and ^{85}Sr between plant parts of spring oilseed rape and spring wheat (Paper II).
4) Extend a trace element cycling model by including wet deposited radionuclides with a description of interception and foliar uptake for wheat (Paper IV).

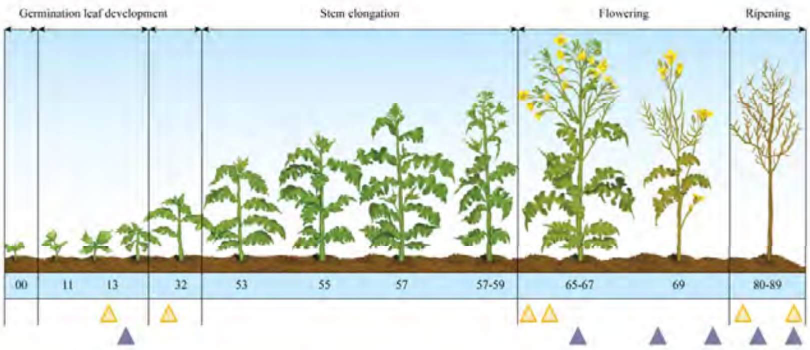
Location of Uppsala

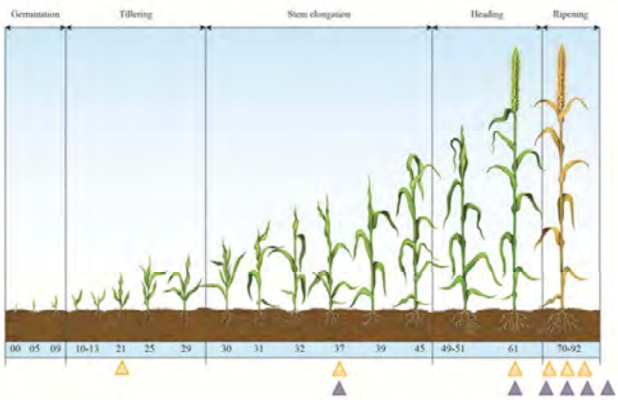
Materials and Methods

- Study area
  - Conducted at Ultuna
  - Two growing seasons

  in 2010 and 2011

Materials and Methods





Materials and Methods

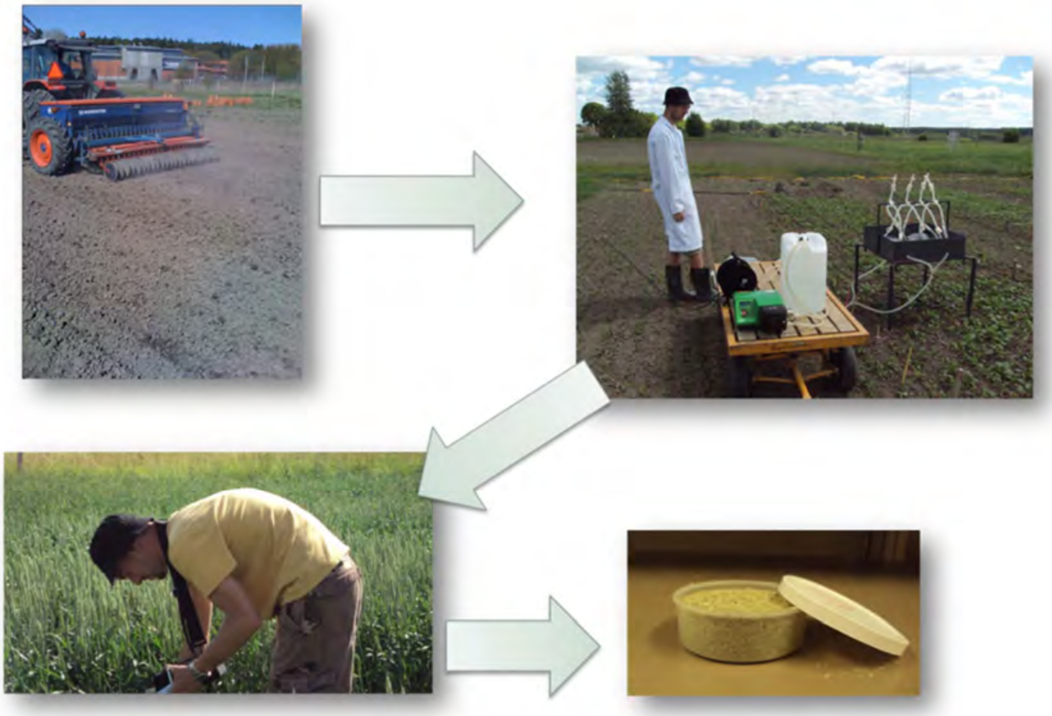
- The sowing in middle of May both years for spring oilseed rape and spring wheat.

- The ley established in 2010 on bare soil.
- The ley was a mixture of grass (90%) and clovers (10%).

- Fertiliser rates were normal for the crops (nitrogene and phosporus).
- No potassium (K) was added

Materials and Methods

- ^{134}Cs was in the form as caesium chloride and ^{85}Sr was in the form as strontium chloride
- 1st year the amounts applied were; 25-31 kBq m^{-2} for ^{134}Cs and 29-50 kBq m^{-2} for ^{85}Sr
- 2nd year the amounts applied were; 40-41 kBq m^{-2} for ^{134}Cs and ^{85}Sr

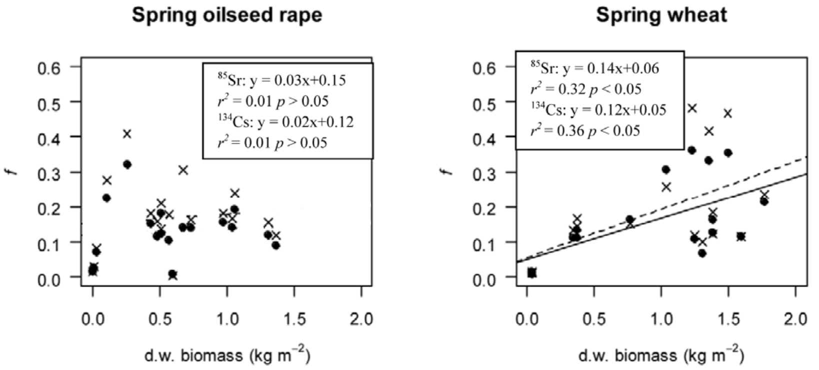


Materials and Methods

- Calculations
  - Interception fraction *(f)* = activity in the standing plant directly after deposition (A_i) divided total amount of activity deposited (A_t)
  - Transfer factor (TF) = activity in edible plant parts (A_c) divided total amount of activity deposited (A_t)
  - Translocation factor (TLF) = activity in edible plant parts (A_c) divided activity intercepted at deposition (A_i)

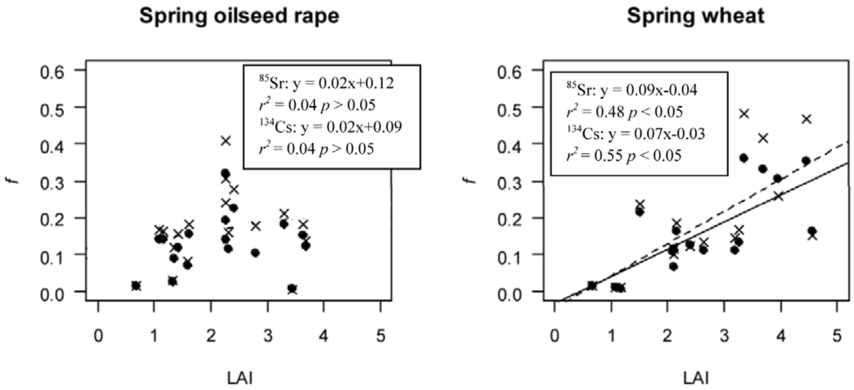
Results and Discussion

- Interception (Paper I)
  - Depended on both biomass and leaf area
  - Increased in relation to biomass for wheat and ley
  - Weaker relation for oilseed rape due to shedding of leaves and increase of biomasss



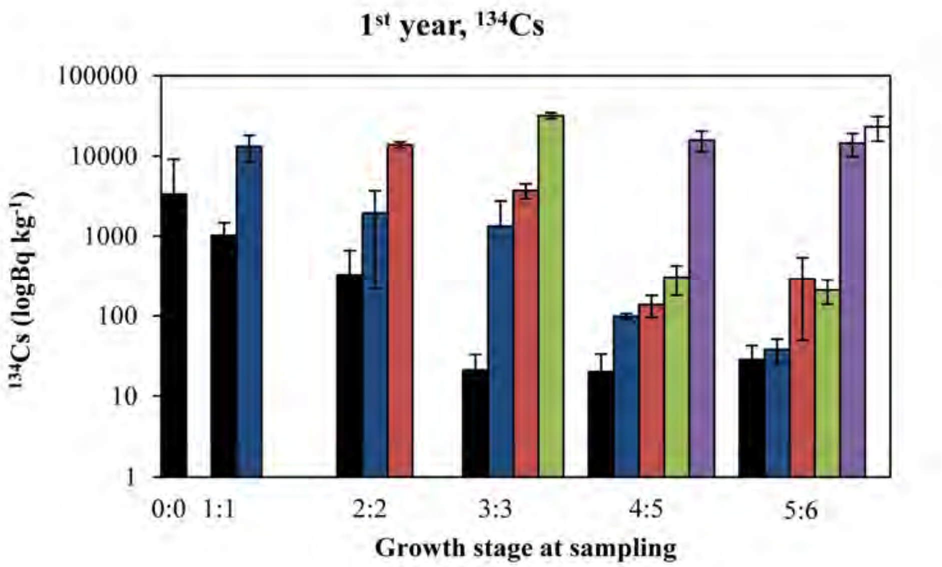
Results and Discussion

- Interception cont. (Paper I)
  - Increasing interception related to LAI for both radionuclides
  - Although weaker relation for spring oilseed rape



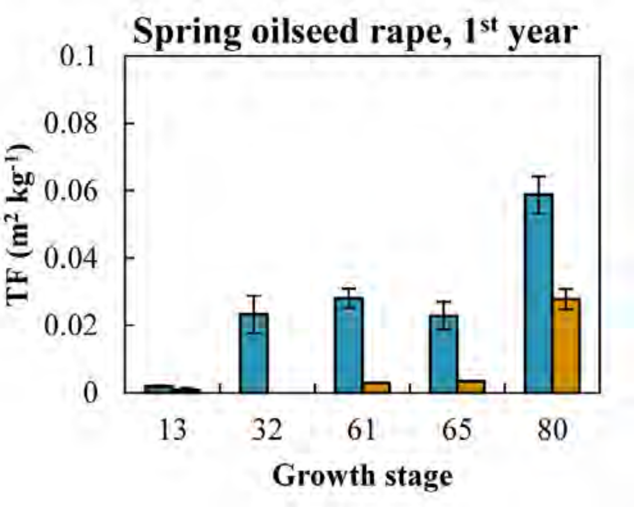
Results and Discussion

- Activity concentration in ley (Paper III)



Results and Discussion

- Foliar uptake (Paper II)
  - TF-values used to estimate uptake of radionuclides
  - TF-values had the same trend as the activity concentration



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- Assoc. Prof. Jan Eriksson
- Assoc. Prof. Annemieke Gärdenäs
- Assoc. Prof. Mykhailo Vinichuk

- Thesis can be found here:

http://pub.epsilon.slu.se/10855/1/bengtsson_s_131017.pdf

- Paper 1:

http://pub.epsilon.slu.se/9012/

- Paper 2:

http://pub.epsilon.slu.se/10789/2/bengtsson_et_al_130916.pdf

- Paper 3:

http://pub.epsilon.slu.se/11527/1/bengtsson_et_al_140929.pdf

4.11 Comparing Cs dynamics in two rice cultivars, Milyang23 and Akihikari, by tracer experiments

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The Fukushima Daiichi nuclear power plant accident occurred in 2011, resulting in the emission of a huge amount of radioactive nuclides, subsequently contaminating farmlands in Fukushima. The rice plant (Oryza sativa L.), which is Japan's main crop, was damaged by radiocesium (Cs-134 and Cs-137). Thus, we explored breeding of a novel cultivar that accumulates less cesium in brown rice. Based on previous reports, it was shown that Milyang 23 accumulates more cesium compared to Akihikari. Therefore, in this study, we compared Milyang 23 and Akihikari in various growth stages to examine the differences in cesium concentrations, focusing on translocation that contributes to cesium accumulation. Phloem sap, which contains cesium, is transported from a source organ to a sink organ; thus, the primary measurement objects were brown rice during the harvesting stage and the youngest leaf (6^{th} leaf) during the juvenile stage. In brown rice, the cesium concentration was twice as high in Milyang as in Akihikari. In the 6th leaf, the result was similar to that for brown rice. Conversely, in the 4th leaf blade, which transports phloem sap to the 6th leaf, levels in Akihikari were higher than Milyang. These results suggest that Milyang transports more cesium than Akihikari by translocation.

Keywords: Fukushima Daiichi nuclear power plant accident, radiocesium, rice plant, translocation, tracer experiment

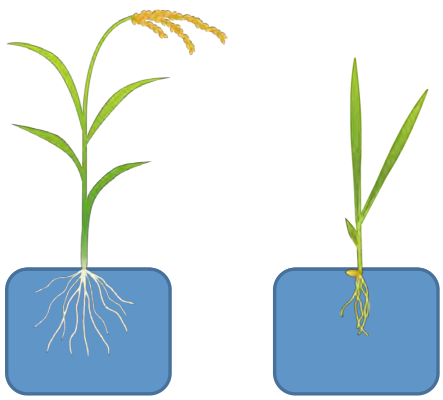
Comparing Cs dynamics in two rice cultivars, Milyang 23 and Akihikari, by tracer experiments.

Shuto Shiomi; Tatsuya Nobori; Natsuko I Kobayashi;
Keitaro Tanoi; Tomoko M Nakanishi

Graduate School of Agricultural and Life Sciences,
The University of Tokyo

Outline

1. Background & Strategy
2. Tracer Experiments: Grown-up Rice Plant
3. Discussions
4. Tracer Experiment: Young Rice Plant
5. Conclusion



2

Background: Contaminated Rice

Radiocesium accumulation in the brown rice

Year	Total number	Over 100 Bq/kg
2012	10,345,207	71
2013	11,005,841	28
2014	11,004,552	2

（ Fukushima-no Megumi Anzen Taisaku Kyogikai webpage ）

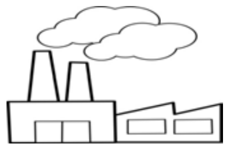
However, rice cropping is still suspended in some areas.

Investigations of all rice in Fukushima

Screening test
Detailed inspection

Under 100 Bq/kg → Shipping

Over 100 Bq/kg → Disposal

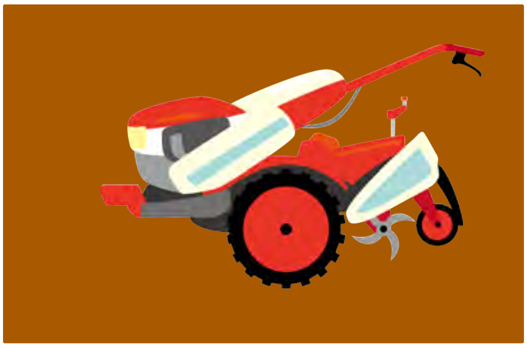


3

Background: Measures and Researches so far

At farmland

- Potassium fertilization
- Deep tillage



Genetics approach

- Investigation of Cs uptake by root (e.g. AtHAK5)

Quantitative Trait Loci(QTL) analysis

4

Strategy: QTL(Quantitative Trait Loci) analysis

Goal: Identifying genes contribute to quantitative trait

Process to the QTL analysis

1 . Cultivar selection

Necessary conditions for two cultivars

① Inbred lines exist.

② Clear differences exist.

2. Phenotyping analysis

Using inbred lines

3. QTL analysis

Analyzing the results and mapping QTL

Strategy: Cultivar Selection

Milyang 23 accumulates much Cs in brown rice. (Ishikawa, et al. 2009)

↓

Milyang 23 is often used with Akihikari as parental lines of the QTL analysis. (e.g. Drought stress)

↓

Are there any differences of Cs dynamics between Akihikari and Milyang ??

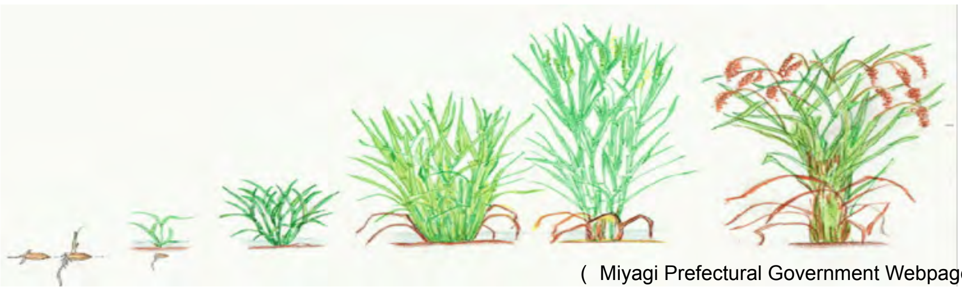
Akihikari	Milyang 23
• Japonica rice • Origin : Japan • High yielding • Early maturing	• Indica rice • Origin : Korea • High yielding • Semidwarf

Seeds of the rice

6

Objective

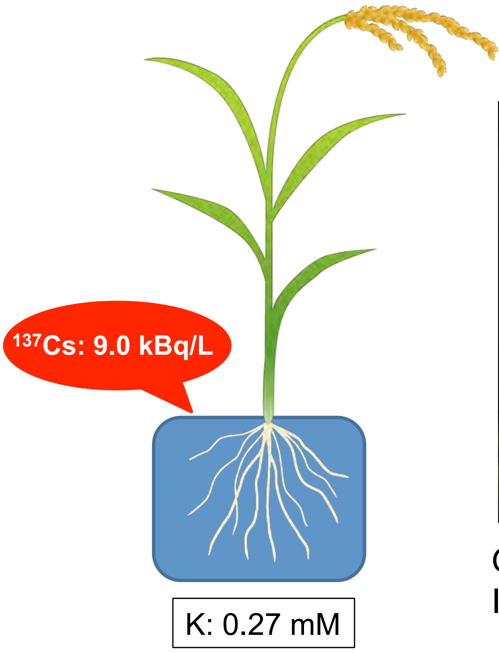
Finding out the differences of Cs dynamics between Milyang 23 and Akihikari



(Miyagi Prefectural Government Webpage)

Juvenile Stage **Heading Stage** **Harvesting Stage**

Experiment 1 Investigations in the heading and the harvesting stages



Growing rice plant
In a growth chamber

Measuring ^{137}Cs by an
NaI scintillation counter

8

Milyang 23 accumulated much Cs in the ears

Heading stage

Graph
radiocesium accumulation and distribution of rice plants.

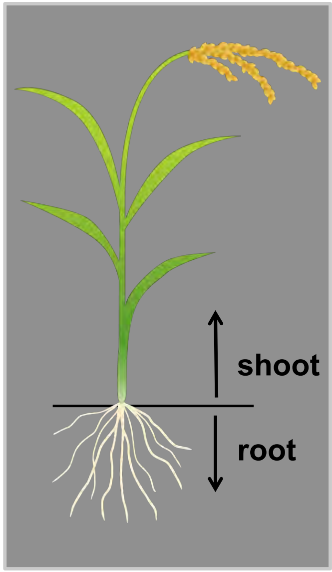
Milyang 23 accumulated much Cs in the brown rice

Harvesting stage

Graph
radiocesium concentration of various tissues of rice plants.

Experiment 2 Cesium uptakes from the roots were at the same level

Graph
radiocesium concentration of shoot and root of rice plants.



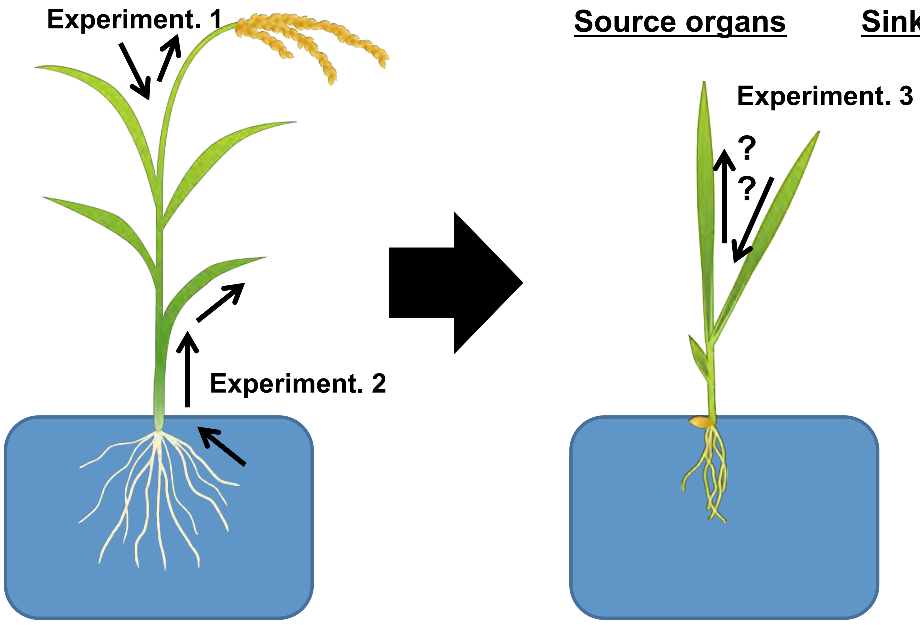
11

Focusing on Translocation

=

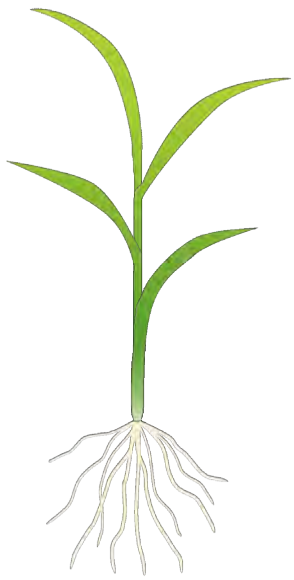
A sap flow in the phloem from the old organs to the young organs

= **Source organs** = **Sink organs**

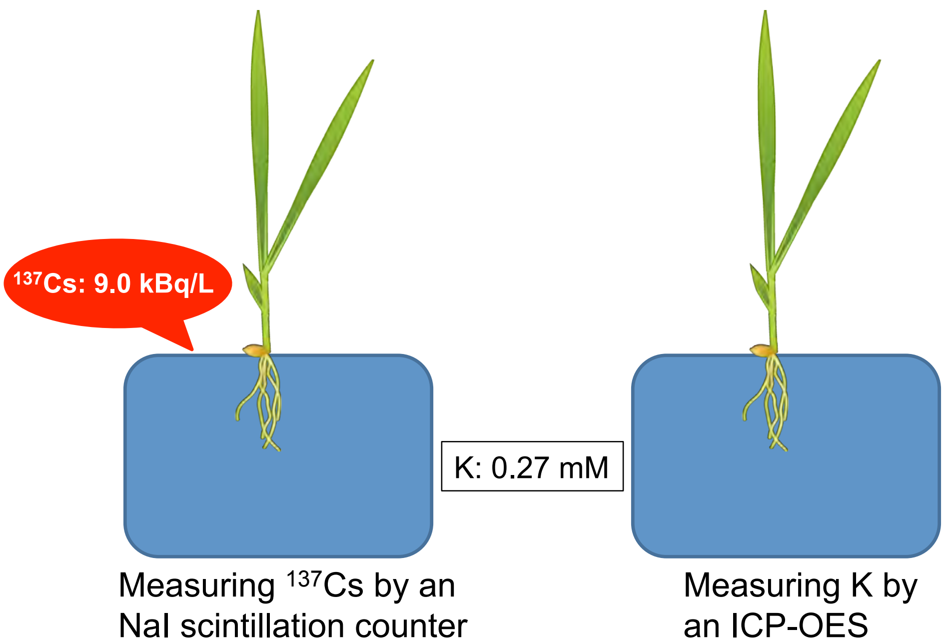


12

Growth process



Experiment 3 Investigations in the Juvenile Stage



14

In K concentration, there was no difference between the two cultivars

Juvenile stage

Graph
potassium concentration of various leaves of seedling rice plants.

Milyang 23 accumulated much Cs in the new leaves

Juvenile stage

Graph
radiocesium concentration of various leaves of seedling rice plants.

16

Conclusion

Cultivar selection

↓

Phenotyping analysis

↓

QTL analysis

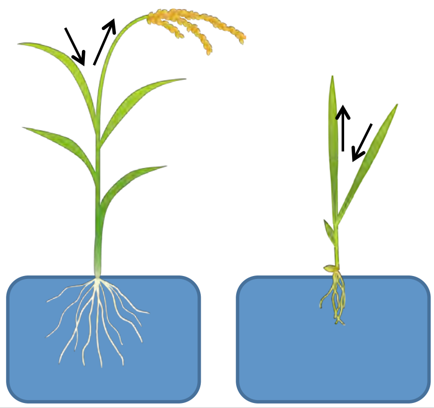
↓

Breeding new cultivars

This research (Cultivar selection)

In progress (Phenotyping analysis)

Milyang 23 accumulated much Cs in
- new leaves in the juvenile stage.
- ears in the heading stage.
- brown rice in the harvesting stage.



Acknowledgements

Rice planting

Harvesting rice

18

Tack för att ni lyssnade

4.12 The characterisation of caesium accumulation in wild radish

Nanami Oshima†, [1], Maki Katsuhara[2], Hiroaki Setoguchi[1]

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2 Institute of Plant Science and Resources, Okayama University, Kurashiki, 710-0046, Japan.

This study evaluated the characteristics of caesium accumulation in two ecotypes of Raphanus sativus L. var. raphanistroides Makino (wild radish). Following the Fukushima Daiichi nuclear power plant accident, radioactive caesium was dispersed across agricultural areas, especially in Fukushima Prefecture. Some of the crops cultivated in these areas accumulated caesium, preventing their use for consumption. However, the ability of these plants to accumulate caesium could be used for the phytoremediation of radiocaesium. Wild radish was chosen because of its high caesium transfer factor. Two ecotypes of wild radish, coastal area and freshwater lakeshore, were analysed to identify their tolerance of and ability to accumulate caesium. They were grown in soils containing increasing caesium concentrations in order to determine the concentrations of caesium and potassium that induce plant death. In another experiment, plants were exposed to three fixed concentrations of caesium solution for 16 days in order to evaluate the responses of the two ecotypes, and the levels of accumulation in the plant body, at each exposure concentration. The concentration of caesium in vacuoles and vessels were also investigated to reveal the localisation of accumulated caesium. Further studies to dissect the physiological and molecular mechanisms of caesium accumulation are needed to develop effective phytoremediation with wild radish in real fields.

Keywords: Phytoremediation, caesium, wild radish, Fukushima Daiichi nuclear power plant accident

The analysis of characterization of cesium accumulation in wild radish

Nanami Oshima (Kyoto University)
Maki Katsuhara (Okayama University)
Hiroaki Setoguchi (Kyoto University)

Kumagawa area in Ohkuma town

Kumagawa area in Ohkuma town is located **3 Km** away from Fukushima Daiichi Nuclear Power Plants.

Air dose rate in 2013 : 20 μSv / h

Annual exposed dose in 2013 : 438 mSv

Kumagawa area in Ohkuma town

About 96% of residential area has been designated to "difficult-to-return zone"

The activity of cesium in the surface of the soil:
85.2 ± 6.10 Bq /g (Cultivation depth = 5 cm,2013)

Preliminary experiment for in laboratory

Watering only once with 5mM cesium chloride (**non radioactive**) and cultivation for 60 days (Setoguchi et al, unpublished)

Artemisia fukudo
(Asteraceae)
(coastal plants, halophyte)

0.16 mg Cs / kg dw

Arabidopsis kamchatica
(coastal and inland ecotypes)

0.47 mg Cs / kg dw

Wild radish
Raphanus sativus

1.96 mg Cs / kg dw

The Result of field experiment for two and half a month in Kumagawa area in 2013 (wild radish from inland area)

Houttuynia cordata : **0.329**

others including Poaceae exhibited **0.060 or less**

(Yamashita et al, 2014)

Wild radish showed relatively high transfer factor value.

Material and methods

Wild radish

- *Raphanus sativus* L. var. *raphanistroides* Makino
- Habitat across Japan, mainly in coastal area.
- Annual plant

Two ecotypes used for this study

Habitat	Location
Coastal	Mie Pref. (Matsunase shore)
Inland	Shiga Pref. (Lake Biwa)

Two ecotypes of wild radish

Different ecological trait (defense mechanism)

= Prevent plants from taking too much harmful components

Coastal

Seawater

Inland

Freshwater

The objective

Different mechanism in each type

↑

Characteristics of each type to cesium

↑

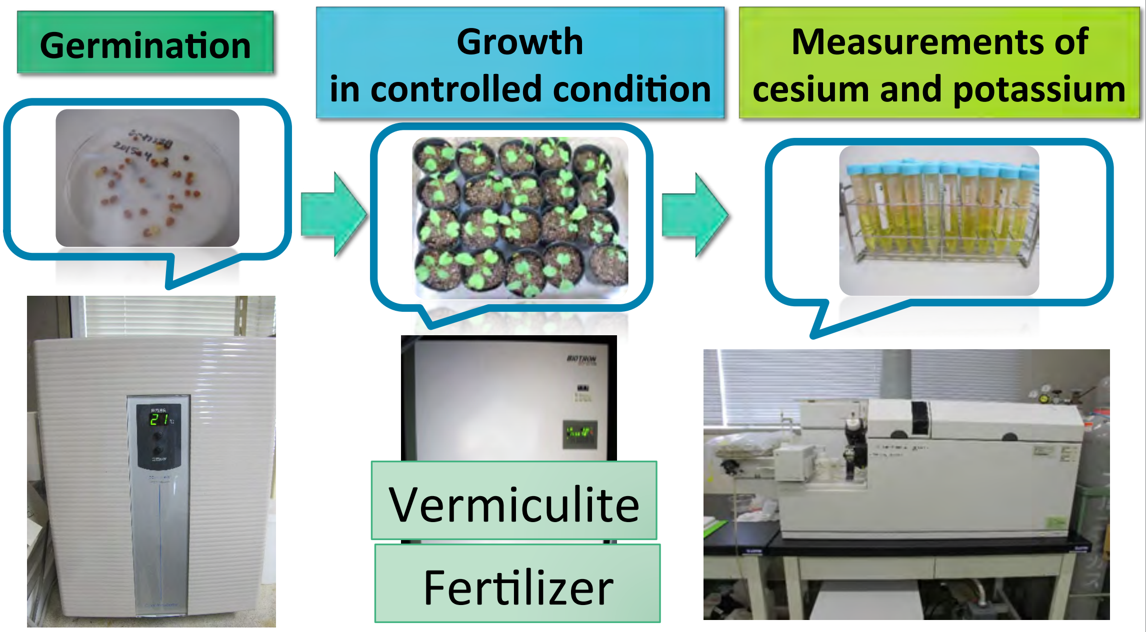
What contributes to characteristics and from which part this comes?

Difference among two types and roots and leaves

	Coastal	Inland
Leaves		
Roots		

What contributes to characteristics and from which part?

Methods



Methods

- Cesium chloride (**Cs 133**) solution was cultured with each replicate after two foliage appeared.

Preliminary experiments

Cultured with incremental increase of cesium solution (up to 30mM)

8 replicates from each types were cultured with each **5mM, 15mM, 25mM** cesium chloride solution every 3 days by 5mM for 16 days .

Dried for 72 hours and crashed and mixed. **0.1g** from this were dissolved in 60 % nitric acid. The concentration of cesium and potassium were measured **only once**.

Results and discussion

Tolerance to high cesium

Preliminary experiment (24 replicates)

	8mM (3 days)	20mM (16 days)	30mM(29 days)
Inland			
Coastal			

Both types could survive under 30mM.

Tolerance to cesium(5mM, 15mM, 25mM)

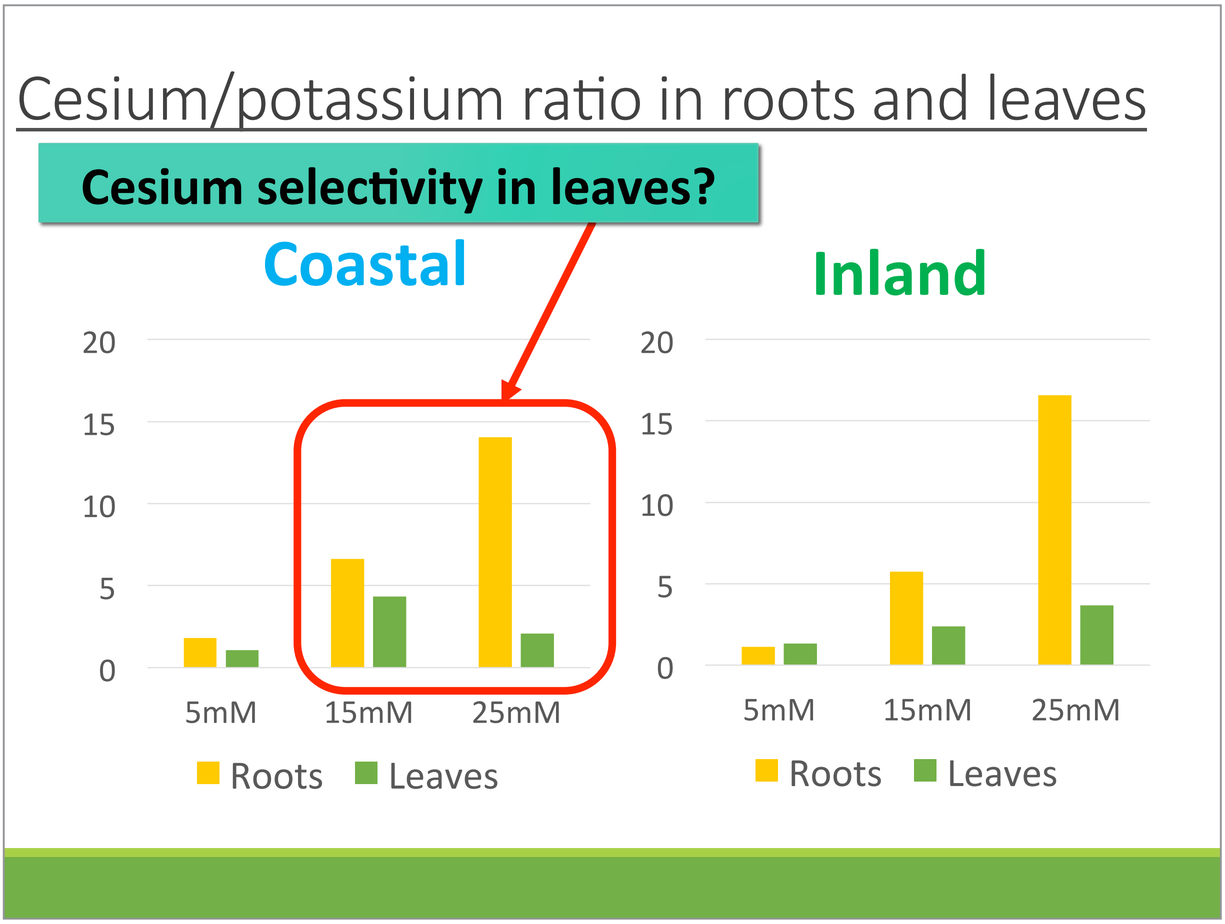
Both types have almost the same tolerance to cesium

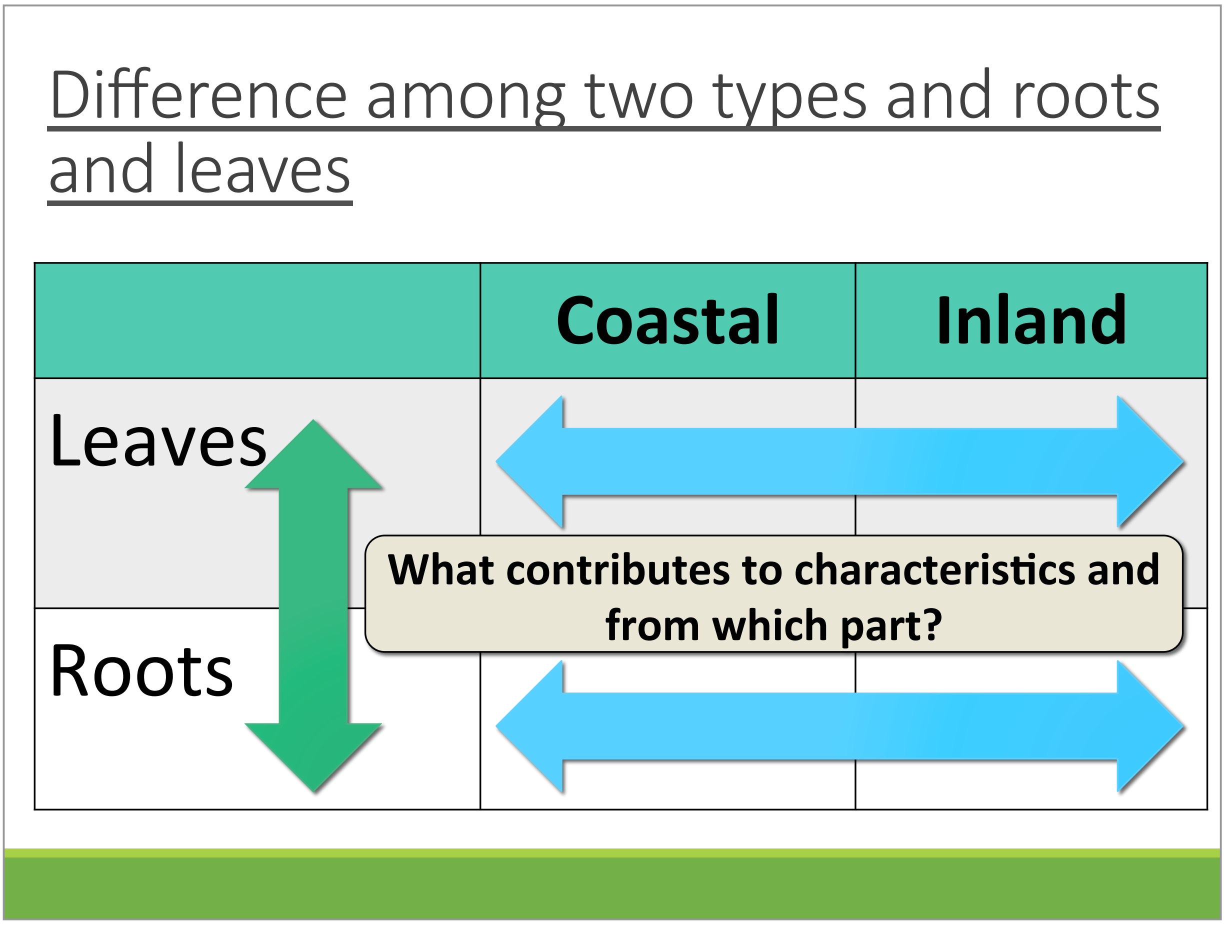
	5mM	15mM	25mM
Inland			7 have died
Coastal			5 have died

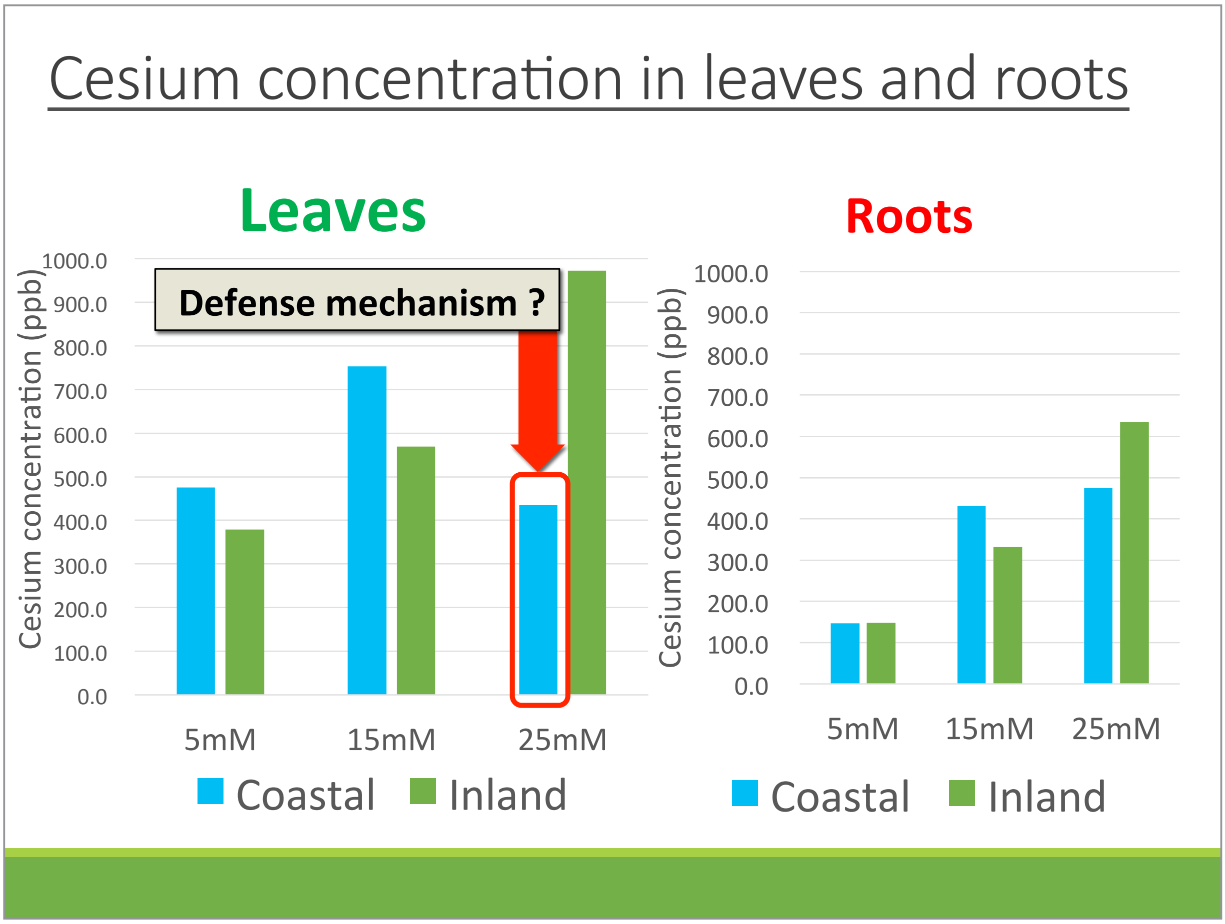
Difference among two types and roots and leaves

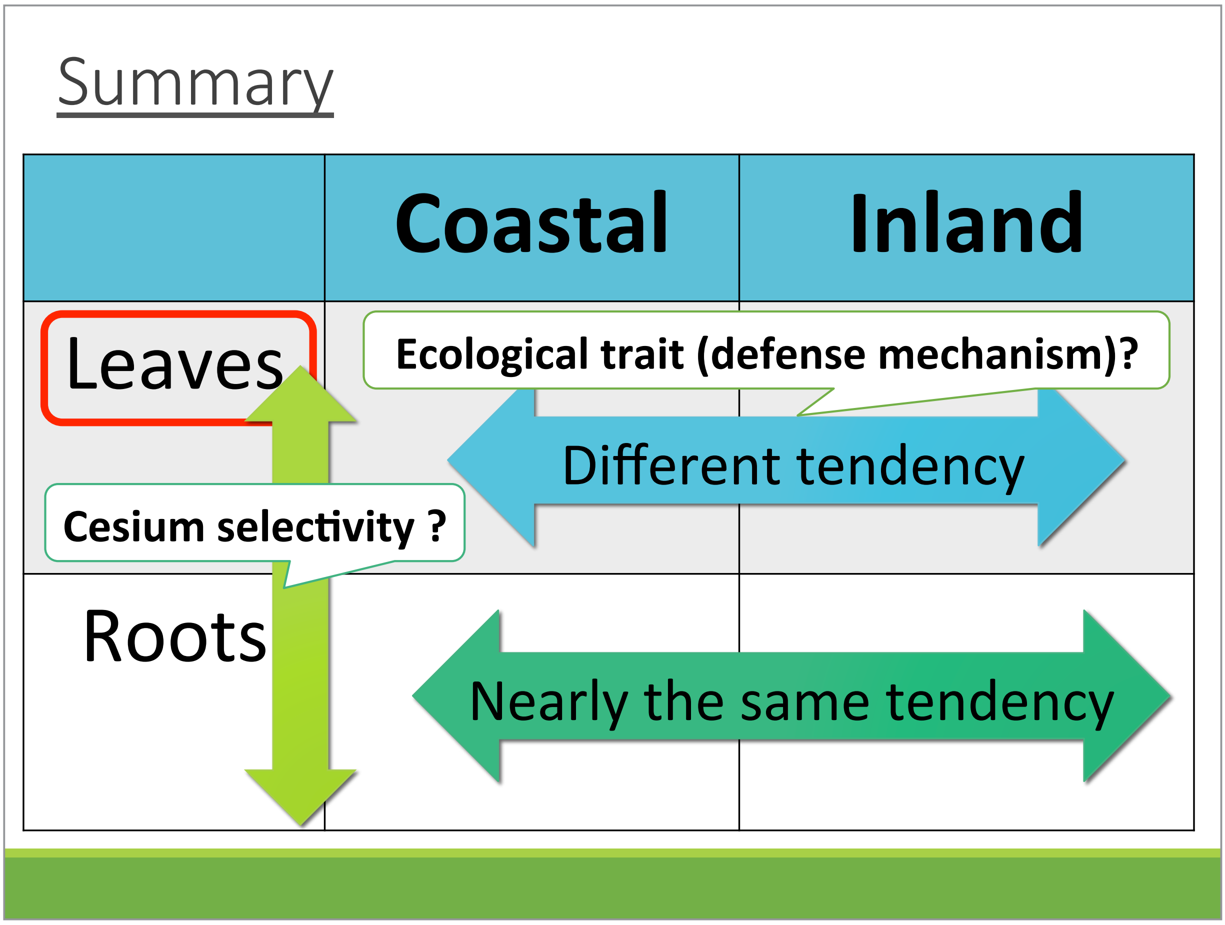
	Coastal	Inland
Leaves		
Roots		

What contributes to characteristics and from which part?


Cesium/potassium ratio in roots and leaves
Cesium selectivity in leaves?
Coastal
Inland
20
15
10
5
0
5mM
15mM
25mM
Roots
Leaves


Difference among two types and roots and leaves
Coastal
Inland
Leaves
Roots
What contributes to characteristics and from which part?


Cesium concentration in leaves and roots
Leaves
Defense mechanism ?
Cesium concentration (ppb)
1000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
5mM
15mM
25mM
Coastal
Inland
Roots
Cesium concentration (ppb)
1000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
5mM
15mM
25mM
Coastal
Inland


Summary
Coastal
Inland
Leaves
Ecological trait (defense mechanism)?
Different tendency
Cesium selectivity ?
Roots
Nearly the same tendency

Discussion

	Coastal	Inland
Ecological trait (defense mechanism)	○	×
Accumulation (Accumulate more cesium as concentration increases in leaves)	×	○
Tolerance	Almost the same	
Selectivity In leaves	○	×

Further research

- Investigate the effect of characteristics on cesium uptake and accumulation
- Plants are grown under low concentration of cesium solution to investigate their affinity to cesium.
- Measure the concentration of cesium in vacuoles in leaves.

Acknowledgement

Ms. Sanae Rikiishi (Okayama University)

All of Setoguchi laboratory members

4.13 The impact of potassium fertilisation: Investigation using a radioisotope tracer experiment

Natsuko I. Kobayashi†, v, Ryohei Sugita[1], Tatsuya Nobori[1, 2], Ryosuke Ito[1], Keitaro Tanoi[1], Tomoko M. Nakanishi[1]

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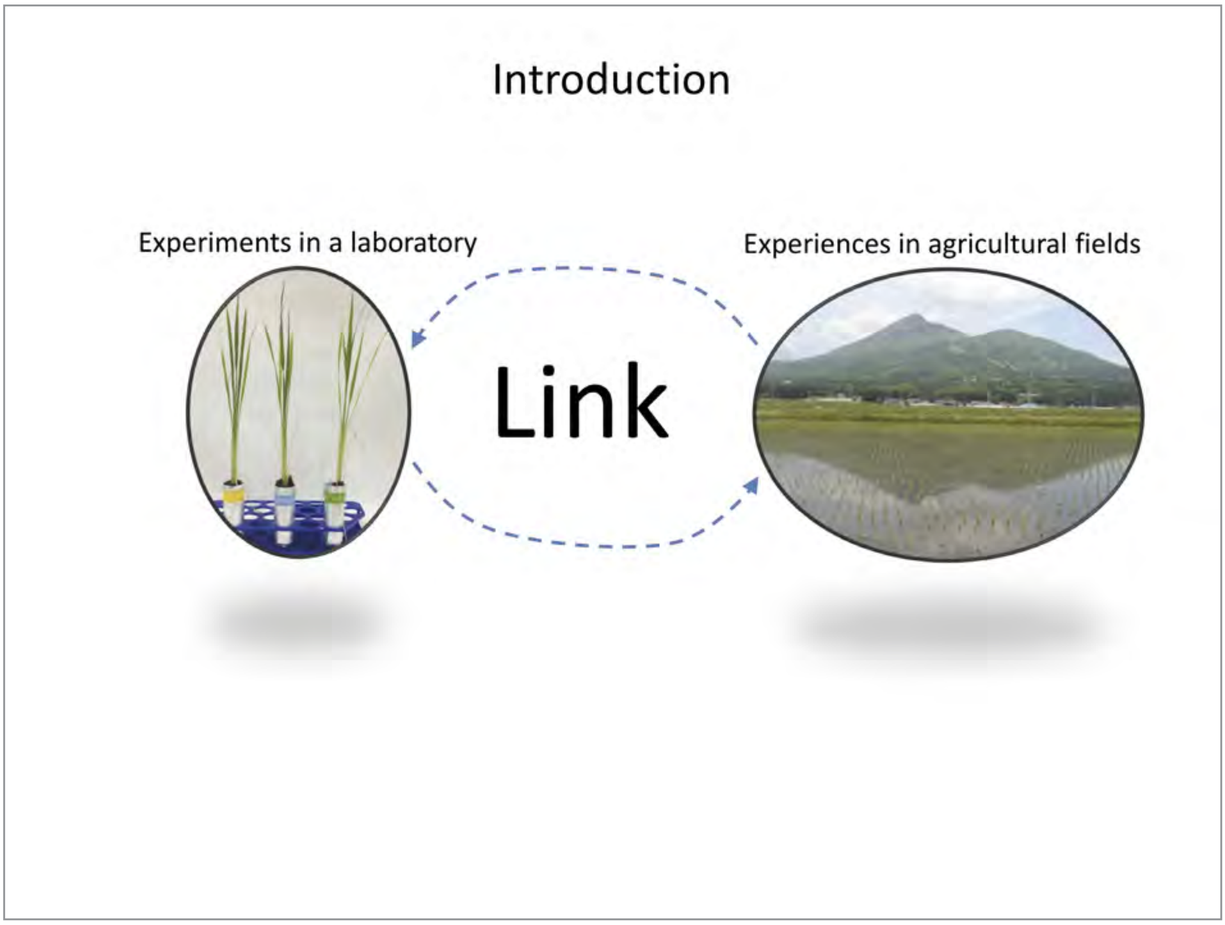
2 Present address; Max Planck Institute for Plant Breeding Research, Köln, Germany

To ensure the reduction of radiocesium contamination in agricultural products, it is important to define the factors affecting radiocesium behaviour in a living plant. For rice, survey data collected from various paddy fields in Fukushima clearly demonstrated that soil potassium (K) content is negatively correlated with radiocesium content in rice plants, resulting in the encouragement of K fertilisation. However, the scientific basis for the effect of K supply on radiocesium uptake and transport remains unclear. Therefore, we performed Cs-137 tracer experiments to investigate the physiological effect of K supply on radiocesium uptake and movement. When rice plants were grown in solution containing 3 mM K for 8 weeks, Cs-137 content in shoots was reduced to less than half of that grown under K deficient conditions. We also found that the amount of Cs-137 transferred from old to new leaves and ears was significantly decreased by supplying K in the solution. As a result, Cs-137 content in the grain was reduced to one-sixth in the presence of K. These effects of K fertilisation could be generally explained by the similar movement of K and Cs in plants, as well as by competition between K and Cs ions during the root uptake process. In this context, we performed several tracer experiments to clearly demonstrate the similarities and differences between the behaviours of the two ions. Our results increased our understanding of the physiological characteristics of radiocesium in plants, which can be used for the development of robust measures in agricultural fields.

Keywords: Tracer, potassium fertilisation, rice, uptake, transport

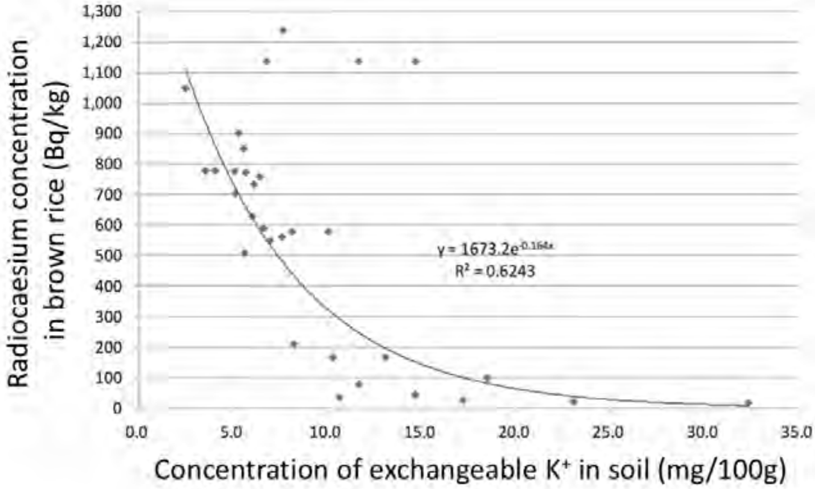

The impact of potassium fertilization:
Investigation by the radioisotope tracer experiment
Natsuko I. Kobayashi
Graduate School of Agricultural and Life Sciences,
The University of Tokyo, Japan


Introduction
Experiments in a laboratory
Experiences in agricultural fields
Link

Introduction

Effect of potassium (K) on radiocaesium in grain

Inverse relationship was found between the concentration of exchangeable K^+ in soil and radiocaesium concentration in brown rice harvested in 2011.



From the interim report released by Fukushima prefecture (25, Dec., 2011)

Purpose of the research

To understand the physiological basis of "K effect"

Characterization of the uptake of caesium (Cs^+) by the root and the accumulation of Cs^+ in the grain

Increased K^+ concentration can effect on reducing the Cs^+ uptake rate in root.

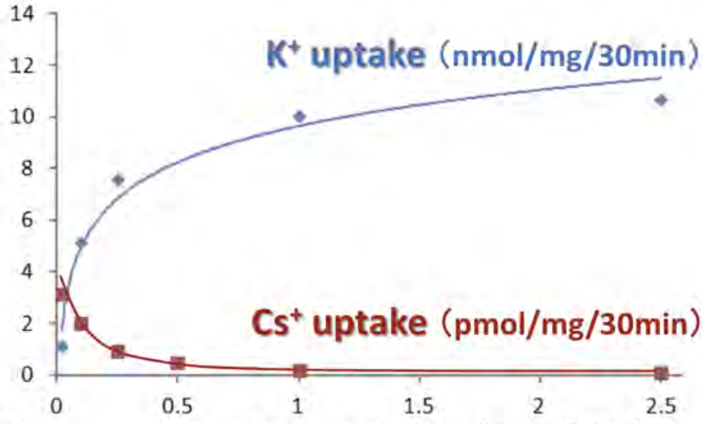
Uptake analysis using radionuclide as a tracer

Nutrient solution

K^+ concentration: 25μM〜2.5mM

Cs^+ concentration: 0.1μM

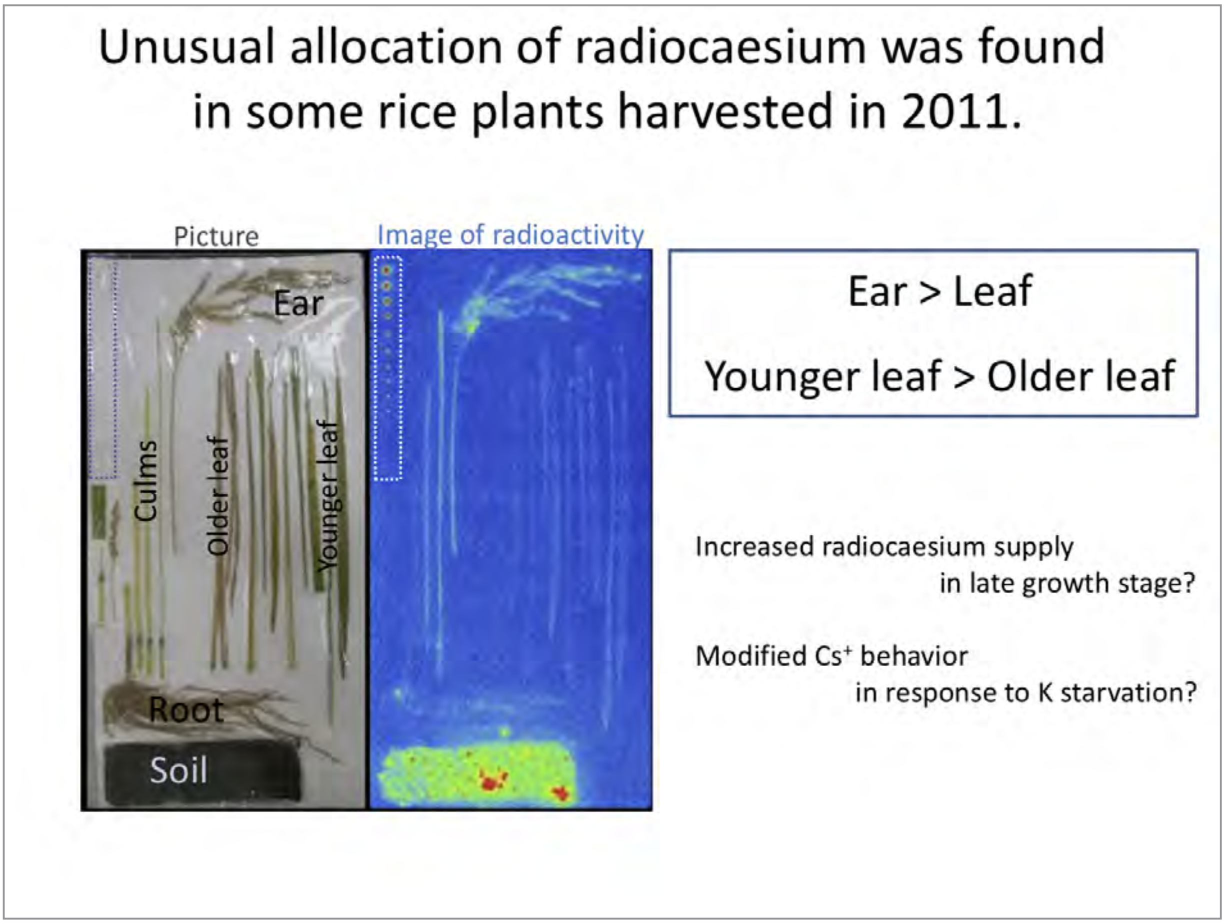
with ^{42}K and ^{137}Cs

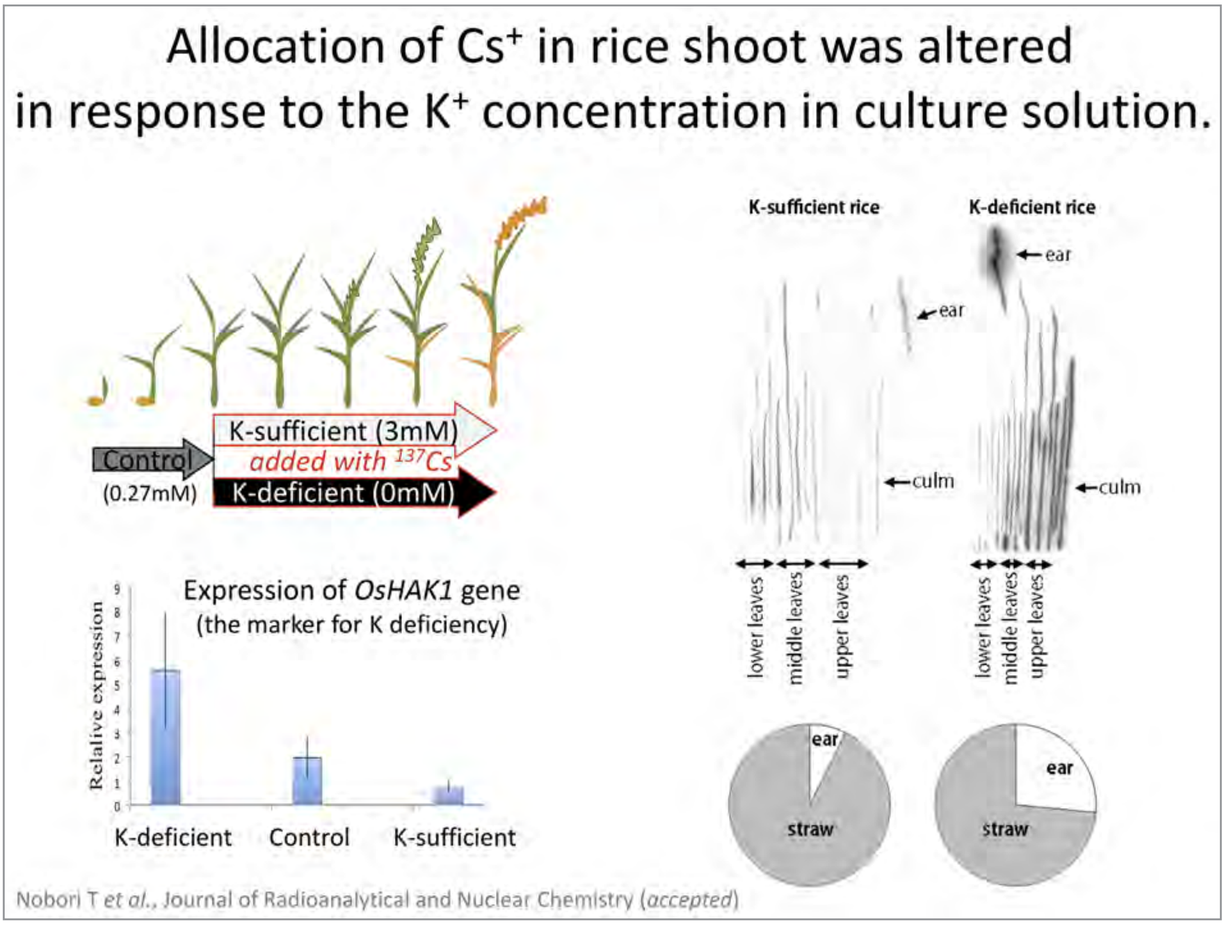


Selectivity factor was decreased under the K-deficient condition.

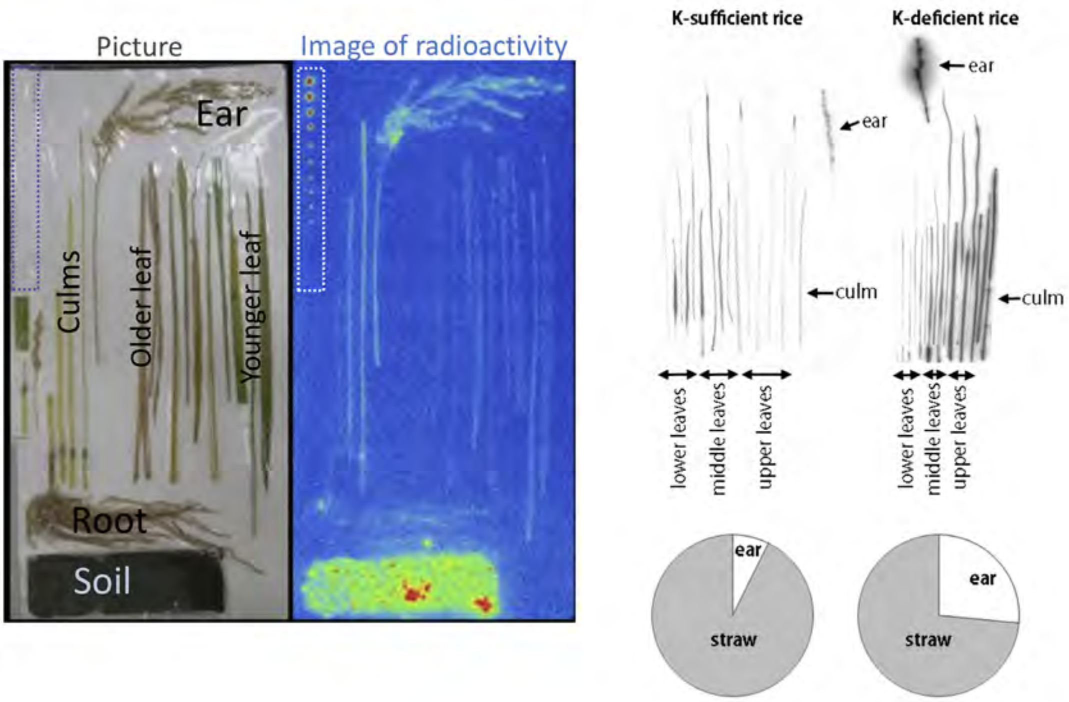
$$\text{Selectivity factor} = \frac{K^+ \text{ uptake rate} / Cs^+ \text{ uptake rate}}{[K^+]_{solution} / [Cs^+]_{solution}}$$

	K-deficient	Control
$[K^+]_{solution}$ = 20 μM	**3.6**	**5.5**
$[K^+]_{solution}$ = 1 mM	**7.0**	**11.8**

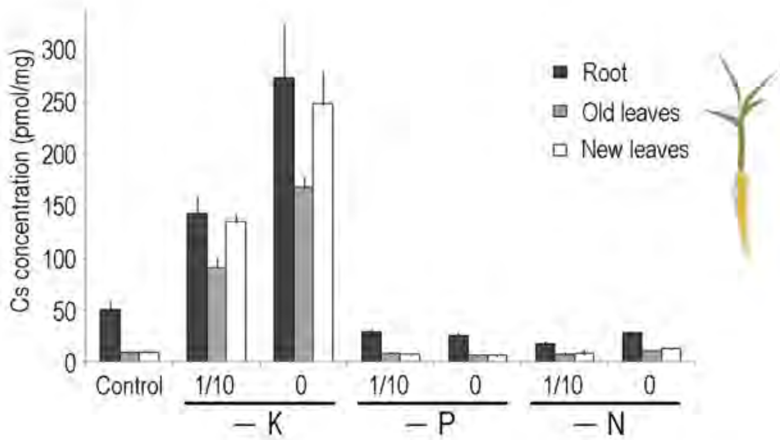

Unusual allocation of radiocaesium was found in some rice plants harvested in 2011.
Picture
Image of radioactivity
Ear
Culms
Older leaf
Younger leaf
Root
Soil
Ear > Leaf
Younger leaf > Older leaf
Increased radiocaesium supply in late growth stage?
Modified Cs⁺ behavior in response to K starvation?


Allocation of Cs⁺ in rice shoot was altered in response to the K⁺ concentration in culture solution.
K-sufficient (3mM)
added with ¹³⁷Cs
Control
(0.27mM)
K-deficient (0mM)
Expression of OsHAK1 gene
(the marker for K deficiency)
Relative expression
K-deficient
Control
K-sufficient
K-sufficient rice
K-deficient rice
ear
ear
culm
culm
lower leaves
middle leaves
upper leaves
lower leaves
middle leaves
upper leaves
ear
straw
ear
straw
Nobori T et al., Journal of Radioanalytical and Nuclear Chemistry (accepted)

Allocation of Cs^+ in rice shoot was altered in response to the K^+ concentration in culture solution.

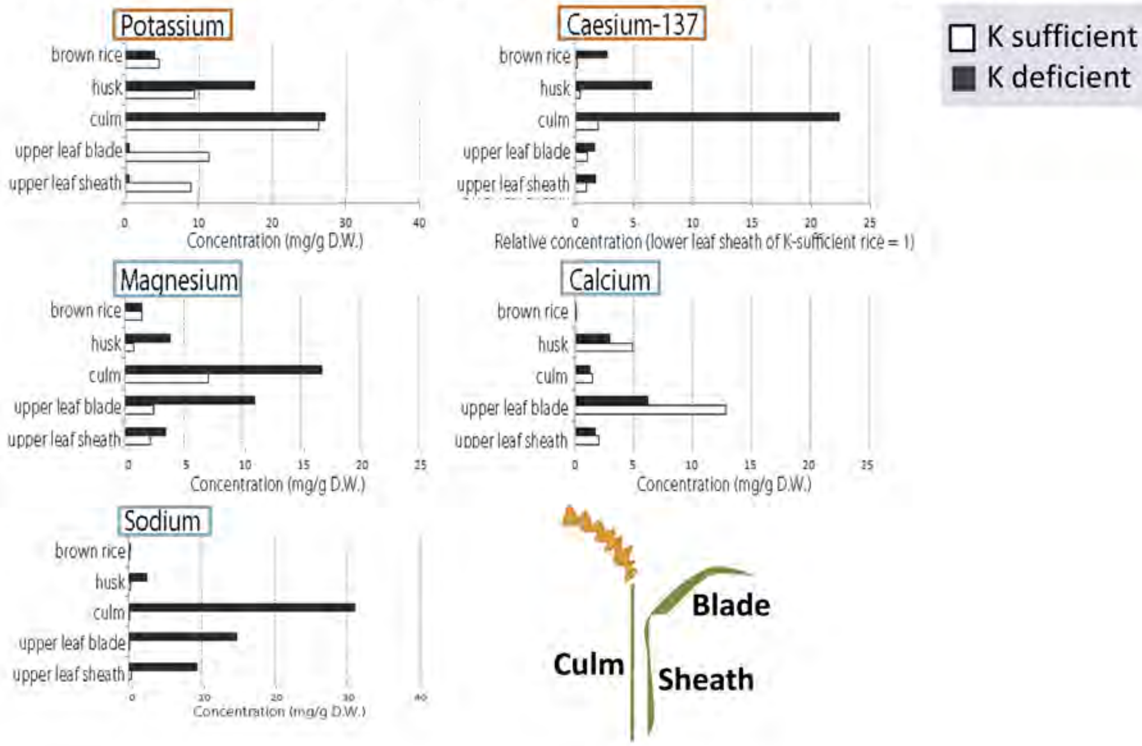


The effect on the uptake and allocation of Cs^+ was specific to the K deficiency.



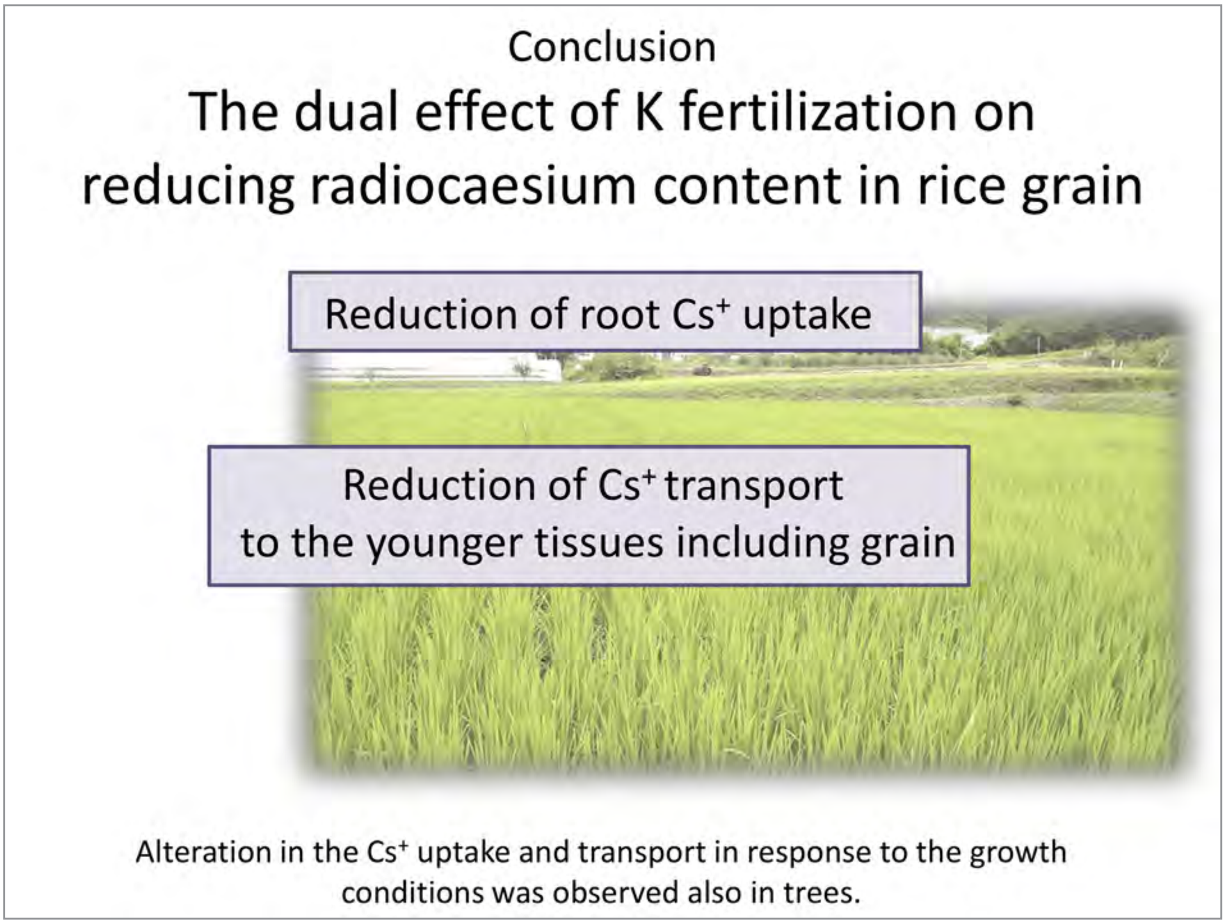
Nobori T *et al.*, Journal of Radioanalytical and Nuclear Chemistry (*accepted*)

Allocation pattern of Cs+ was similar to that of K+. Cs+ and K+ could share some transport systems.



Field study at Fukushima

Total Cs concentration (Bq/kg) in ears was decreased from 350 to 100 as a consequence of the K fertilization.
Cs distribution ratio in ears (%) was also decreased from 11.5 to 6.5 by the K fertilization.

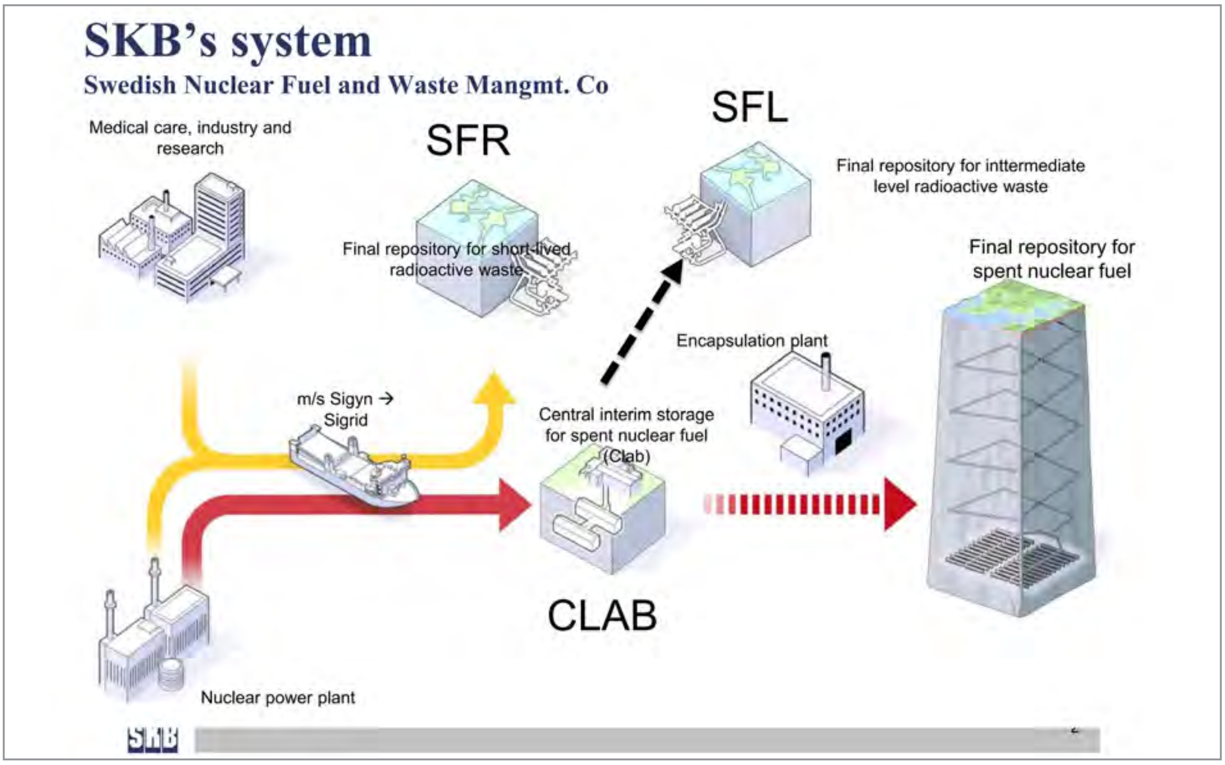

Conclusion
The dual effect of K fertilization on reducing radiocaesium content in rice grain
Reduction of root Cs⁺ uptake
Reduction of Cs⁺ transport to the younger tissues including grain
Alteration in the Cs⁺ uptake and transport in response to the growth conditions was observed also in trees.

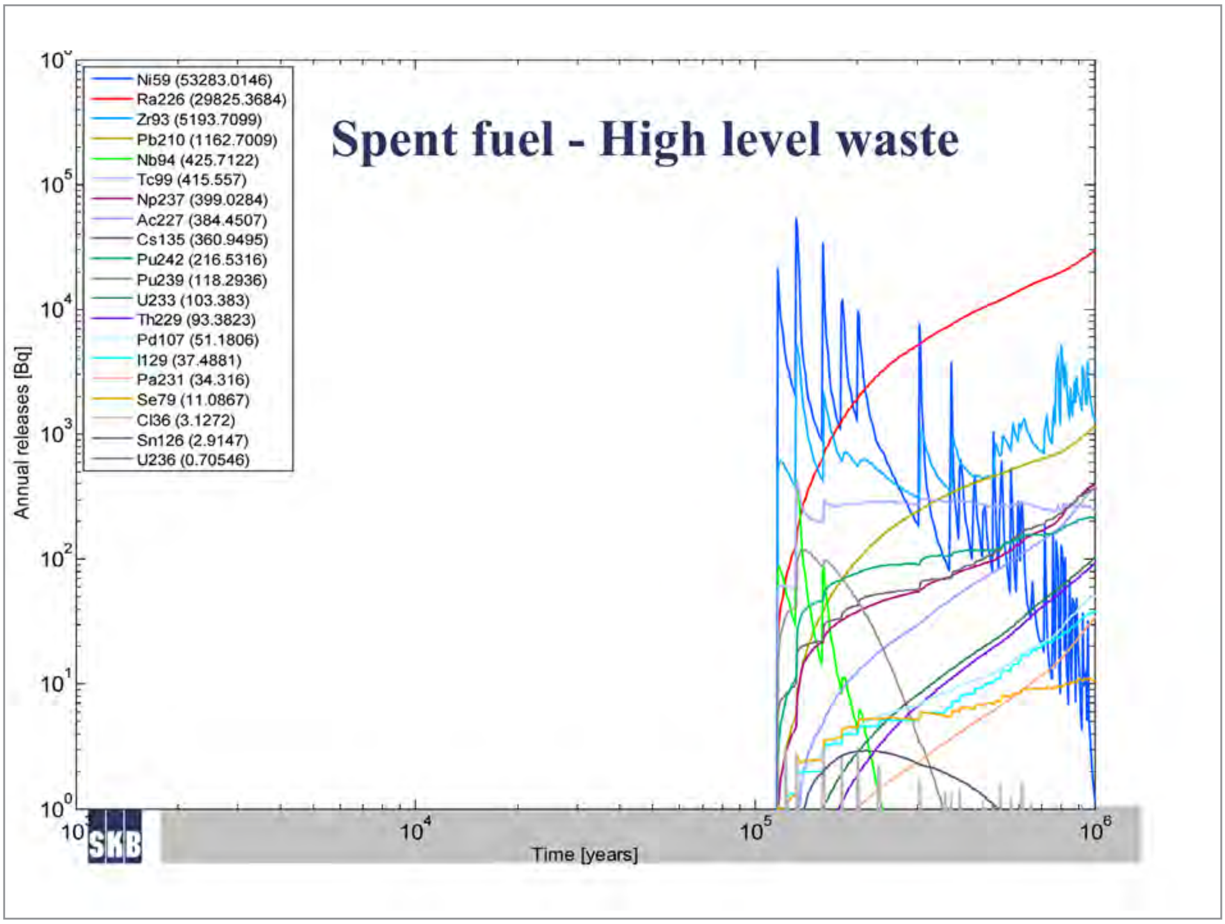
4.14 Really long term radiological assessment of ecosystems and humans

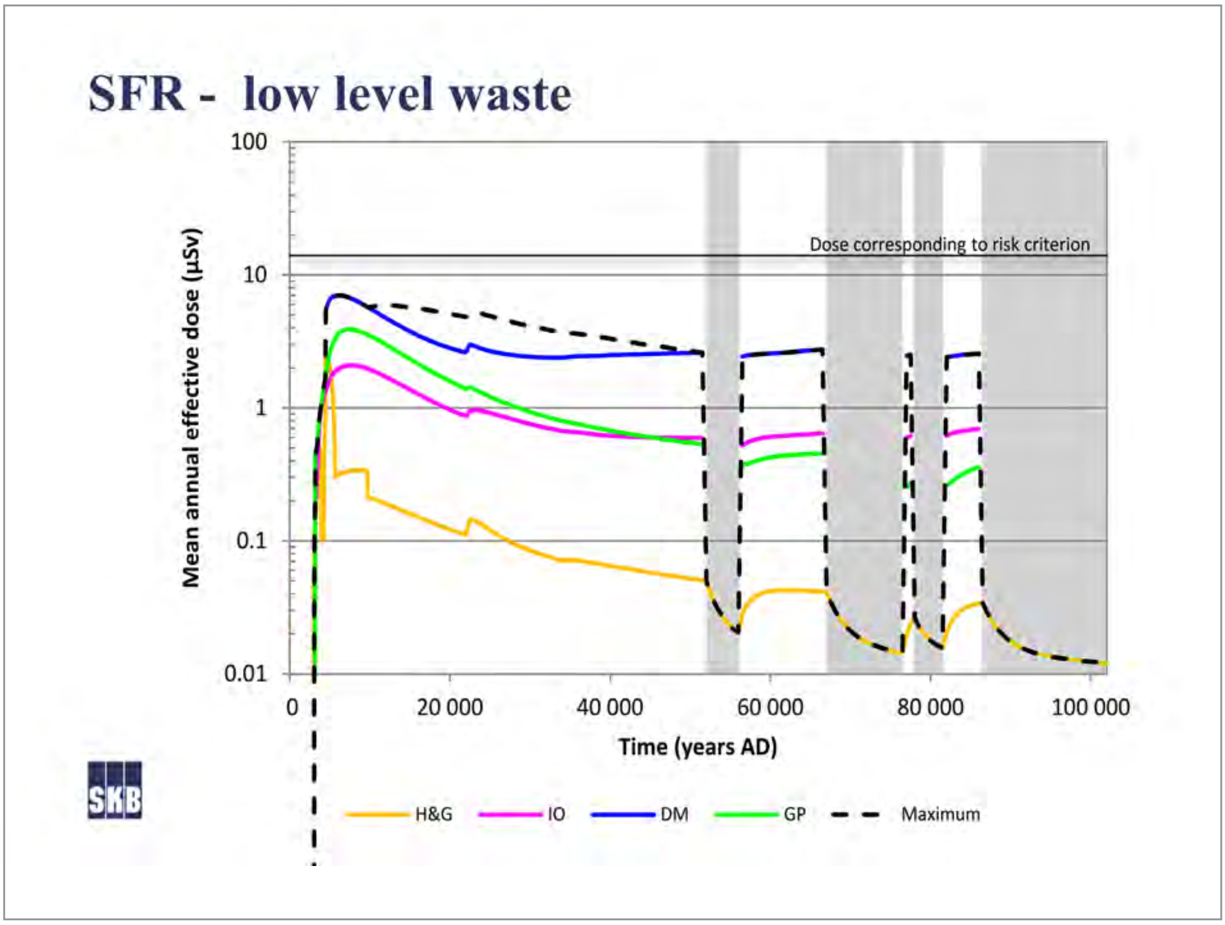
Ulrik Kautsky

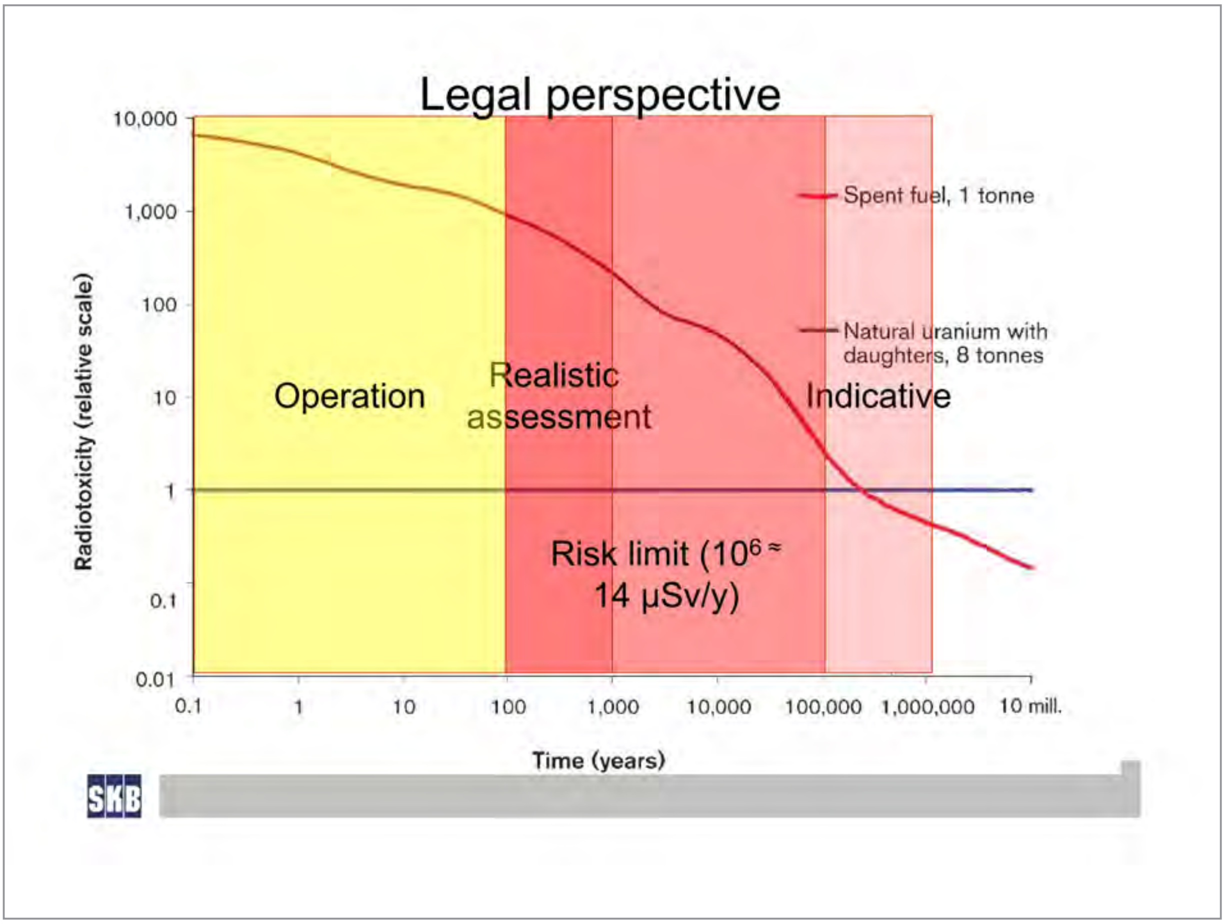
Presenter: ulrik.kautsky@skb.se

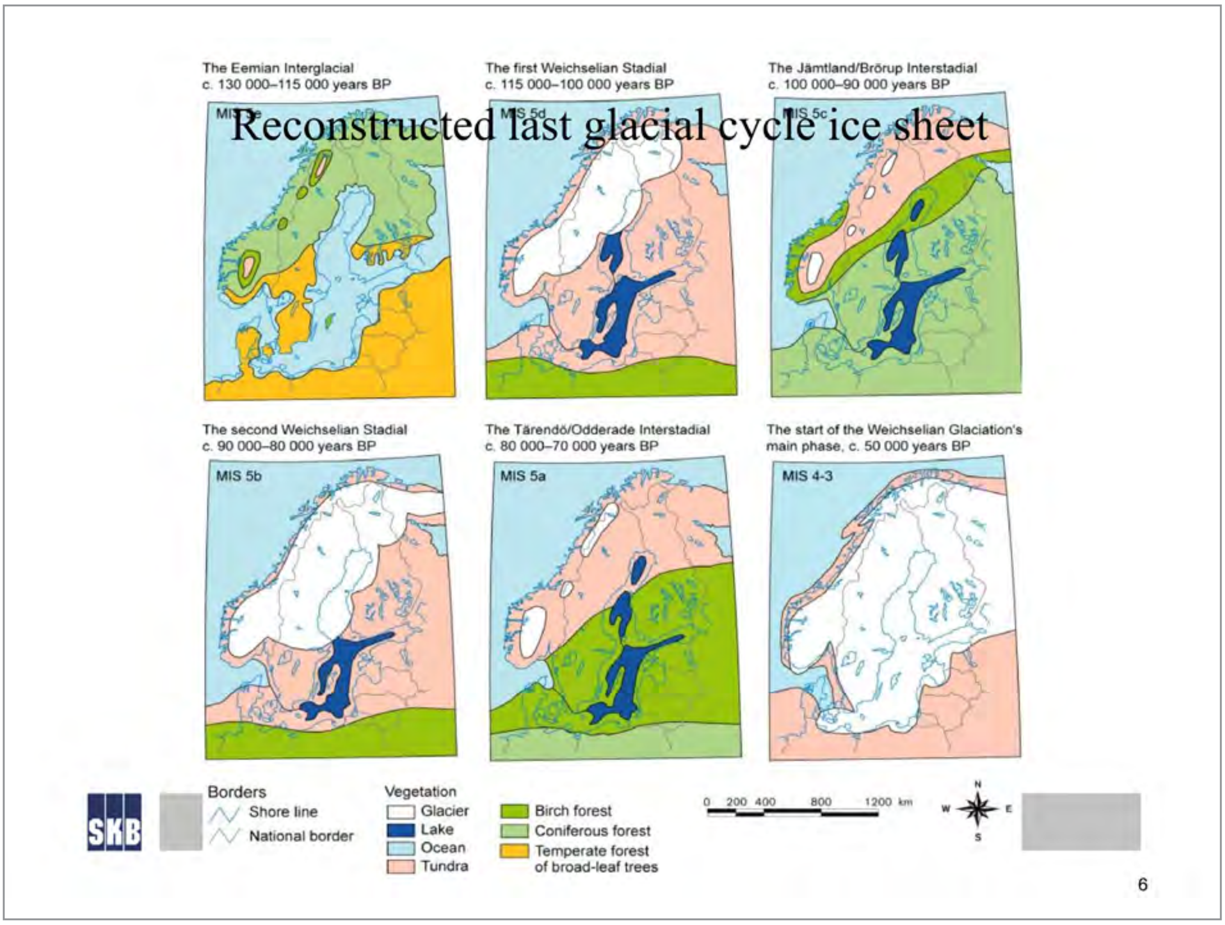
Swedish Nuclear Fuel and Waste Management Company (SKB)

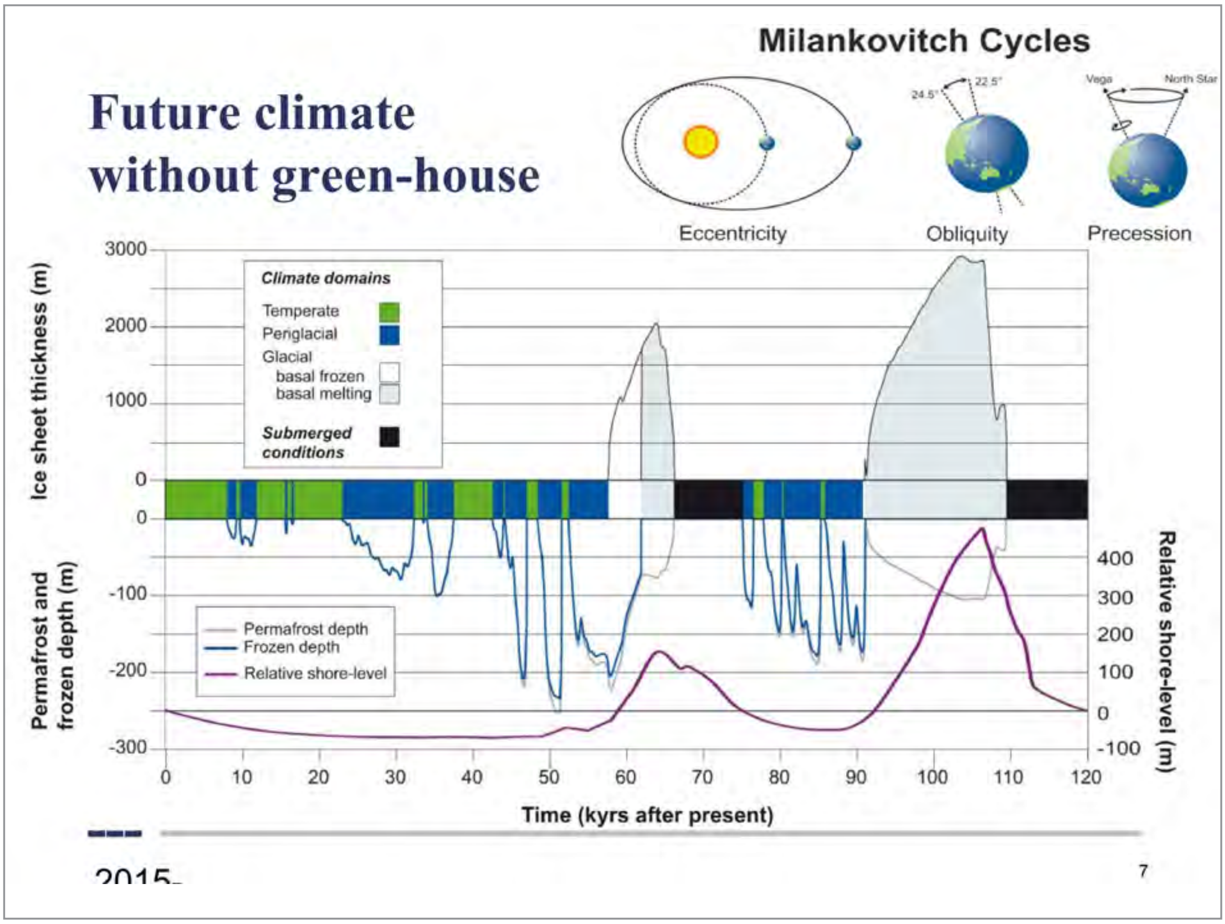



Spent fuel - High level waste
Ni59 (53283.0146)
Ra226 (29825.3684)
Zr93 (5193.7099)
Pb210 (1162.7009)
Nb94 (425.7122)
Tc99 (415.557)
Np237 (399.0284)
Ac227 (384.4507)
Cs135 (360.9495)
Pu242 (216.5316)
Pu239 (118.2936)
U233 (103.383)
Th229 (93.3823)
Pd107 (51.1806)
I129 (37.4881)
Pa231 (34.316)
Se79 (11.0867)
Cl36 (3.1272)
Sn126 (2.9147)
U236 (0.70546)
Annual releases [Bq]
Time [years]
SKB

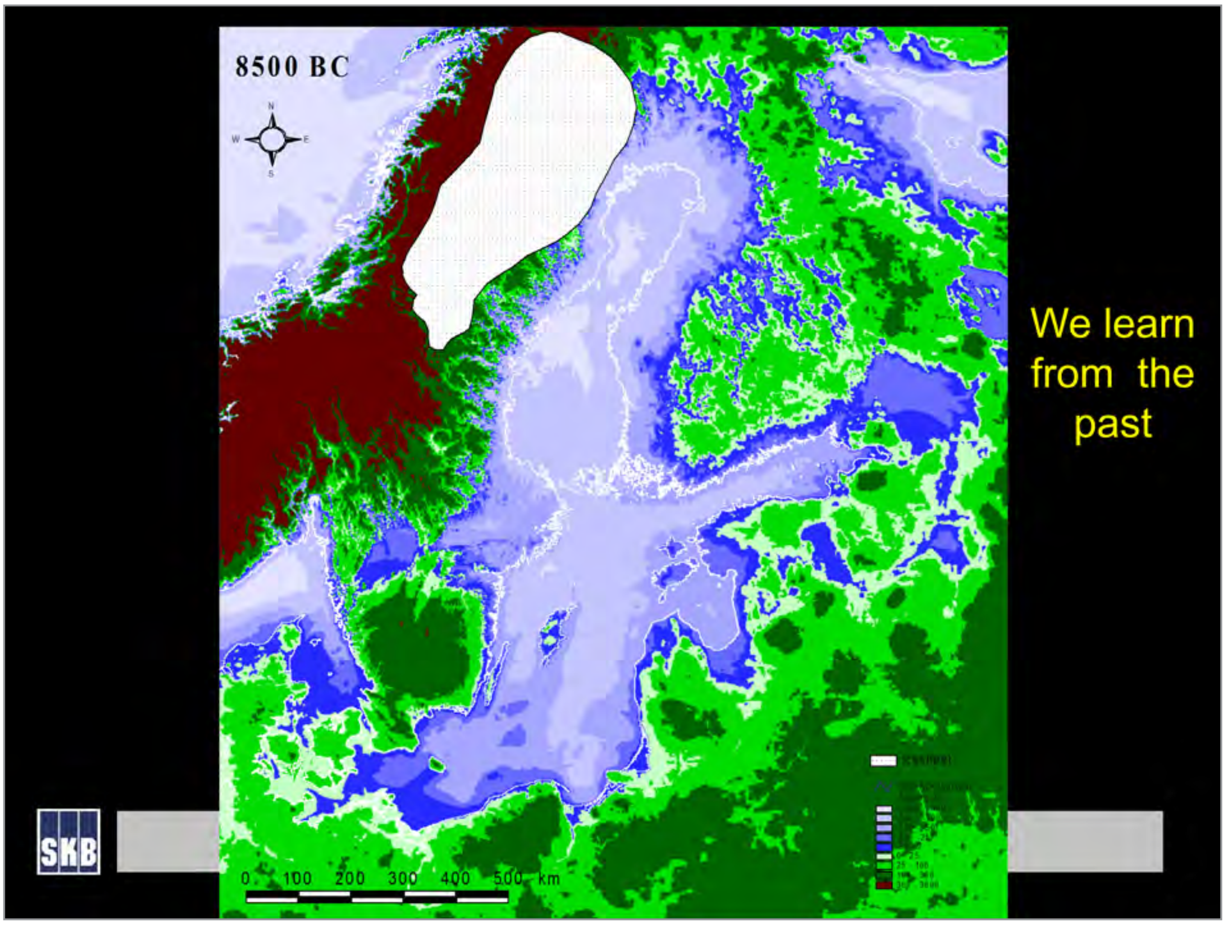

SFR - low level waste
Mean annual effective dose (µSv)
Dose corresponding to risk criterion
Time (years AD)
H&G
IO
DM
GP
Maximum
SKB


Legal perspective
Radiotoxicity (relative scale)
10,000
1,000
100
10
1
0.1
0.01
Operation
Realistic assessment
Indicative
Spent fuel, 1 tonne
Natural uranium with daughters, 8 tonnes
Risk limit (10⁶ ≈ 14 µSv/y)
0.1
1
10
100
1,000
10,000
100,000
1,000,000
10 mill.
Time (years)
SKB

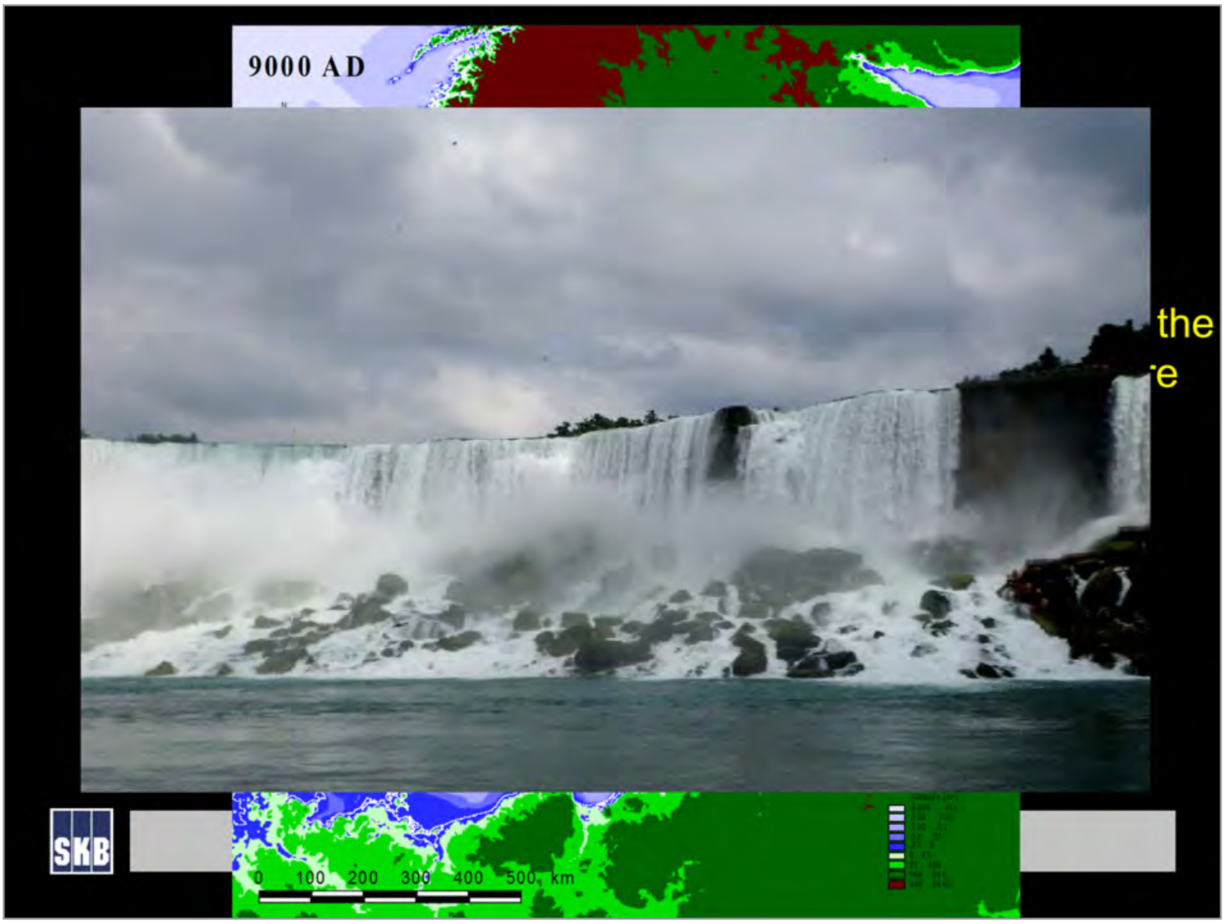

Reconstructed last glacial cycle ice sheet
The Eemian Interglacial
c. 130 000–115 000 years BP
The first Weichselian Stadial
c. 115 000–100 000 years BP
MIS 5d
The Jämtland/Brörup Interstadial
c. 100 000–90 000 years BP
MIS 5c
The second Weichselian Stadial
c. 90 000–80 000 years BP
MIS 5b
The Tärendö/Odderade Interstadial
c. 80 000–70 000 years BP
MIS 5a
The start of the Weichselian Glaciation's
main phase, c. 50 000 years BP
MIS 4-3
Borders
Shore line
National border
Vegetation
Glacier
Lake
Ocean
Tundra
Birch forest
Coniferous forest
Temperate forest
of broad-leaf trees
0 200 400 800 1200 km
N
W
E
S
SKB
6



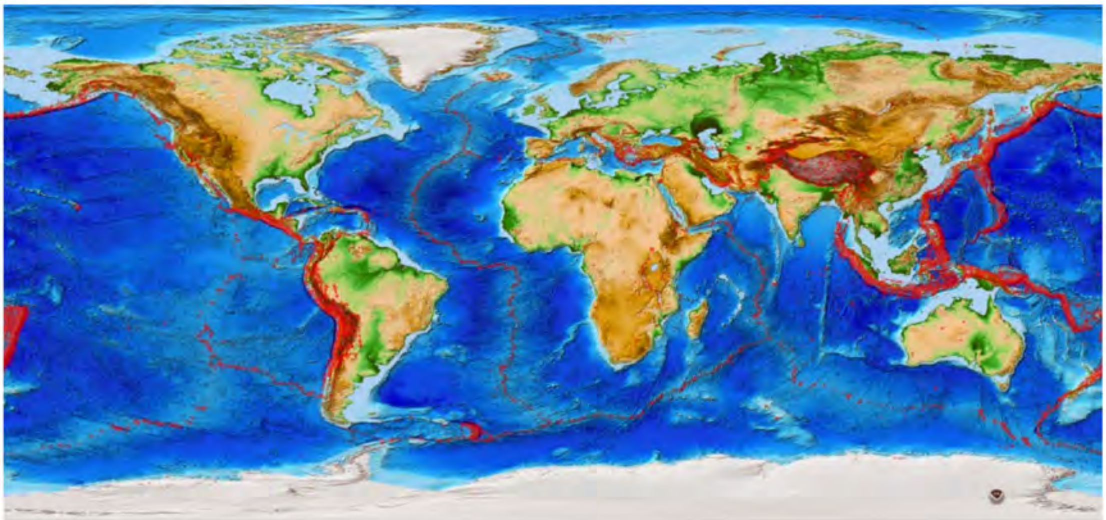
Milankovitch Cycles
Future climate without green-house
Eccentricity
Obliquity
Precession
Vega
North Star
24.5°
22.5°
Ice sheet thickness (m)
Permafrost and frozen depth (m)
Relative shore-level (m)
Climate domains
Temperate
Periglacial
Glacial
basal frozen
basal melting
Submerged conditions
Permafrost depth
Frozen depth
Relative shore-level
Time (kyrs after present)
7



8500 BC
We learn from the past
SKB
0 100 200 300 400 500 km



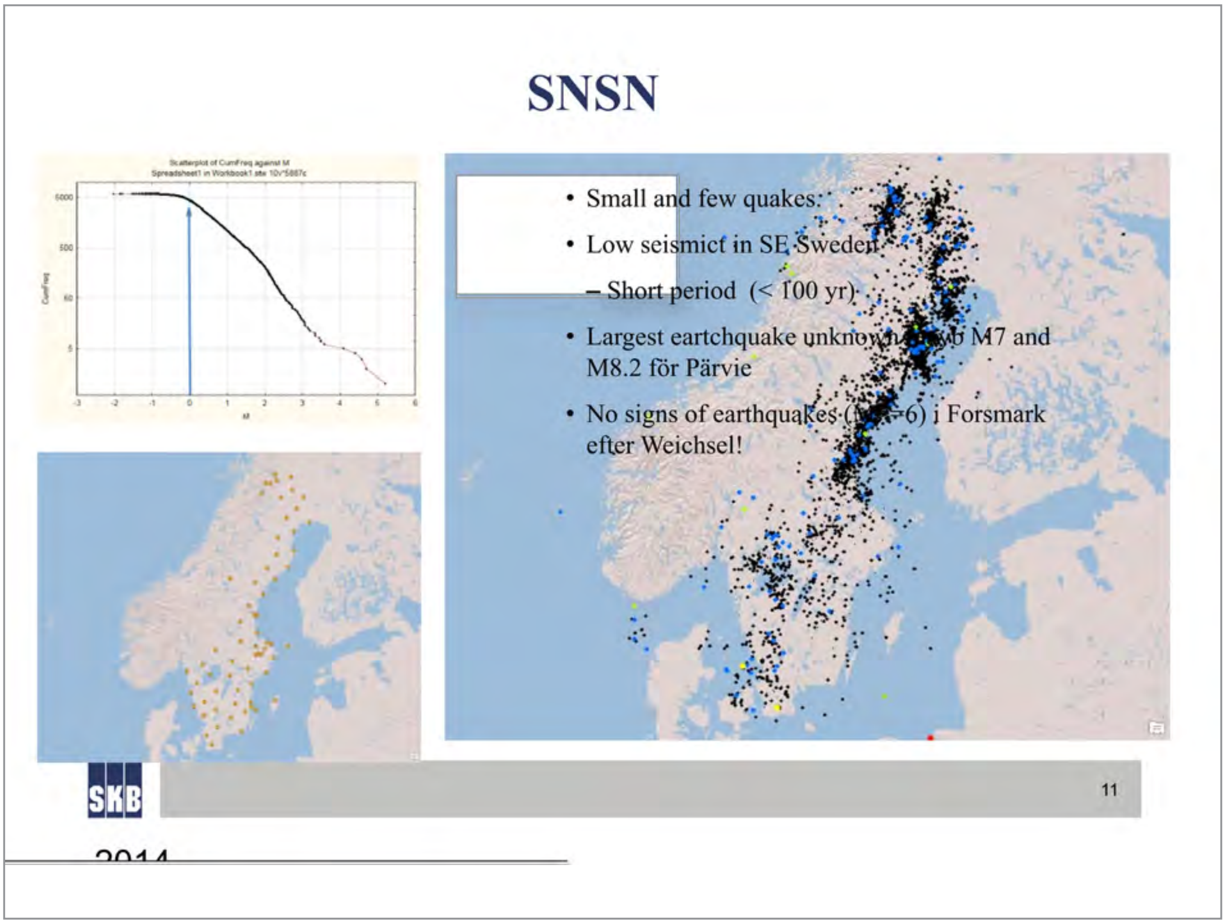
$M_w \geq 5$, 1973-2014

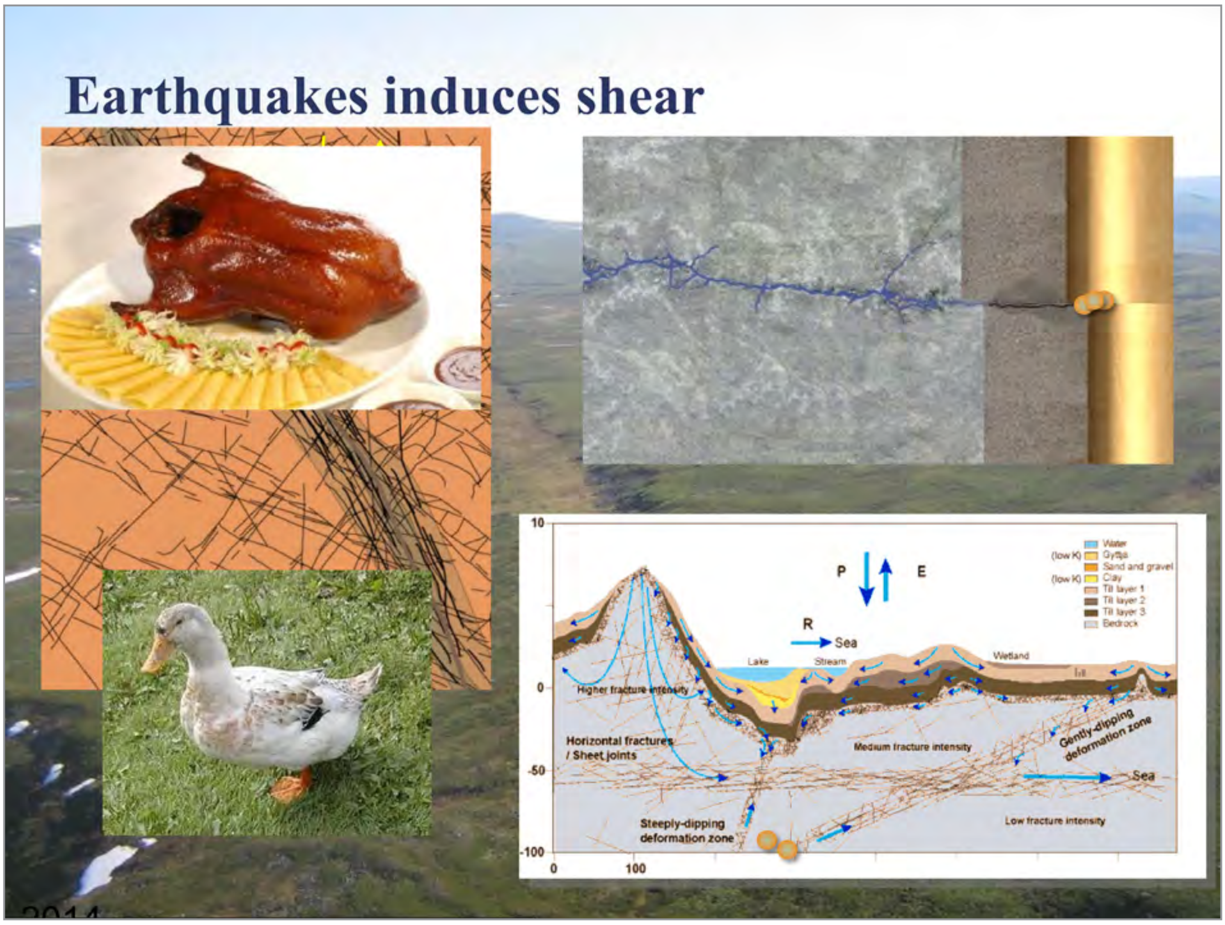


Källor:
NEIC, http://earthquake.usgs.gov/regional/neic/
Slunga, R. S., 1991. The Baltic Shield earthquakes. Tectonophysics, 189(1-4), pp 323-331

2014

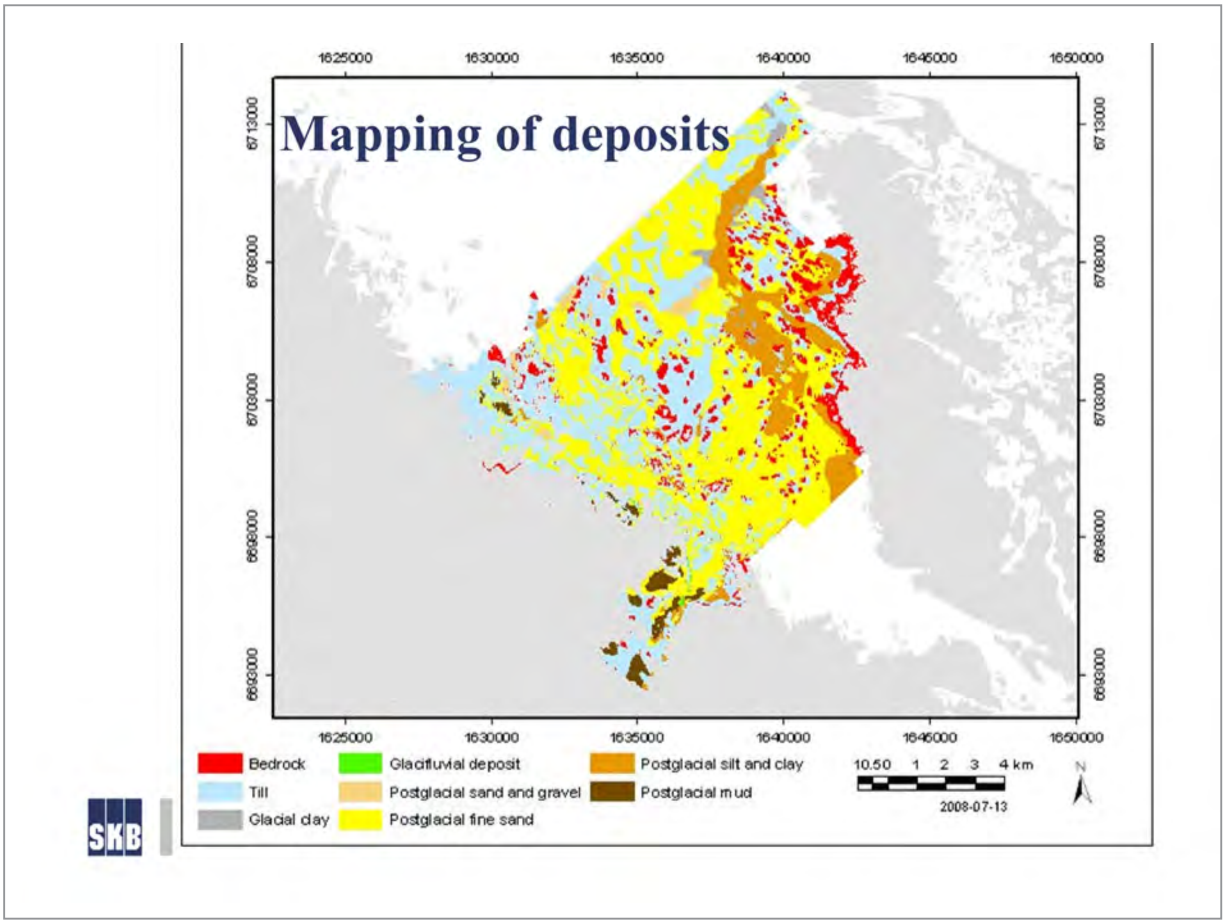
10

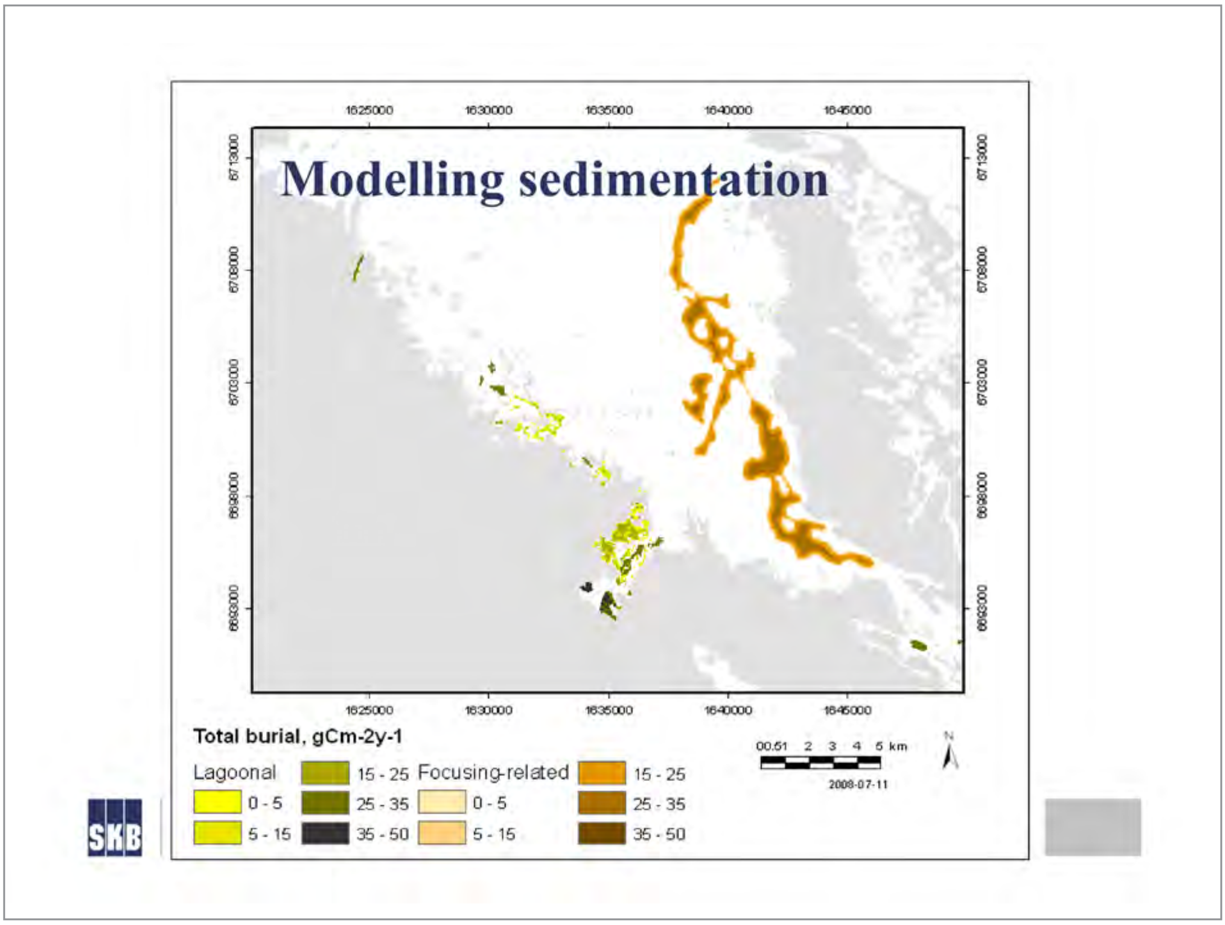

SNSN
Small and few quakes:
Low seismict in SE Sweden
– Short period (< 100 yr)
Largest earthquake unknown
M7 and
M8.2 för Pärvie
No signs of earthquakes
i Forsmark
efter Weichsel!
SKB
11
2014


Earthquakes induces shear
P
E
R
Sea
Lake
Stream
Wetland
Till
Water
Gyttja
Sand and gravel
Clay
Till layer 1
Till layer 2
Till layer 3
Bedrock
(low K)
(low K)
Higher fracture intensity
Horizontal fractures / Sheet joints
Medium fracture intensity
Gently-dipping deformation zone
Sea
Steeply-dipping deformation zone
Low fracture intensity
10
0
-50
-100
0
100


SFR facility, SR-PSU safety assessment


Site investigations 2001-2011 for high level repository
Mapping of life

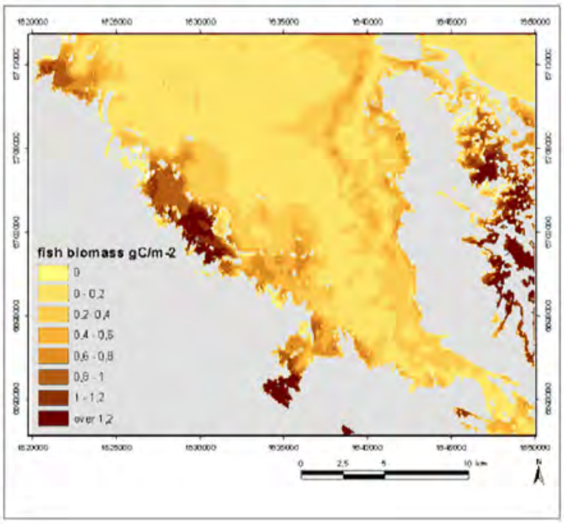

Mapping of deposits
1625000
1630000
1635000
1640000
1645000
1650000
6713000
6708000
6703000
6698000
6693000
Bedrock
Till
Glacial clay
Glacifluvial deposit
Postglacial sand and gravel
Postglacial fine sand
Postglacial silt and clay
Postglacial mud
1 0.5 0 1 2 3 4 km
2008-07-13
N
SKB


Modelling sedimentation
1625000
1630000
1635000
1640000
1645000
6713000
6708000
6703000
6698000
6693000
Total burial, gCm-2y-1
Lagoonal
0 - 5
5 - 15
15 - 25
25 - 35
35 - 50
Focusing-related
0 - 5
5 - 15
15 - 25
25 - 35
35 - 50
0 0.5 1 2 3 4 5 km
2008-07-11
N
SKB

General description - fish

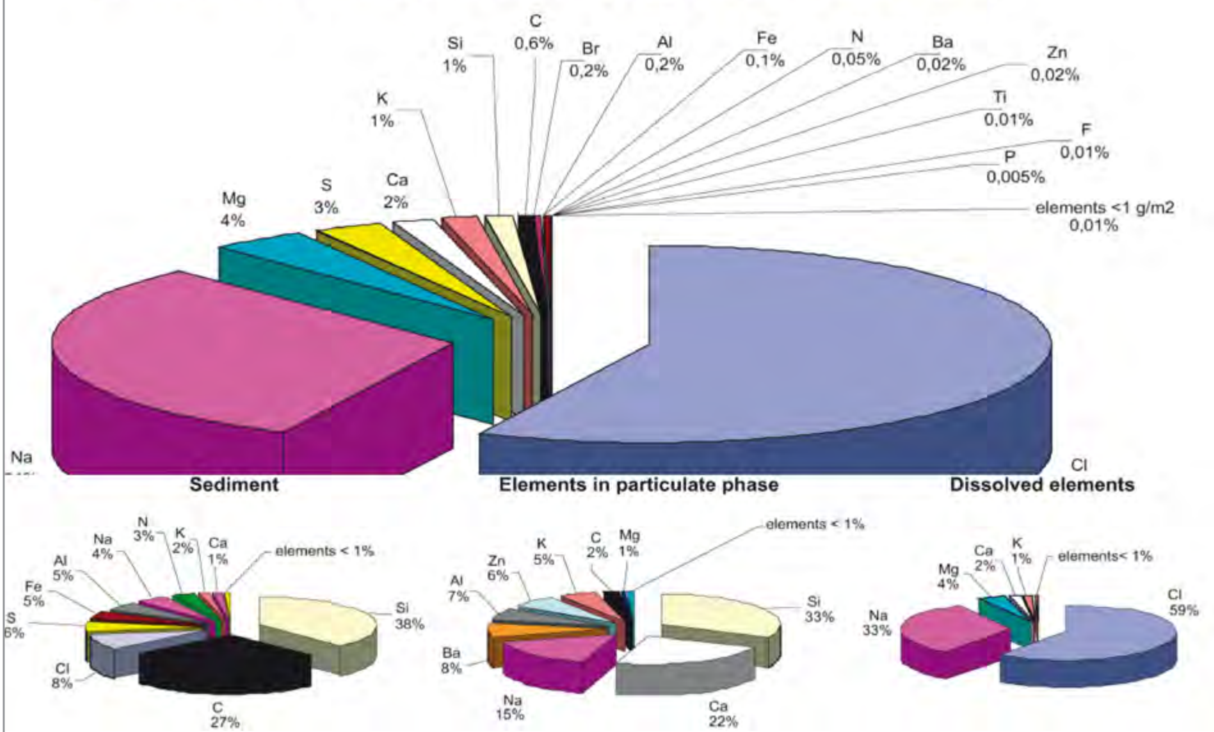
•Coastal fish community, Herring and sprat dominates (60-70 kg/ha)

•Inner bays, perch, roach and white bream dominates



Bradshaw, C., U. Kautsky, L. Kumblad. 2012. Ecological stoichiometry and multi-element transfer in a coastal ecosystem. *Ecosystems* 15: 591–603.

Chemical composition (e.g. ICP-MS, AS)



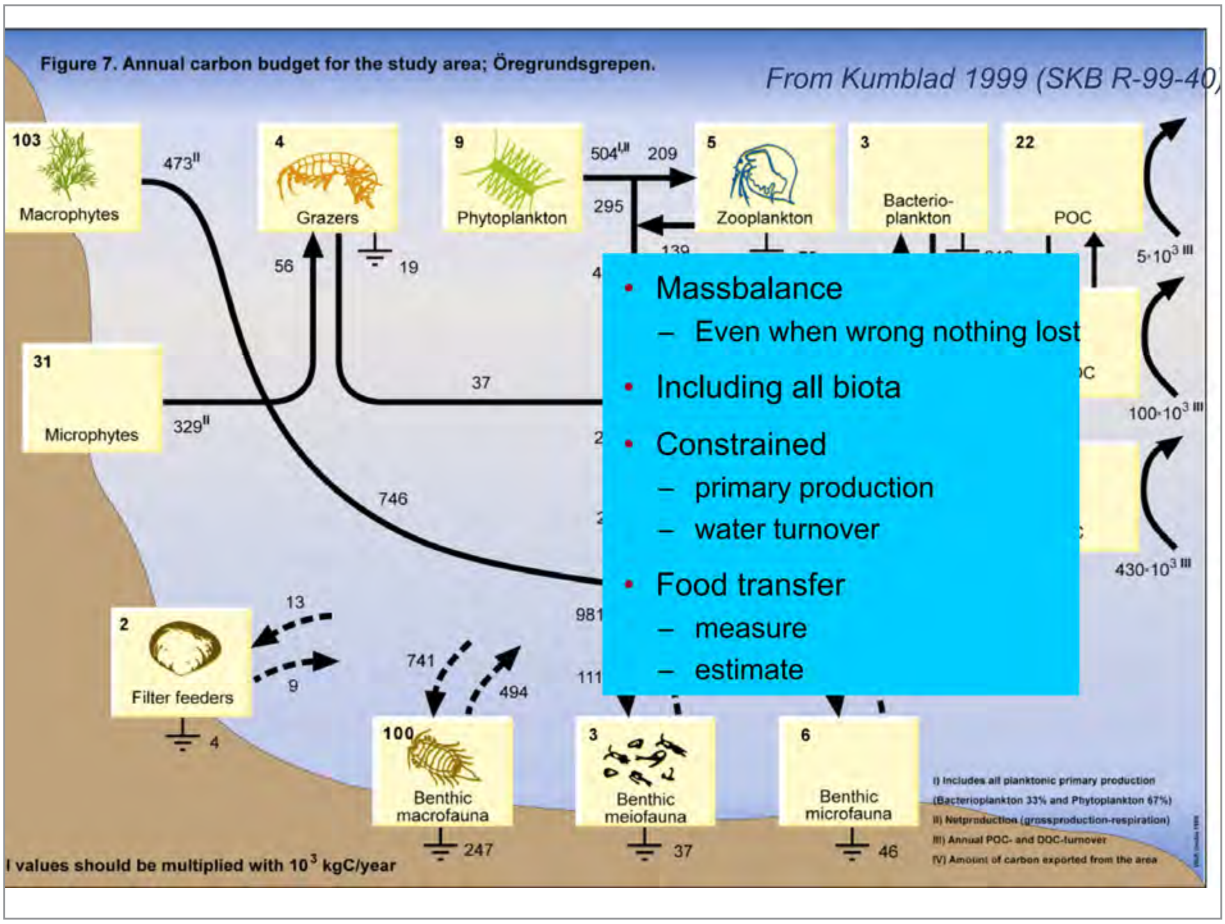
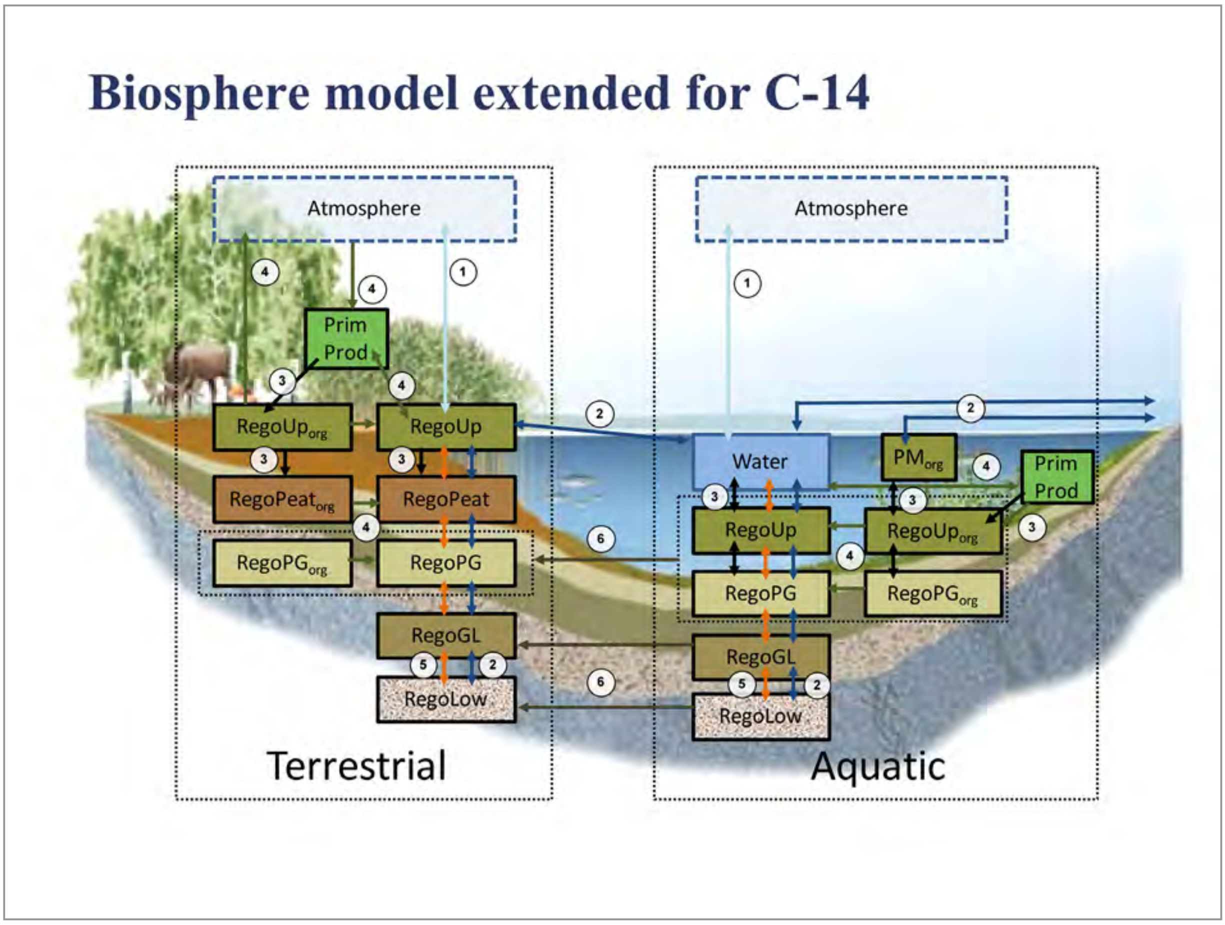
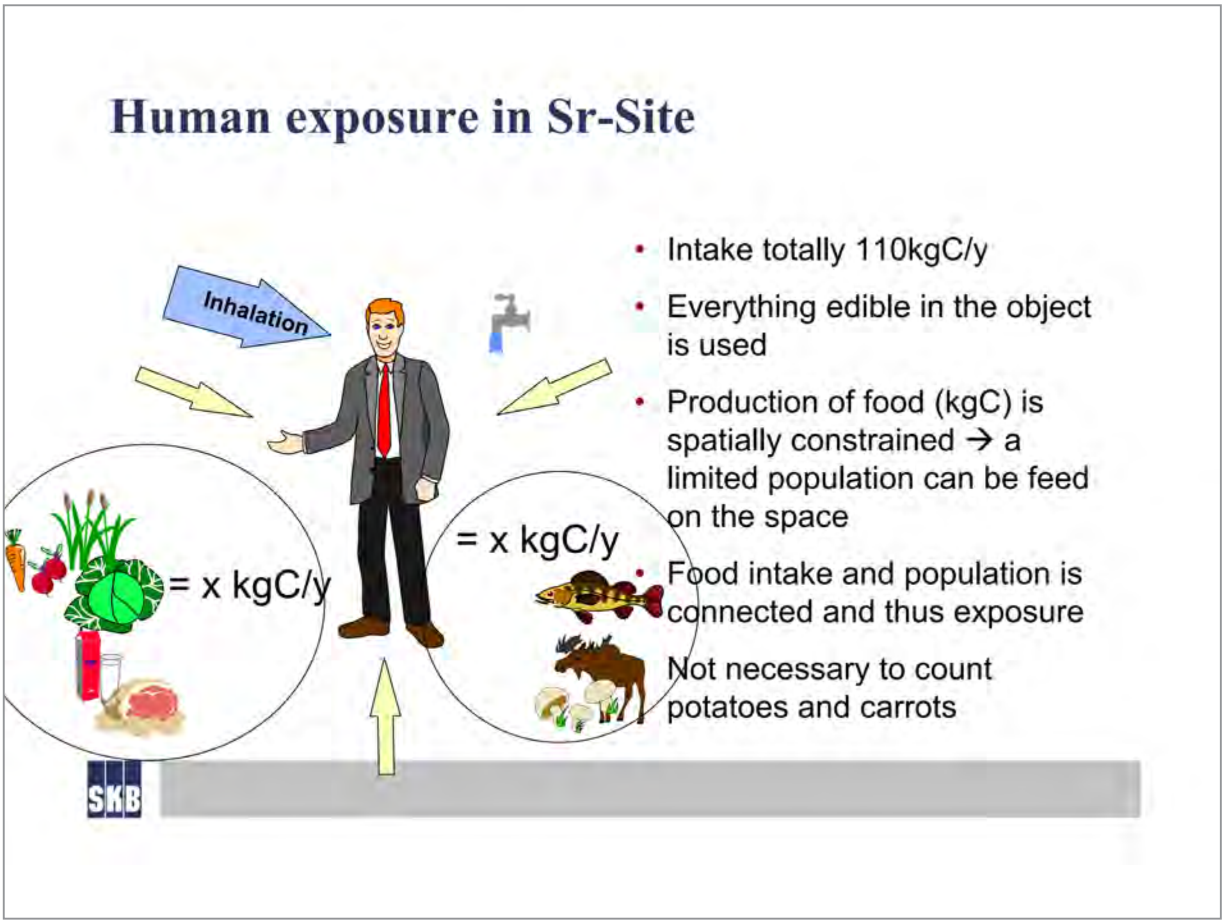
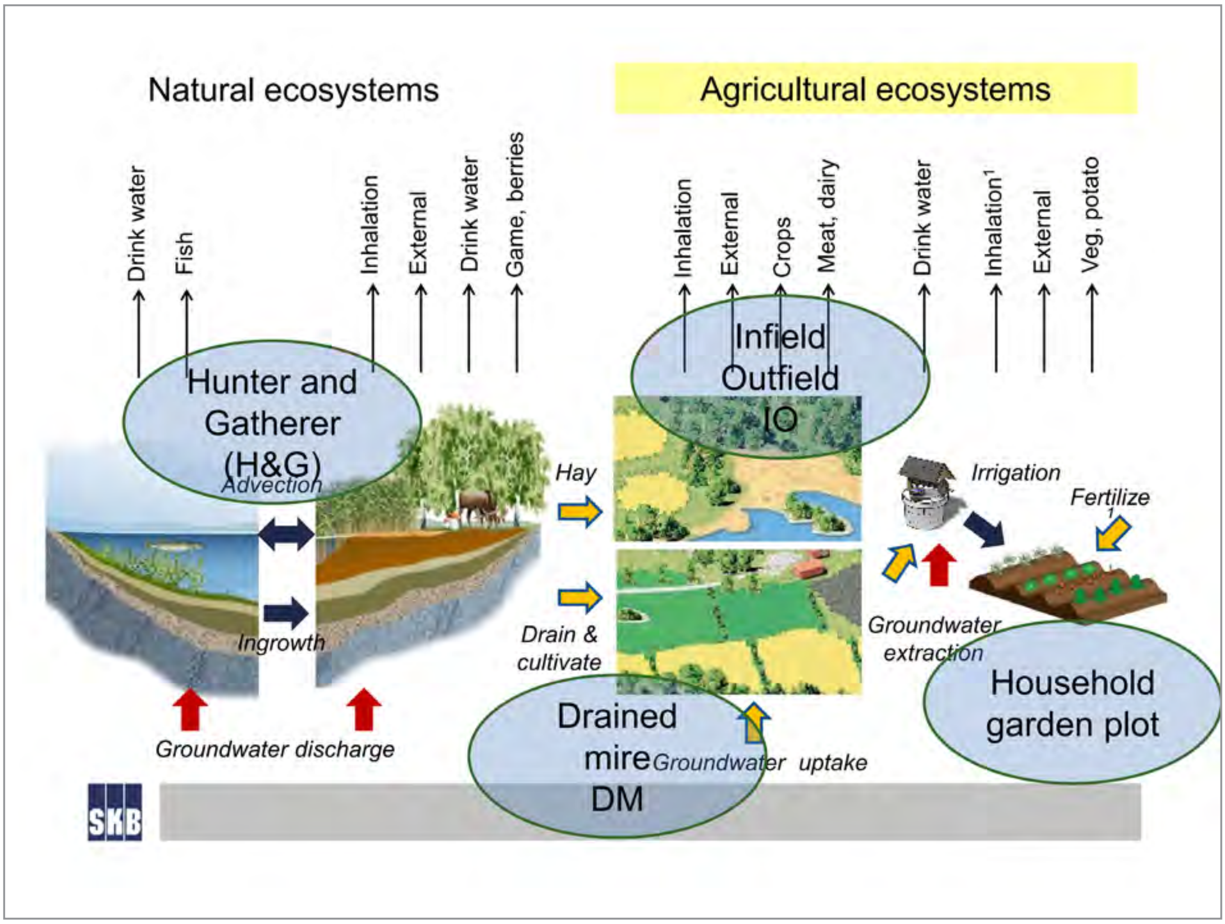


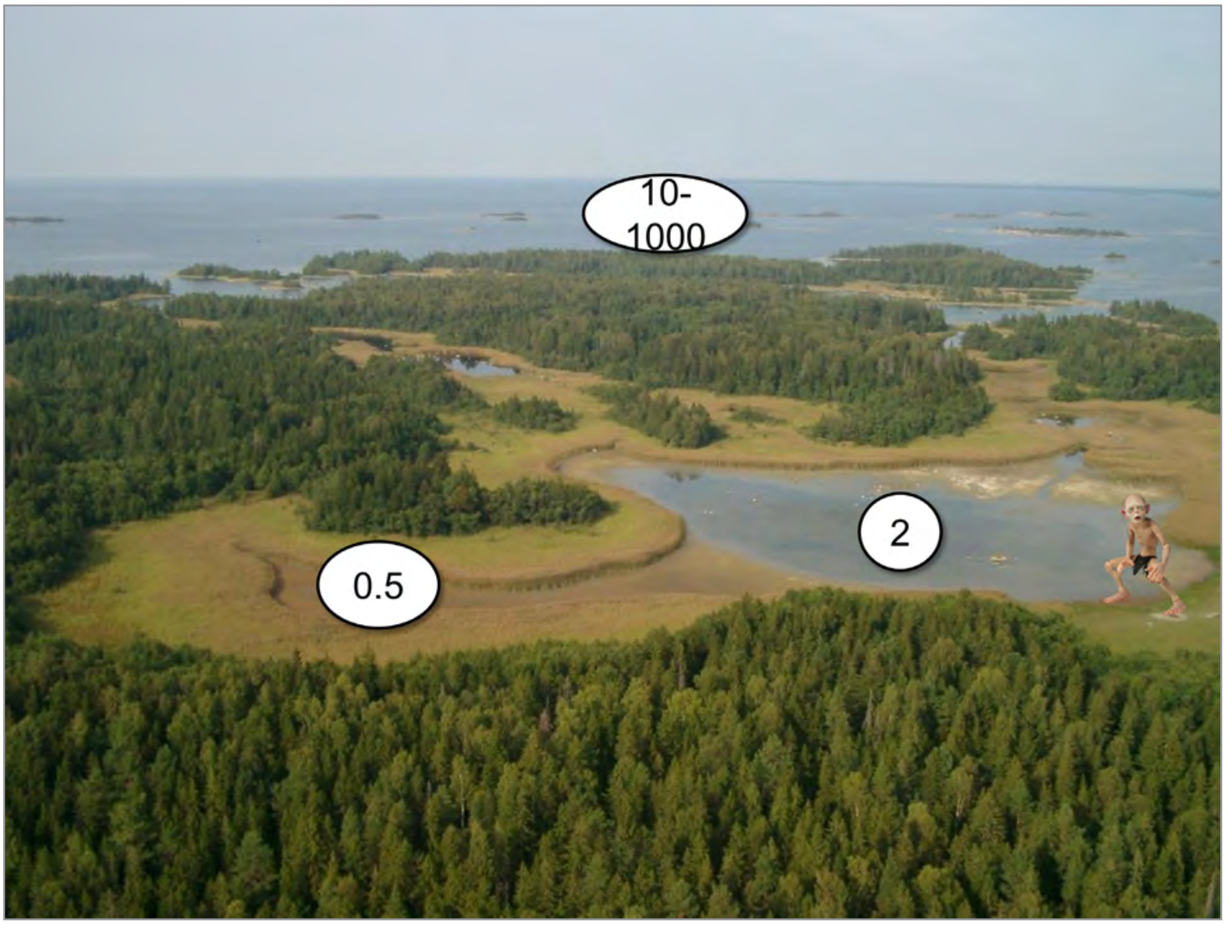
Figure 7. Annual carbon budget for the study area; Öregrundsgrepen.
From Kumblad 1999 (SKB R-99-40)
103
Macrophytes
473II
4
Grazers
56
19
9
Phytoplankton
504I,II
209
295
5
Zooplankton
3
Bacterio-
plankton
22
POC
5·10³ III
31
Microphytes
329II
37
746
100·10³ III
430·10³ III
2
Filter feeders
13
9
4
741
494
981
111
100
Benthic
macrofauna
247
3
Benthic
meiofauna
37
6
Benthic
microfauna
46
I) Includes all planktonic primary production
(Bacterioplankton 33% and Phytoplankton 67%)
II) Netproduction (grossproduction-respiration)
III) Annual POC- and DOC-turnover
IV) Amount of carbon exported from the area
l values should be multiplied with 10³ kgC/year
Massbalance
– Even when wrong nothing lost
Including all biota
Constrained
– primary production
– water turnover
Food transfer
– measure
– estimate

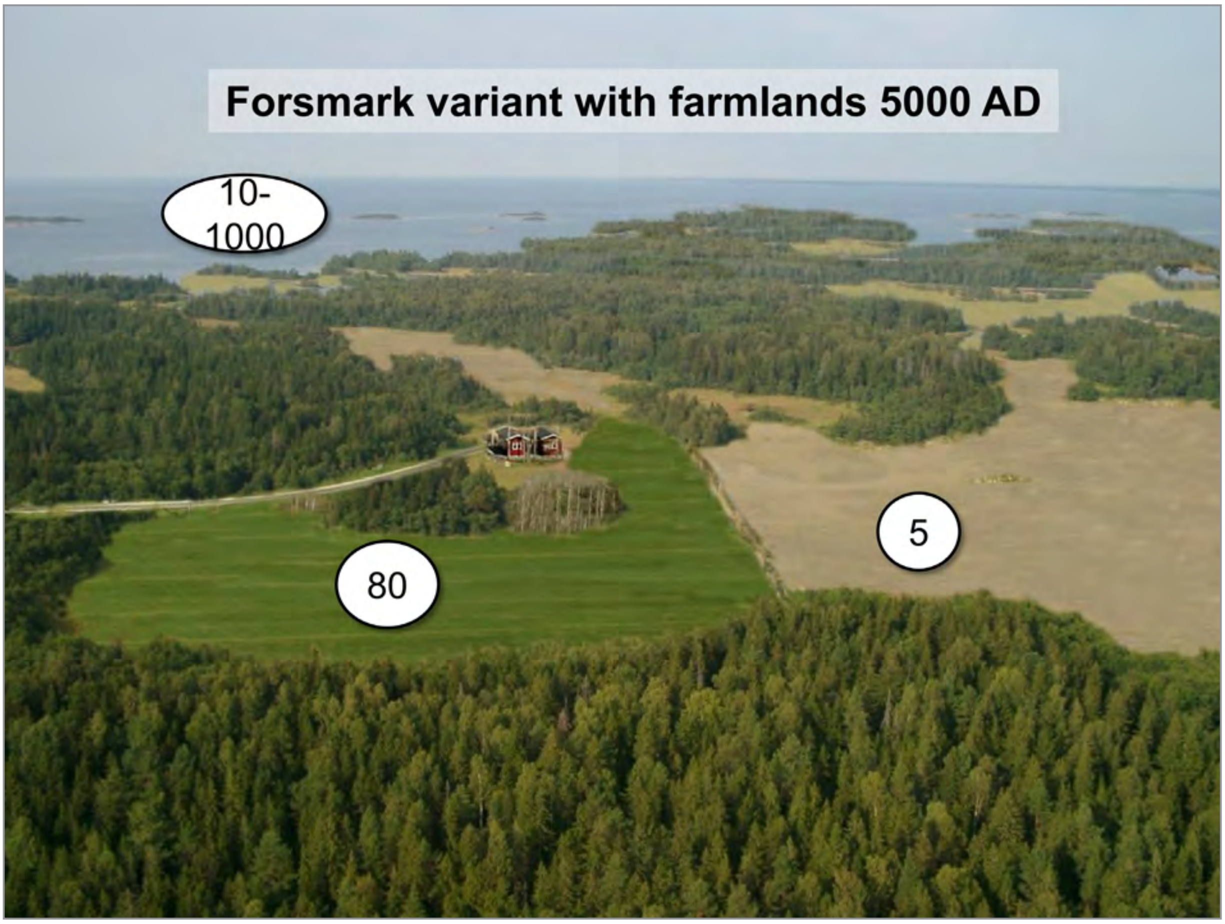

Biosphere model extended for C-14
Atmosphere
Prim
Prod
RegoUp$_{org}$
RegoUp
RegoPeat$_{org}$
RegoPeat
RegoPG$_{org}$
RegoPG
RegoGL
RegoLow
Terrestrial
Atmosphere
Water
PM$_{org}$
Prim
Prod
RegoUp
RegoUp$_{org}$
RegoPG
RegoPG$_{org}$
RegoGL
RegoLow
Aquatic

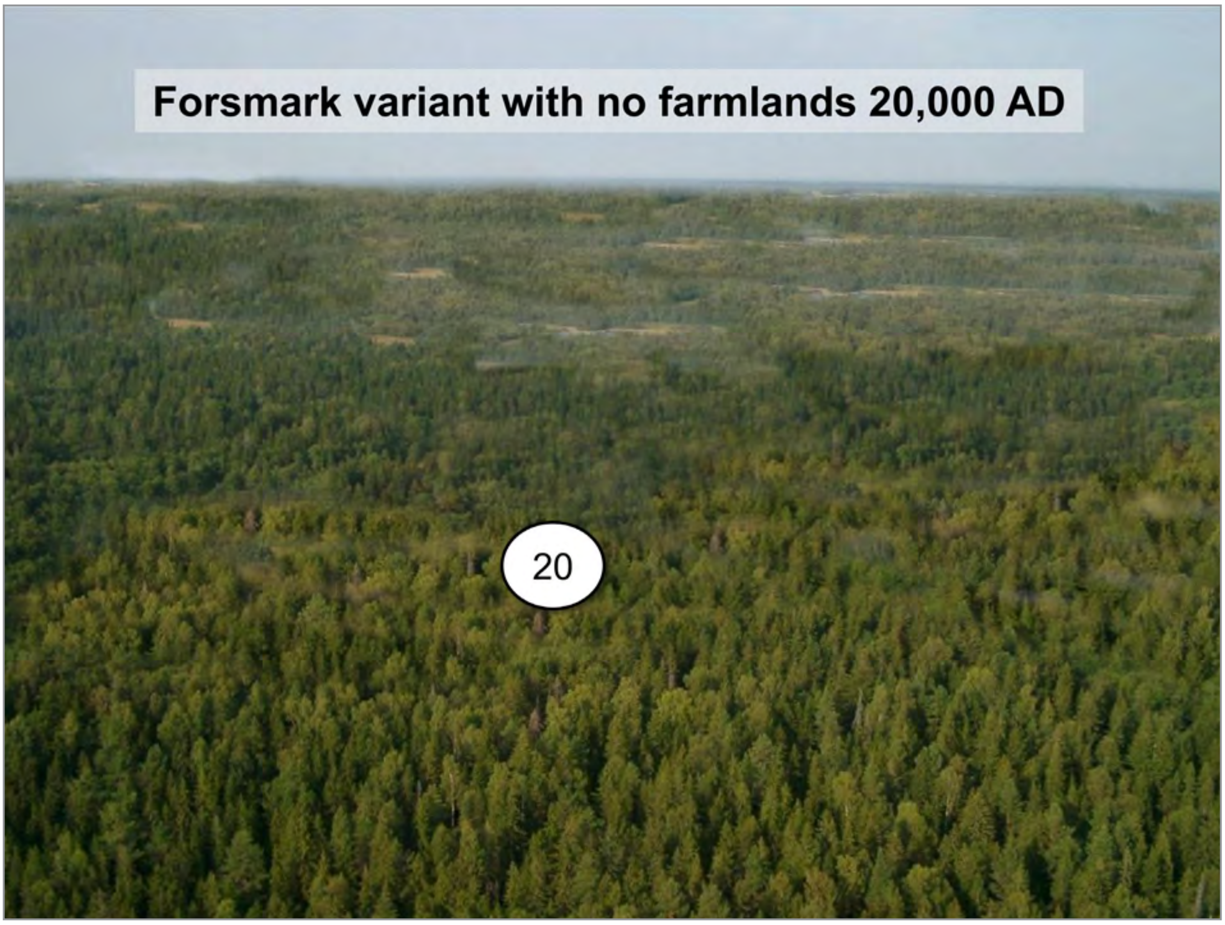

Human exposure in Sr-Site
Inhalation
= x kgC/y
= x kgC/y
Intake totally 110kgC/y
Everything edible in the object is used
Production of food (kgC) is spatially constrained → a limited population can be feed on the space
Food intake and population is connected and thus exposure
Not necessary to count potatoes and carrots
SKB

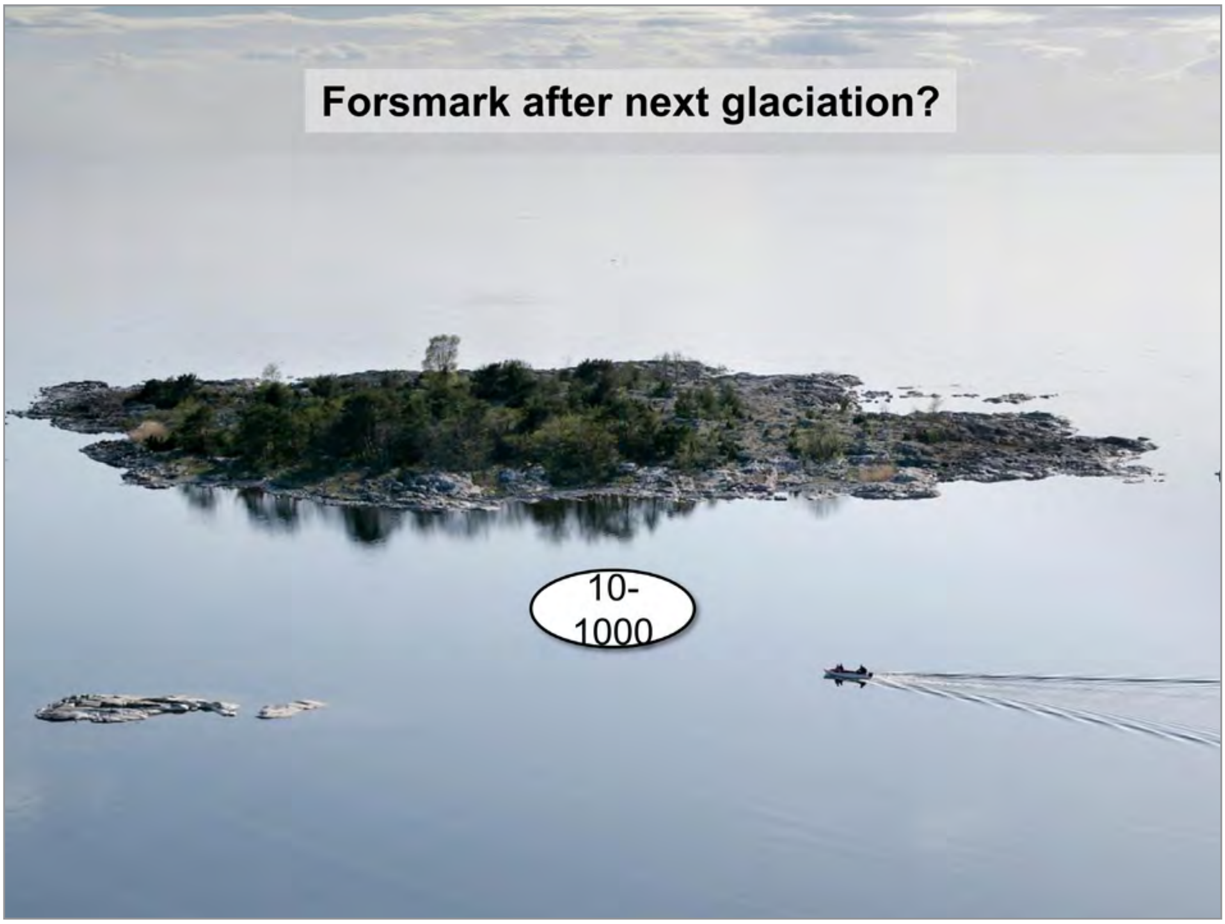

Drained Mire cultivation 1911


Natural ecosystems
Agricultural ecosystems
Drink water
Fish
Inhalation
External
Drink water
Game, berries
Inhalation
External
Crops
Meat, dairy
Drink water
Inhalation1
External
Veg, potato
Hunter and Gatherer (H&G)
Infield Outfield IO
Advection
Ingrowth
Hay
Drain & cultivate
Irrigation
Fertilize
Groundwater extraction
Household garden plot
Drained mire DM
Groundwater uptake
Groundwater discharge
SKB


10-1000
2
0.5

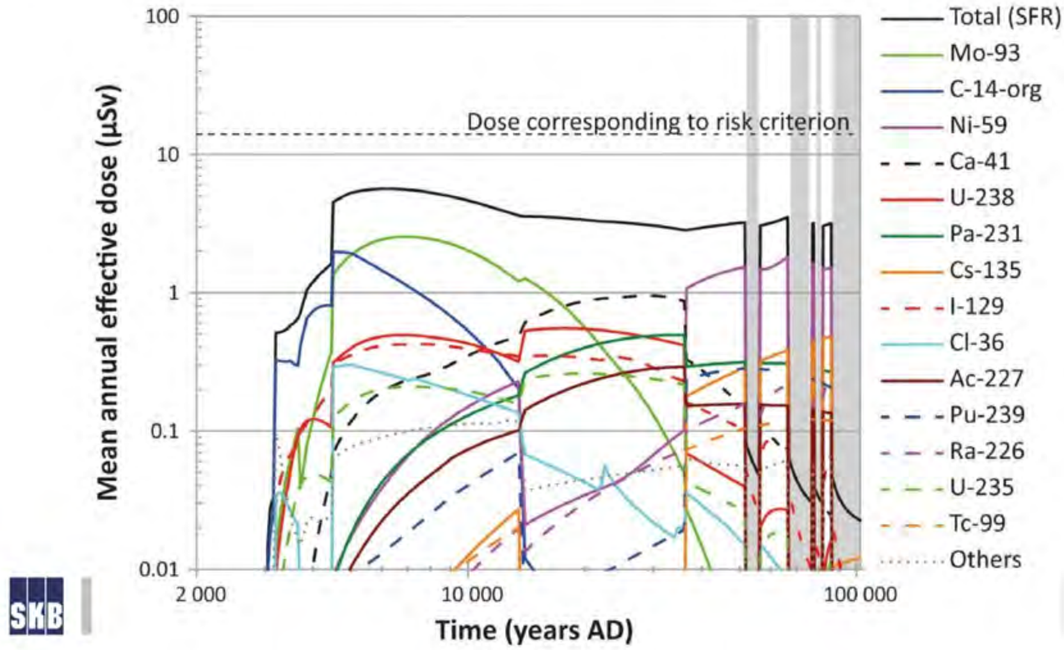

Forsmark variant with farmlands 5000 AD
10-
1000
5
80

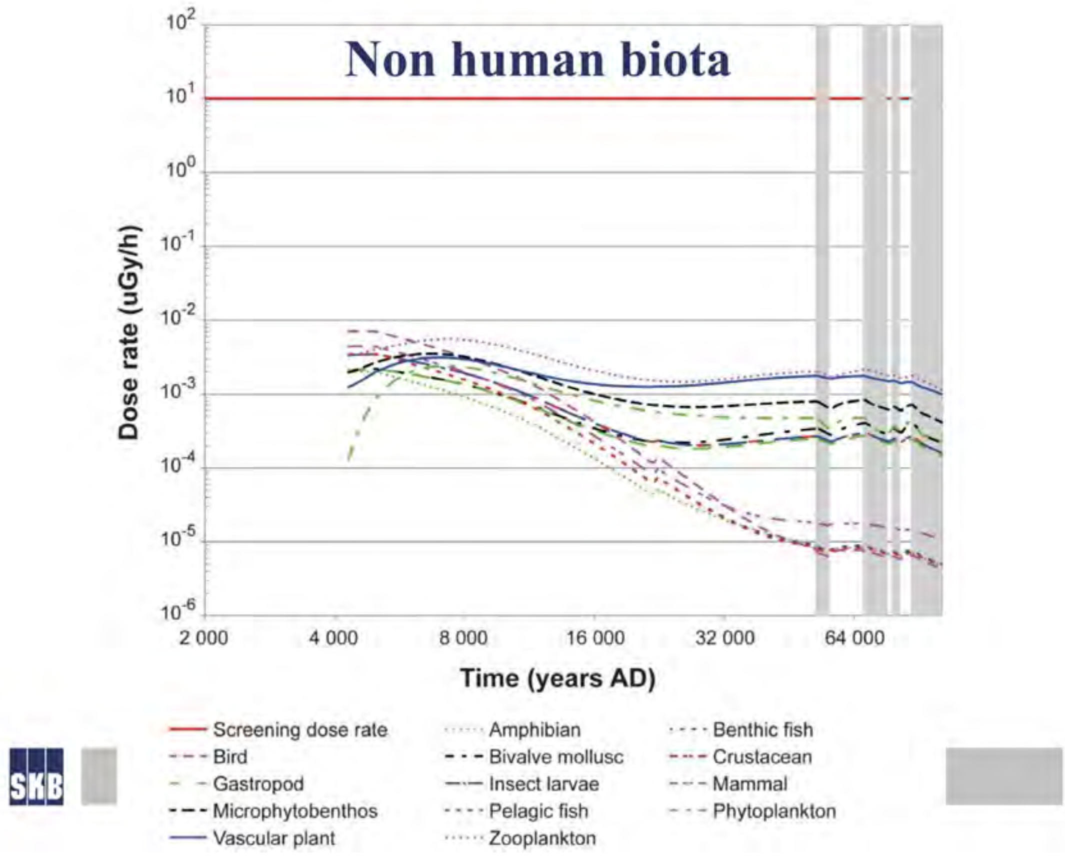

Forsmark variant with no farmlands 20,000 AD
20


Forsmark after next glaciation?
10-
1000


...or during next glaciation?
0

Results from LLW (SFR)






Summary
• A ecosystem focused assessment
– Natural productivity
• Constrained in space
– Nutritional demand
• Population constraint
• Habitat constraints
– Non human biota
– Other environmental hazards
• Site specific data
– Reduced variability
– Realistic combination of data
• Shore line displacement driver
– Geometry the major factor
• Next step to use element concentration modelling for radionuclide uptake
• Report at www.skb.se
SKB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THE ROYAL SWEDISH ACADEMY OF SCIENCES
A JOURNAL OF THE HUMAN ENVIRONMENT
• AMBIO 2013 vol 42:4
• Open access http://link.springer.com/journal/13280/42/4/page/1
Special Issue:
Humans and Ecosystems Over the Coming Millennia: A Biosphere Assessment of Radioactive Waste Disposal in Sweden
Guest Editor: Jack Valentin
Guest Editorial Board: Ulrik Kautsky and Tobias Lindborg
Journal of Environmental Radioactivity
Available online 14 July 2015
In Press, Corrected Proof — Note to users
ELSEVIER
The impact of low and intermediate-level radioactive waste on humans and the environment over the next one hundred thousand years
Ulrik Kautsky, Peter Saetre, Sten Berglund, Ben Jaeschke, Sara Nordén, Jenny Brandefelt, Sven Keesmann, Jens-Ove Näslund, Eva Andersson
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4.15 Visit to Forsmark

Orientation for visiting the final repository for radioactive operational waste and the ecosystem monitoring sites for the proposed deep repository for nuclear waste at Forsmark operated by SKB, Swedish Nuclear Fuel and Waste Management Co.

See the photographs record of Day 4 on 4 Sep 2015 in Chapter 6.

SKB

Programme

2015-09-04

10:00	Arrival at Forsmark.
10:00	Presentation of SKB Forsmark.
11:00	Check-in at SFR. Passport- and security control.
11:15	Guided tour exhibition underground.
12:30	Lunch at Forsmark's Inn.
13:30	Out in the field with Sara Nordén – site investigations for the proposed deep repository for nuclear waste. We will visit a range of different ecosystems in the area.
16:00	Departure.

Important information when visiting our facility

Visitor services at our facilities are an important part of the comprehensive work we put into informing the public about the management of Sweden's nuclear waste. Regarding the visit, please find some important information below.

Final repository for radioactive operational waste, SFR

Active side (approx. 2 hours)

The visit starts with information about the facility. This is followed by a guided tour underground, down to a depth of 50 metres. SKB's own bus will be used for the underground tour. Please note that the tour includes a 400 metres long walk underground in steep slopes and stairs.

Minimum age: 18 years.

For the safety of each visitor the following regulations must be attended when visiting our facilities:

- Each person has to be able to walk without support in SFR. Therefore, no wheel chairs, walkers, crutches or sticks are permitted underground.
- Alcohol may not be consumed before or during the visit.
- We recommend comfortable shoes and casual clothing.
- We do not allow visitors to bring cameras, cell phones or bags during the visit in SFR-facility.

It is incumbent on the group leader to pass this information on to all participants.

According to unpredictable activities in our facilities, we reserve ourselves the right of changing the programme or if necessary cancel the visit.

Those who, after considering the above, choose to abstain from the tour are welcome to contact us to discuss how we, in an alternative way, can provide required information.

Kind regards,

Svensk Kärnbränslehantering AB
(Swedish Nuclear Fuel and Waste Management Co.)
Visitor's administration
Telephone: +46 173 883 00
Email: linda.bergman@skb.se

Chapter 5
Student Reports

5.1 Attending the Japan-Sweden workshop

Nobuko Mitsuoka
Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1, Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan

1. Introduction

As a researcher studying the impact of the Fukushima nuclear power plant accident, I was also very interested in the impact of the Chernobyl accident on agriculture. I have read many studies related to the Chernobyl accident in an attempt to gain more knowledge that could enhance my own research. Although the scale and location of the accident differ between Fukushima and Chernobyl, in my opinion there are many similarities, and a significant body of scientific knowledge has accumulated as a result of the Chernobyl accident from which the Japanese can greatly benefit. Thus, I wanted to attend the workshop and hear the stories of researchers who were leading experts during the Chernobyl accident. Besides my interest in the accident site and studies on the area, an additional motivation for me to attend the workshop was to improve my scientific communication skills. Since I had never given a presentation in English at an international workshop or academic meeting, I wished to gain such experience.

I was originally interested in heavy metal contamination of soil and wrote my senior thesis on the topic. I was in my senior year of undergraduate studies when the Great East Japan Earthquake happened. I was studying abroad in the US at the time and did not experience the earthquake directly. However, it was extremely shocking news for me and I was very concerned about its impacts. After the earthquake, next came the Fukushima Daiichi Nuclear Power Plant accident. This was such a devastating event, and I could not believe the response of the Japanese government. When I returned to Japan in May 2011, the country was still experiencing the aftermath of the disaster. Shipment of most of the agricultural products from Fukushima was suspended. Even after the ban was lifted for certain products, people did not want to buy them because of harmful rumours. At this time, I felt the urgent need for scientific evidence and communication with the general public to get rid of the negative image of agricultural products from Fukushima. Before the nuclear accident, Fukushima was renowned as a rich agricultural area. I hoped to contribute to the restoration of Fukushima's image as a major agricultural area using my scientific knowledge on soil contamination. For this reason, I chose to study soil caesium contamination and its phyto-availability.

Some of my findings were reported at the Fukushima Contamination Commission by my professor; with this, I felt that I was partly able to contribute to the restoration of Fukushima's reputation. Attending the workshop was also a wonderful opportunity for scientific communication, allowing me to present the latest research on Fukushima to people from another country, and furthering understanding in this field of study.

2. What I felt in Sweden

2-1. Impressions after attending the workshop

This was my first presentation in English at an official event, and so I felt very nervous before attending the workshop. However, it turned out to be an excellent opportunity for scientific communication. Although my English skills are not perfect and there are many areas in which I can improve, several of the Swedish students and professors showed interest in and praised my presentation. I also received constructive feedback for future improvement.

All of the presentations were extremely interesting and I gained considerable new insights into the field of radioecology. I found the case of pit lakes particularly interesting. In the first instance, I had never heard of pit lakes and the problems connected with radioactive contamination. Although some lakes can contain a certain amount of uranium-related radioactive material, even if they are not uranium mining sites, it surprised me to learn that, without knowing this fact, some people spend their holidays and swim in those lakes. I thought that it would be an important research topic to create a distribution map of radioactivity levels in pit lakes across Sweden.

It was also interesting to learn more about events at the time of the Chernobyl accident. Since I was not very familiar with Sweden or its geography, I did not know how close Sweden was to Chernobyl and the extent of the effects of the accident in the country. There are many similarities between Japan and Sweden. I wish we had known about the knowledge accumulated by the Swedes as this could have helped us to respond more rapidly to the Fukushima accident.

2-2. Swedish nuclear waste management site

In my opinion, nuclear power plants are currently necessary in Japan because of the problems of thermal power plants, such as their high CO_2 emissions and the limited reserves of fossil fuels. Ideally, we would gradually shift to renewable energy to ensure sustainable energy production to protect the futures of both people and nature. However, for now, it is extremely difficult to cover Japan's energy needs with renewable energy; therefore, in my opinion, nuclear power plants should resume operation in Japan. The largest challenge is how to manage nuclear waste. This has been the topic of long discussion in Japan, and remains unresolved. In Sweden, the discussion has been ongoing since before 1970, and studies to determine suitable waste management sites and procedures have been carried out since that time. It is astonishing to me to learn that Sweden has had to deal with this issue for such a long time, and has a thorough plan for nuclear waste management for nuclear power plants in operation throughout the country. In my opinion, there are many useful things that Japan can learn from Swedish nuclear management planning.

1-3 Food, nature and people in Sweden

1-3-1 Food in Sweden

As I expected from my preconceptions of Northern Europe, I had many opportunities to eat salmon! Although I ate salmon almost every day, I never became tired of it because it was so delicious! At the reception event at Gothenburg University, people from the university treated us to large amounts of seafood, including salmon, shrimp, and crayfish. There were three varieties of salmon; smoked, fermented, and grilled. It was surprising for me to see people eating fermented fish; however, really, it was not that bad at all! The most shocking food I ate during my stay was "surströmming" which we were introduced to by professors at Stockholm University. Surströmming is known as "the stinkiest food in the world." The smell was hundreds of times worse than I had imagined, and some of us had to rush into the toilet to get rid of the smell. It was an interesting cultural experience, but I would not like to eat it again….

1-3-2 Nature in Sweden

We experienced Swedish nature through excursions on the second day at Gothenburg University and the fifth day in Forsmark. The birch and cedar forests were somewhat similar to those in Japan, such as in Nagano or Hokkaido. There were also many Japanese species in the botanical garden at Gothenburg University. However, some parts were very different from Japan, and I got to experience true Scandinavian nature. Enormous mushrooms and berries (lingonberries and blueberries) could be found everywhere. It felt very comfortable walking in the deep forest feeling softly piled soil underneath my feet. Walking through Swedish nature was one of the experiences that made the greatest impression during my visit.

1-3-3 People in Sweden

I was extremely impressed by the excellent English skills of Swedish people. I talked to many people in Sweden including taxi drivers, shop assistants, and restaurant staff, and had no problems at all communicating with them in English. Everybody seems to understand and speak English very fluently with perfect pronunciation. I asked one Swedish person, "How come you speak English so well?" He answered that they have been watching English language television programs with subtitles since their childhood and that English is deeply rooted to their lives. I was envious of Swedish people for having such an environment and I wish that Japan could be like that. I also found Swedish people were very helpful, polite and humble. I asked the way several times when I got lost in the city and everyone gave me directions in a very polite way. Some Japanese people would just say, "I don't know" if they were asked directions by a foreigner, but everyone in Sweden responded to me politely, despite the fact that I was from another country. I became a big fan of Sweden and its people, and I hope to visit the country again in the near future.

3. Summary

I would like to express my immense gratitude to the NPO group and professors from all of the participating universities for providing me with the opportunity for such a wonderful and memorable experience. This was my first time visiting a European country and I was excited and nervous at the same time to be travelling around with people I had never met before and to give a presentation in English in a foreign country. However, it turned out to be an incredible experience. Everything I saw in Sweden was beautiful, and the people were lovely. The workshop and fieldtrip were extremely interesting and I learned a lot about nuclear power plants and radioactivity. I am sure that knowing that so many people in Sweden are still conducting research after Chernobyl will motivate me to deepen my research and to publish the outcomes for people who are waiting for the most up-to-date results. I plan to build upon the experience and knowledge that I gained in Sweden during my future research.

5.2 My first workshop on radioecology

Kyoko Ichikawa
Graduate School of Agriculture and Life Sciences, The University of Tokyo, 1-1-1, Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan

1. Introduction

At the time of the Great East Japan earthquake, I was visiting a pear (Pyrus spp. L.) orchard about 7 km from the Fukushima Daiichi Nuclear Power Plant, and the farmers and I evacuated to the safety of a peach farmer's house. In response to this experience, I decided to study the effects of radiocesium contamination on peach production. Therefore, the workshop described below was a good opportunity for me.

I was concerned that only a few people would participate in a workshop that focused on the Fukushima Nuclear Power Plant accident, because I thought that the effects of radioactivity on agriculture were little studied. I did not know other students who studied the Fukushima incident, but I looked forward to meeting them.

2. Main section

2-1. Swedish researchers

Scientists from the University of Gothenburg and Stockholm University participated in this workshop. Several researchers from the University of Gothenburg had previously studied the Chernobyl nuclear accident. The University of Gothenburg provided both experienced participants and a hospital. It was, however, difficult for me to understand their very technical scientific reports. Based on their experience with the Chernobyl accident, I felt that Swedish citizens might be more inclined than Japanese to take the issue of nuclear safety seriously. The Chernobyl accident was the first catastrophic nuclear power plant accident, and its scale was even greater than that of the Fukushima accident. I was interested in reports of the effects of using 'the whole body counter' rather than the effects on a particular species or area of residence.

Because there were many biological presentations, I was interested in the seminar at Stockholm University. The Swedish presentations of results from studies of wild animals such as reindeer and moose were interesting.

2-2. Japanese researchers

The aim of this workshop was for Japanese students to experience Swedish culture and learn more about radioecology. It also gave me the opportunity to meet Japanese students who were studying the Fukushima accident. The group in my laboratory was relatively small, and I felt particularly motivated to stay with them during the workshop. It was a good opportunity to discuss our research and share ideas. I will keep in touch with the workshop participants in the future.

2-3. Swedish ecology

Visiting the forest near the Forsmark nuclear power plant was particularly interesting. It was my first opportunity to enter a near-virgin forest. I thought the difference between Japan and Sweden was related to the ice age. Most forests in Japan are located in a temperate zone, with many types of deciduous trees. Fallen leaves litter the ground and contribute to increasing the soil organic matter content. In addition, the numerous volcanoes in Japan have produced a class of soil that contains volcanic ash. Swedish forests contain large rocks from the ice age. As most of Sweden is located in a frigid zone, the country has many coniferous trees, and the breakdown of organic waste in the soil is slower than that in Japan.

I was surprised that many berries grow on the moss found on the rocks (picture). Berries make fruits in just one year, despite their shallow roots and the heavy snow in winter. It seems that moss growing near the Fukushima nuclear plant should readily absorb radiocesium. I concluded that the radiocesium concentration in berries was higher because they grow on moss. The minimum acceptable level of radiation in food grown in the wild was increased from 300 Bq/kg to 1500 Bq/kg in Sweden.

3. Summary

I was near the Fukushima Daiichi Nuclear Power Plant at the time of the catastrophic earthquake at nearby Tohuku. Thereafter, I participated in a workshop in Sweden, the home of scientists who had studied the Chernobyl nuclear accident. I met many scientists and students who shared my interests. I have studied the different approaches taken by scientists from Japan and Sweden following their respective nuclear power plant accidents. I enjoyed learning about Swedish ecology. The workshop facilitated contact with other young scientists studying the Fukushima accident.

5.3 A wonderful experience in Sweden

Osamu Hashimoto
Master course, Graduate School of Agricultual and Life science, The University of Tokyo, 1-1-1, Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan

1. Introduction

First, I would like to explain why I am studying the radioactive materials emitted from Fukushima Daiichi Nuclear Power Plant (FDNPP). My hometown is Koriyama City, Fukushima Prefecture, located 50 km west-northwest from the FDNPP, so my hometown lies within the zone affected by radioactivity from the accident. As everyone knows, high radiation doses cause serious damage to human health, and no one wants to live under such circumstances. Those people who decided to leave Fukushima have been gradually moving to other prefectures, and the people who decided to stay in Fukushima need support. I wish to help these people, including my family, and this is why I study radioactive materials.

I study the absorption and translocation of radioactive caesium by roots from soils. However, I found that the more I studied this topic, the more I also needed knowledge of other subject areas. To have a thorough understanding of my study topic, I need a broad knowledge of other related study areas. For me, this workshop was very appealing because I could learn a lot about both Fukushima and Sweden based on the impacts of Chernobyl. The information on Sweden was particularly interesting for me. It is easy for me to obtain information on Fukushima, but I cannot easily learn about Sweden. Thus, I decided to participate in this workshop because I thought it was an excellent opportunity.

2. The experience in Sweden

2-1 Difficulty of communication

The main difficulty I faced was in communicating in English. It was particularly difficult to talk with Swedish researchers about my study, despite the fact that it was my major. I had felt confident in my English skills, but I realised that I had been wrong! When I travelled overseas in the past, I had no problems with communication. This, I realised, was because the context was informal, and it was not necessary to speak correct English. However, when I wanted to explain about my study, I felt that I needed to speak correct, clear English. I found even conversations about my research difficult, so it was natural that my presentation felt like somewhat of a failure. I was unable explain myself clearly, and this felt extremely frustrating.

2-2 The presentations by other Japanese students

All of the presentations by the other Japanese students were excellent, and no one seemed to have problems with their English, except me. The topics were very interesting, and I enjoyed the presentations. But when they finished their presentations, the students seemed to have various regrets about them. I was surprised to see their obvious desire to improve their skills. I experienced problems in speaking English, but other students tried to raise their English, presentation, and other skills. This experience served as motivation for me.

2-3 The presentations by Swedish researchers

The presentations by Swedish researchers provided me with motivation from an academic point of view. I found it surprising that they focused on naturally occurring radioactive materials in the natural environment. I had thought that the quantities of these radioactive materials were so small that their effects could be ignored. However, in some areas in Sweden, higher levels of radioactive materials occur in the natural environment than we tend to be aware of, so I realised the importance of considering their effects.

At the end of the workshop we were asked, "How can we recruit new students? Most Swedish people have forgotten the Chernobyl accident, and they don't pay any attention to radioactivity." This question made quite an impression on me, and I realised that Japanese people will also gradually forget the FDNPP accident. If we completely forget the accident, a similar disaster could be repeated in the future. It may be necessary to maintain people's interest, but how do we do that? I do not have any immediate answers to this question. If we continue to study the FDNPP accident, we will eventually have to face this question, and at some point in the future, we will need to find the answer.

3. Summary

By participating in this workshop, I was able to obtain significant knowledge about radioactivity. I found all of the presentations very interesting, and each one taught me something new. I was very pleased to have attended the workshop. I was left with two main impressions. One was my awareness of my poor English skills. Other students had competent English skills, but I was unable to speak to Swedish people with fluency, and I found I was unable to present my study as I would have liked, which I found very frustrating. The other point was realising the fact that people gradually forget such terrible accidents and perhaps become complacent over time. I feel that this is a serious problem and a difficult one to address. Swedish people have faced this problem with Chernobyl. I find myself asking when the Japanese will also face the same problem and how will we address it.

These new perspectives and the added motivation the experience gave me make me feel so grateful to have been able to participate in this workshop, and I know I will draw on my experience in Sweden in my research in the future.

5.4 What I learned at the Japan–Sweden workshop

Momo Takada
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1. Introduction

The purpose of the Japan-Sweden workshop was to learn about cutting-edge radioecology research and emergency preparedness for radiation disasters in Europe.

I study radiocaesium dynamics in forest soils, focusing on the temporal variation and spatial heterogeneity. I first learned about the academic discipline "radioecology" after the Fukushima nuclear power plant accident about 4 years ago. I also knew that radioecology evolved in northern European countries, including Sweden, where it has been studied since the Chernobyl nuclear power plant accident, which occurred 30 years ago. Therefore, I expected radioecology in Sweden to be 25 years ahead of studies in Japan.

I am interested in the social responses to the Chernobyl accident in Europe. I also wanted to learn about the emergency preparedness of European countries for future radiation disasters. Few Japanese expected the Fukushima accident after the Great East Japan Earthquake in 2011 and the accident lead to great confusion. As Sweden experienced the Chernobyl accident about 30 years ago, I wanted to learn about the current situation in Sweden regarding future accidents.

2. Radioecology in Sweden and Japan

2-1. University of Gothenburg, Stockholm University

We heard about actual experiences following the Chernobyl accident, including details of the accident, environmental measurements, the detection of radioactive materials, and surprise at the results. I found the talks interesting because my university professors also spoke about their experiences following the Fukushima accident, which were similar to the experiences associated with the Chernobyl accident. I postulated that a series of steps always follows a nuclear accident, i.e. the accident itself, measurements, detection, and surprise. Various studies related to radioecology have been conducted. I wanted to learn more about studies on radiocaesium dynamics in forest ecosystems.

I heard several presentations about the temporal changes in radioactivity in wild animals. I learned that the most effective measure to protect humans and society from radiation is to control the amount of radionuclide intake in food. Therefore, food monitoring is important and has long been conducted. In Japan, radioactive materials are dealt with as special substances. In Sweden, radioactive materials produced by the Chernobyl accident are dealt with as an environmental pollutant, like heavy metals.

The University of Gothenburg has a course on emergency preparedness. This interested me, so I asked a PhD student about the course content. Possible emergency situations are accidents occurring at industrial nuclear facilities, including nuclear power plants. Preparedness involves preparing equipment for measuring radiation and practicing with the equipment. I understood that preparedness is important and the development of human resources for emergencies should be enhanced. However, researchers may not contribute much to emergency preparedness.

2-2. Studies of Japanese students and my presentation

The conference represented a good opportunity for me to learn about research involving graduate students in Japan because I do not have many other opportunities to learn about their research. The research themes and results obtained by graduate students at other universities are also interesting. I got to know PhD students from other universities and talked about our research goals and concerns for the future. I also learned about cutting-edge research on radioecology after the Fukushima accident from professors at the University of Tokyo. Several Japanese academic societies study radioecology, including forestry, agriculture, and ecology societies, but there is no unified academic society for radioecology. Therefore, I would not have had a similar opportunity in Japan.

I have presented my study at international conferences several times. On this occasion, I thought that my English was the best has ever been, although I still need to improve. As the audience were from various backgrounds, my talk might have been too specific, difficult, and boring for many. Nevertheless, I believe that my research results are important and interesting, but I need to give a presentation that appeals more to a non-professional audience.

2-3. SKB (Swedish Nuclear Fuel and Waste Management)

The process of disposal of radioactive wastes in Sweden is completely different from that in Japan. Sweden seems to be 50~100 years ahead of Japan because Japan has not designated a disposal site for radioactive wastes. I tried to identify differences between Japan and Sweden, but I could not. I assumed that the difference is due to differences in social and political systems; perhaps geological differences between Sweden and Japan also made site selection easier in Sweden, as Japan is frequently affected by earthquakes and volcanoes.

I was interested in the results of the site investigation at Forsmark from 2002 to 2007 because my research background also includes cycles of materials such as carbon and nitrogen in forest ecosystems. I was impressed by the detailed environmental assessment conducted at Forsmark before building the repository. The result of the environmental assessment is also important academically. As a PhD student studying material cycles in a forest ecosystem, I wanted to join the site investigation team.

This was my first opportunity to see a boreal forest because my study sites are temperate forests in Japan and tropical forests in Malaysia. The coniferous forest in Forsmark was very beautiful, and the understory vegetation and soil were very different from what I know in Japan and Malaysia.

3. Summary

My goals at the Japan-Sweden workshop were to learn about cutting-edge radioecology research in Japan and Sweden and emergency preparedness for radiation disasters in Sweden. I learned that radioecology is evolving in both Sweden and Japan. This has increased my motivation. I also learned that Sweden is ahead of Japan in terms of protecting humans, society, and the environment from radiation. The university in Sweden has a course on radiation emergency preparedness, and careful environmental assessments are conducted in Sweden before building nuclear facilities.

5.5 Report on the Japan-Sweden Workshop

Tomoya Hori
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1. Introduction

The Chernobyl nuclear plant accident was one of the first cases in which neighbouring countries faced radioactive contamination and its effects on human health. Japan has examined how countries such as Sweden have coped with radionuclide problems. Sweden has experienced nuclear weapons fallout and is regarded as a pioneer of studies of radioecology, radionuclide contamination, and treatment management. Many articles on Chernobyl and its effects on Sweden, including radioecology, have been published. Nevertheless, international conferences are one of the few opportunities for Japanese to discuss these issues with foreigners. This workshop was a wonderful opportunity to collaborate and share our knowledge with Swedish pioneers on radioactive studies and to advance Japanese research.

I study fish movements in coastal areas in Fukushima affected by the 2011 earthquake and tsunami. There are few reports on the fine-scale activities of fish and their ecology in disturbed environments, and such information can contribute to environmental reconstruction activities following disasters. In terms of radioecology and food safety in Fukushima, radionuclide dispersal in marine food resources should be considered. The fine-scale monitoring of fish movements may be a key factor for clarifying radionuclide uptake in fish.

At the workshop, I wanted to learn more about current and historical studies of radioecology in Japan and Sweden, for future study ideas. The fisheries in Fukushima are still regulated and limited to small-scale trial fishery operations. Many of the fishery people that I meet in the course of my studies want to return to the work they had before the earthquake. Radioactive contamination of fish and its effects on human health are important concerns. I hoped to get ideas on how to clarify these problems.

2. Workshop reviews

2-1 Workshop at the University of Gothenburg

I discovered a great deal of new information at the presentations in the workshop at the University of Gothenburg. First, I was surprised to learn that the Swedish regulatory limit for radioactive Cs in foods was 300 Bq/kg, albeit not for all food resources. The Japanese limit for food is 100 Bq/kg and some Japanese feel that the value is lax compared with the limits in other countries. I also learned that the radioactive contamination of grasslands, which affects cows and milk, is important in Sweden, while Cs contamination of rice still attracts the most attention in Japan. These differences arise from cultural and historical differences between the countries, and the food safety policies of each government have to consider the Cs contamination of food in ways that protect food producers from consumption declines.

The most interesting information that I learned at the workshop was about pit (mining) lake studies. The artificial aquatic environment in these lakes is contaminated with metallic elements from the mining effort. This results in external dosing of visiting animals and people. The release of specimen fish is one possible way to test the radioactive uptake by fish in order to study the effects of radionuclides on animals in the lake. My study can contribute to this research since the study of fish movement and distribution appears to be important experimentally.

2-2 Workshop at Stockholm University

I was more at home at the Stockholm University session because many speakers talked about the radionuclide contamination of animals. Although there were many interesting talks about the radioecology of animals (e.g. wild boars and amphibians) and plants (e.g. crops, rice, and wild radish), I found the study on the intentions of customers to purchase salted salmon from Japan the most interesting. As I explained in the Introduction and Subsection 2-1, consumers in Japan are still concerned about the safety of seafood and both economic and social studies are essential to establishing safe marine products for recovering seafood markets in Japan. Even if basic studies of the radioactive contamination of food resources clarify the various safety issues, people may still not feel confident about food safety. This study showed that these concerns are also important in other agricultural products and trade markets in other countries. Although the talk focused on specific areas, I also learned how to use my fish ecology studies to clarify problems that fisheries in Fukushima are currently facing.

3. Summary

I had expected that this workshop would be a good opportunity to collaborate with Swedish scientists and to consider future avenues of research. I obtained a great deal of new knowledge and talked with pioneers in the study of radioecology from Sweden and Japan. I developed some ideas for future studies and met Swedish and Japanese scientists with whom I may have a chance to collaborate in the future.

5.6 Long-term desorption kinetics of Cs from contaminated soil

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1. Introduction

It is necessary to investigate the mobility and kinetics of caesium (Cs) in the subsurface environment as part of soil decontamination following nuclear accidents, as well as to assess the environmental impact of the disposal of high-level radioactive waste. Among the radionuclides contained in contaminated soils following the accidents at the Fukushima Dai-ichi and Chernobyl nuclear power plants, ^{137}Cs is of particular concern because of its long-term environmental effects due to its long half-life of 30 years. Radiocaesium is also contained in spent fuel from nuclear plants. Furthermore, the mobility of 135Cs (which has a half-life of approximately 2.3 million years) should be taken into account in the disposal of high-level radioactive waste.

In Japan, the locations for new repository sites for decontaminated radioactive waste and high-level radioactive waste have not yet been decided. This is due both to technical problems, such as understanding the chemical properties of radiocaesium in soils, as well as to social issues. The Swedish nuclear fuel and waste management company SKB has selected repository sites for spent fuels, even though Sweden suffered radioactive contamination due to the Chernobyl accident. In this workshop, we are interested in the differences between Japan and Sweden in terms of public perception of the disposal of high-level radioactive waste and selection of repository sites. I am grateful to have had the opportunity to learn about these differences by visiting Forsmark and attending a research presentation by Dr. Kautsky, and from my many conversations with Swedish researchers.

2. Differences between Japan and Sweden

2-1 Public awareness

I was interested in the effects of the Chernobyl accident on public awareness of radiation and disposal of radioactive waste. One Swedish researcher has stated that Swedish students are indifferent to the accident. Although it is possible that there are different trends in other generations, the adverse effects of the accident do not appear to be a significant concern, at least for now. This is thought to be because approximately 30 years have passed since the accident, which occurred in a country that does not share a border with Sweden.

The public confidence in atomic energy companies and the government in Sweden is particularly interesting. The main reason for lack of progress in feasibility studies in Japan is the opposition of local residents. Another Swedish researcher stated that this confidence stems from a lack of failure incidents. After hearing this opinion, I realized the need for greater effort from Japanese atomic energy companies and authorities to recover public confidence following the Fukushima Dai-ichi nuclear accident, which resulted in considerable disaffection towards nuclear power, electric companies and the government's handling of the disaster.

2-2. Publication

SKB have investigated not only the subsurface environment, but also the surrounding ecosystem of geological repositories for long periods of time. A booklet is available from SKB providing a summary of their research, and is accessible to the public. There are many introductions to individual researchers, with pictures illustrating their research work. These are thought to be effective in providing a positive view of the researchers and their work, which helps to build public confidence. Although similar material is available in Japan, these publications are mainly composed of data on the safety of disposal.

2-3. Technical aspects

Earthquakes or fault activities are important factors in the selection and assessment of disposal sites in Japan, whereas Swedish researchers have studied long-term models considering glacial periods, where repositories are covered by snow year round. In practice, however, the planning of the disposal of nuclear waste is similar between the two countries. It follows that social aspects are particularly important in nuclear waste disposal, and may indeed be of greater importance than the technical details of waste management.

3. Summary

My experience of this workshop showed me that there are significant differences in public confidence in relation to the disposal of radioactive waste between Japan and Sweden and, furthermore, that public confidence is of crucial importance in the future development of the nuclear industry; indeed, it is arguably of greater significance than technological progress. In conclusion, in Japan we must concentrate our efforts to recover public confidence in the nuclear industry.

A photograph of a conversation with Dr. Nordén.

5.7 Importance of international communication among researchers

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1. Introduction

When I was a student at Kitasato University, which is located within the area affected by the 2011 great east Japan earthquake, I lived in the tsunami-affected area and experienced the loss of my house and one of my friends. Furthermore, I learned about several problems in the reconstruction of fishery industry when I talked with acquaintances who worked in fisheries. One of the biggest problems was the economic damage to the affected area caused by people avoiding purchasing fish products because of concerns about radioactive contamination. Thus, I wanted to contribute to solving this problem and started my research on consumer attitudes towards seafood produced in affected area.

After the great east Japan earthquake and Fukushima Daiichi nuclear power plant accident in 2011, some media and researchers reported that some foods produced in the affected area exceeded the radio cesium standard, leading consumers to avoid purchasing them. This problem is similar to the situation in Sweden after the Chernobyl nuclear power plant accident in 1986. In the case of Chernobyl, radioactive substances leaked into atmosphere, and some of them reached Sweden. As a result, Swedish consumers and food producers worried about the radioactive contamination of food. Moreover, because Swedish researchers had been monitoring radioactive substances in the field and hydrosphere, they had abundant knowledge about nuclear hazards and the potential for damage to nature and society.

My purpose in participating in this workshop is to communicate with researchers from other countries not only by presenting and discussing my research but also by integrating interdisciplinary knowledge.

2. Outcomes of the workshop

2-1. Recognition of the importance of international discussion

I recognized the importance of international discussion and the sharing of research themes, methods, and results with researchers from other communities. In particular, comments about my research and an explanation of the Swedish government's countermeasures in response to the Chernobyl accident encouraged my scientific study of nuclear disasters. For example, Dr. Leif Moberg mentioned the regulation of ^{134}Cs and ^{137}Cs; the limit is 300 Bq/kg in normal food and 1500 Bq/kg in some foods (e.g. freshwater fish and mushrooms). As these regulations differ from Japanese food regulations (100 Bq/kg in normal food), it was important to me, and this information gave me an opportunity to assess people's awareness of the regulation of radioactive substances in Sweden. In addition, this information about the Swedish regulations gave me a chance to think about the possibility of reducing Japanese consumers' concerns about the radiation standard by providing information about Swedish regulations.

Furthermore, many participants offered opinions about my research during discussions, breaks, and field trips.

My research topic was consumer awareness of seafood produced areas affected by the 2011 great east Japan earthquake. In particular, my interest was in consumers who wanted to contribute to reconstruction by purchasing and in behavior and concerns related to the radioactive contamination of seafood. Thus, I conducted a questionnaire survey in 2012 and found that consumers who wanted to contribute to the reconstruction through their purchasing behaviors had lower levels of concern about radioactive contamination. I presented this result at Stockholm University, but many participants from the University of Gothenburg also offered opinions over meals and during field trips. In particular, one participant offered the following meaningful comments and encouraged me to continue my research: "This is a new aspect compared with former research about risk communication" and "It sounds interesting when the difference in consumer altruistic behavior and consciousness is clarified by country".

Fig.1 International human network involving participants of this workshop

2-2. Knowledge from different fields

As I am interested in research on radiation undertaken in other fields, this workshop was a good opportunity for me to learn about new points of view. Dr. Juan Mantero presented an introduction to research focused on mining-related radioactivity in a lake. I was impressed by the demands placed on the lake as a tourist site, which it had become because of its good scenery and clear water. However, the lake includes minerals that emit radiation, rendering it important to monitor for ^{226}Ra to clarify the risk of radiation exposure when people swim in the lake. This case requires the development of strategies to both the monitor the situation and inform the society about the results. Thus, I recognized that research topics related to radioactivity (including nuclear disasters) are related to not only the natural sciences but also the social sciences. Thus, an international and interdisciplinary approach is needed to solve these problems.

Fig.2 Opportunities to gain interdisciplinary knowledge

3. Summary

This workshop provided information about the countermeasures taken by the Swedish government in response to the effects of the Chernobyl accident and about the research that has been conducted in this domain. In addition, participants from Japan gave presentations about the mechanisms by which radioactive substances move and are adsorbed into the soil and organisms, including by the species living in the hydrosphere after the Fukushima Daiichi nuclear power plant accident. I also gave a presentation on the results of my post-disaster consumer research.

The main theme of this workshop is nuclear disasters. Thus, participants gave presentations related to this theme and discussed it relative to their specialties. This kind of international discussion is important for the communication of and reflection on our research. Furthermore, it is important that researchers who focus on topics that have natural and social science aspects participate in interdisciplinary collaborations so that they can adopt a broad view that extends beyond individual specialties. This workshop taught me about the importance of international discussions and motivated me to engage in international collaborative work with researchers from different areas.

Finally, I am grateful to the professors, secretaries, and participants who organised this forum and provided this opportunity to me.

5.8 What I felt throughout the Japan-Sweden workshop

Shuto Shiomi
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1. Introduction

When I watched the news regarding the Fukushima Daiichi nuclear power plant (FDNPP) accident, I realised that I wanted to perform research on the damaged area. Then I became a member of a laboratory of Radioplant Physiology and have been performing research related to Cs transportation within rice plants. The reason I chose this theme is that vast areas of paddy fields were damaged by radiocesium and there are areas where rice cropping is still suspended in the Fukushima Prefecture.

Before I visited Sweden, I had an understanding regarding the relationship between Sweden and the Chernobyl accident. First, Sweden was the first country that alerted the world about the Chernobyl accident. Second, after the Chernobyl accident occurred, Sweden focused on exploring the effects to the environment and conducting counter measures for radionuclide contamination.

Based on my understanding, I thought that this Japan-Sweden workshop would allow me to obtain new knowledge regarding radioecology and provide guidance for my research. Thus, I decided to participate in this workshop.

2. People's accurate understanding of radiation and the nuclear accident

2-1. After accident

In Sweden, the information pamphlet "Efter Tjernobyl (in English: After Chernobyl)" were distributed to all households in the autumn of 1986 (Fig. 1). This pamphlet helped people understand the effects of radiation and the Chernobyl accident. Since I observed numerous people who were confused by a variety of inaccurate information regarding the FDNPP accident, I was impressed when I heard this topic and read this pamphlet at Stockholm University. I appreciated the importance of disseminating correct information to the people.

2-2. Final depository

I attended a presentation on the "final depository for spent nuclear fuel in Forsmark" by a member of the SKB staff and understood that there are two necessary conditions to build the final depository; namely, safe technical solutions and a consensus with the people who live in the district. In this presentation, the staff member said, "Knowledge is power, but most power is people who live here". These words left a strong impression on me. Surprisingly, nearly 90% of residents were in favour of having the storage site in their community in Forsmark. I believe that this consequence was due to the SKB's long-running effort and people's earnest attitude to understand the necessity of the final depository. If people have an ambiguous understanding regarding the final depository's safety and necessity, they may not agree with this policy.

3. Summary

Through this workshop, I did not acquire new knowledge regarding my research; however, I learned new things, such as the final depository and Sweden's concrete efforts to cope with the Chernobyl accident, that I was not aware of before visiting Sweden. Using this experience, I would like to focus on radiation issues and continue my research more deeply.

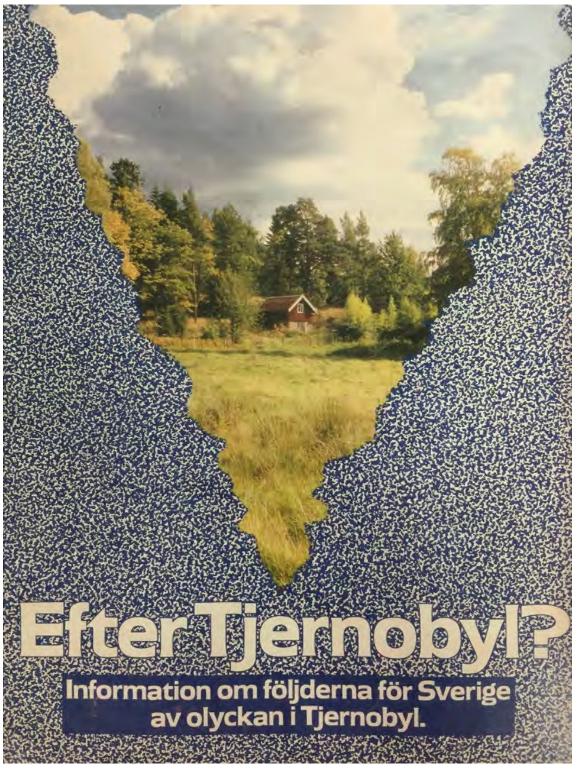

Fig.1 Efter Tjernobyl

5.9 What I learned in Japan–Sweden workshop, 2015

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1. Introduction

The Great East-Japan earthquake happened when I was a high school student in Kyoto. The disaster caused by the tremendously powerful tsunami and the Fukushima Daiichi Nuclear Power Plant accident made me think about what I could do for people in the Tohoku region, but I had no answer at that time. However, when I had the opportunity to give a presentation about nuclear power plants last year, I learned what researchers have done to deal with the nuclear power plant accident. That has motivated me to study phytoremediation, which is one solution to the agricultural problems caused by the accident. I actually started my study this April, but had few opportunities to communicate with others about the accident and associated research activities. Therefore, I felt that joining this workshop would enhance my communication with others and improve my research.

In addition, I was interested in how researchers in Sweden and other countries have dealt with the Chernobyl accident. People in the Tohoku region are still confused about radiation contamination and it is unclear how long this situation will last. Furthermore, despite the Chernobyl accident, nuclear power plants in Sweden still generate most of the energy needed in Sweden. I believe that exchanging information with Swedish researchers will provide clues about how to deal with the Fukushima accident.

This was also the first time that I presented my study. I have learned how difficult it is for me to convey my thoughts well enough for others to understand them. In preparing for my presentation, I received a great deal of advice from the academic staff and other participants. I found the process a bit difficult but very stimulating at the same time. These interactions helped me recognise problems in my study and motivated me to study more.

2. What I learned in the workshop

2-1 The importance of having various views

I learned a great deal from both the Japanese and Swedish participants in this workshop. While my research has focused primarily on plants, other participants study diverse topics such as the effects of radiation on humans, animals, and fisheries, and the spatial distribution of radioactive material. While listening to the presentations, I came to feel that it was necessary to think of connections or relationships among the various topics and fields of research. Professors in my faculty, the Faculty of Integrated Human Studies, often say that it is necessary to integrate other fields in order to deal with problems, but I had not fully understood what they meant. However, the presentations at this workshop, given from various perspectives, have given me insight into this concept. In addition to collaborating with other researchers, I found that it is also important for me to approach my problem from various directions. Understanding this will clarify the steps to be taken in order to tackle my specific problem.

I also found that I need to understand the problem from the perspectives of both the arts and science. For example, people might not be certain about the border between safe and dangerous levels of contamination in food. As some presenters said, we cannot precisely identify a limit for what is dangerous. However, it is natural for people living in the contaminated area and those with children to worry about this kind of problem. I feel that scientists should not only give these people scientific solutions, but also understand their viewpoints, even if what they think is not scientific. This is the first step to knowing why people think the way that they do and it is crucial in order to understand and evaluate problems scientifically.

2-2 The importance of knowledge

Visiting Forsmark during the workshop left a lasting impression. I had not considered spent nuclear fuel. Visiting the repository has stimulated me to study how Japan deals with spent nuclear fuel.

I was also impressed how the importance of knowledge was stressed in the explanation of Forsmark. In Japan, the TV, radio, and internet provide a great deal of information about nuclear power plant accidents and radiation. However, too much information can be confusing and makes it difficult to judge which information is correct. Some commentators say that nuclear power plants should be banned and viewers are affected by the commentators' opinions because they do not have enough knowledge of their own to counter them. A lack of knowledge frightens people more than it should. I think this is one of the factors that confused people after the nuclear accident in Japan. Electric power companies should provide this information directly, including the negative aspects.

In addition, I was very surprised to learn that 80% of the residents agreed with the construction of the repository in Sweden. This was because SKB earned their trust through conversations and communication with residents over a long period. I wondered whether this would be possible in Japan in the case of the construction of nuclear power plants. In Japan, the representatives change frequently and politicians seem to avoid direct communication with residents, especially with regard to nuclear power plants. Even if the governor of a city knows that some residents disagree with the construction of nuclear power plants, he might accept the plan because the city can get more money as a benefit of having a nuclear power plant. Consequently, politicians lose the trust of the people. I hope that this will change and that electric power companies will provide enough information and give people the opportunity to ask questions.

2-3 About radiation

When we visited the University of Gothenburg, we had a chance to see some machinery and learn about radiation. Although I had read about radiation in books, this was the first time I heard an explanation. It was sometimes difficult to understand, but others helped me. I need to learn more about radiation and how it is applied in various fields.

When I returned to Japan, I discovered that one of the groups at my university has developed a car for emergencies similar to one I saw in Sweden. Although I did not known how my university was prepared to respond to accidents, my experience in Sweden helped me recognise these activities.

2-4 What I learned from other participants

I learned not only about radiation and radioecology but also how I should deal with problems in my own study. I was very nervous about giving my presentation and lost confidence in the results of my study because there is a lot of room for improvement. However, one of the Swedish participants gave me some very good advice: everybody was once a beginner! If I need to improve, I can get advice from others to help me to improve. This advice cheered me. I had an opportunity to reflect on my study through my preparations and listening to other presentations. I have also learned how to approach a study using appropriate experiments and methods.

3. Summary

In this workshop, I learned the importance of having various views of a problem and thinking about the relationships among various factors. In addition, visiting the repository stimulated me to learn more about nuclear power plants and radiation. I simultaneously discovered that I lacked knowledge on these issues. I want to learn more about nuclear power plants and be able to evaluate the future of nuclear power. Other participants also taught me how to approach my study, which will improve it.

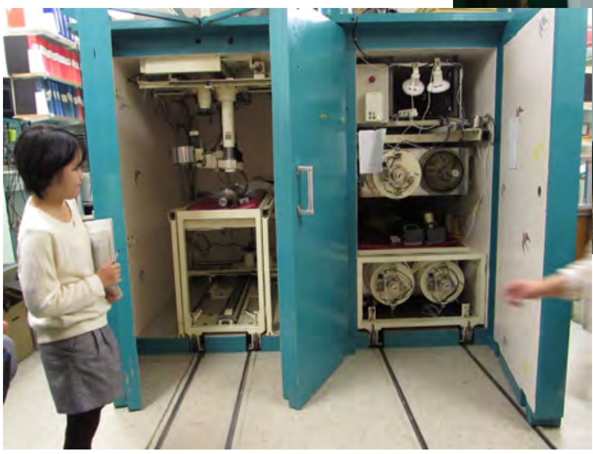
Finally, I was able to spend some very stimulating days in Sweden. I appreciate all of the people involved in this workshop and am grateful for having this precious opportunity.

Chapter 6
Photographs of Activities

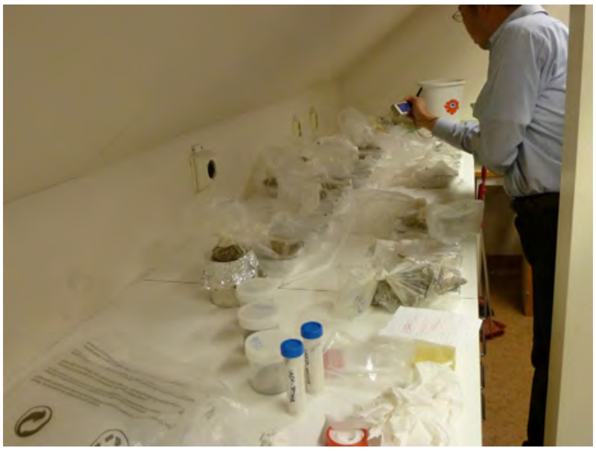

Gula stråket 2B at Sahlgrenska University Hospital

The emblem of "cruiser Sheffield" on the old iron shield of the whole body counter at Sahlgrenska University Hospital

The campus map of Sahlgrenska University Hospital, Gothenburg, Sweden. Dept of Radiation Physics, Institute of Clinical Sciences, located at Gula stråket 2B


A whole body counter


An old germanium semiconductor detector


A pretreatment room for samples in the field

Mobile equipment for field sampling and measurement of radiation

A soil core sampler

A mini lecture for alfa ray spectrometry by Dr. R. Thomas

Simulated setting up of an electrodeposition cell for uranium alpha source preparation

Änggårdsbergen Nature Reserve

Gothenburg botanical garden and Änggårdsbergen Nature Reserve

Gothenburg botanical garden

Japanese cherry tree, Prunus sargéntii Bergkörsbär in the nature reserve

Japanese cypress, Chamaecyparis obtuse in the nature reserve

Japanese pond in the nature reserve

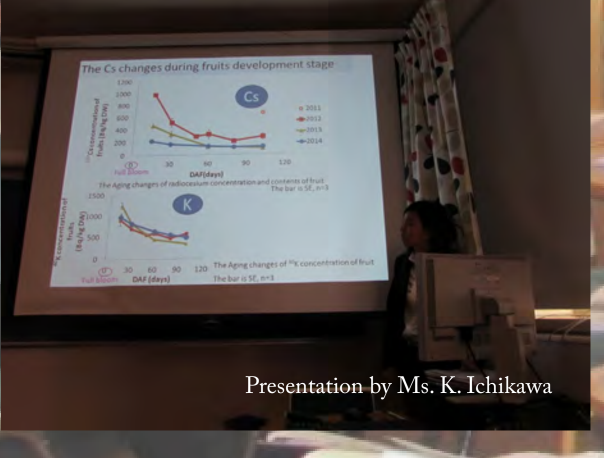
The workshop participants at the hilltop of Änggårdsbergen Nature Reserve

The city of Gothenburg

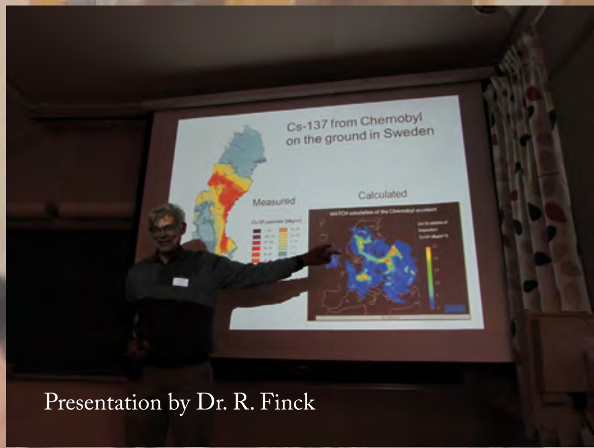
The welcome event (mingel) at Dept of Radiation Physics

Presentation by Prof. S. Mattsson

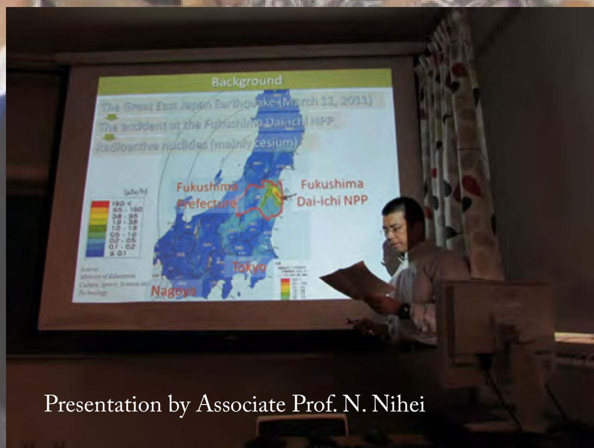

Presentation by Ms. N. Mitsuoka



Presentation by Ms. K. Ichikawa



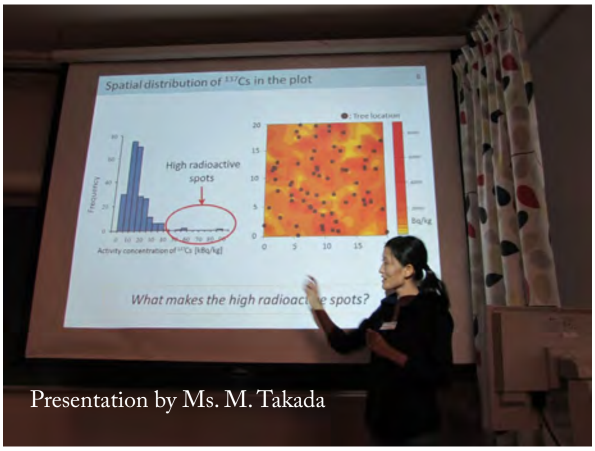
Presentation by Dr. R. Finck



Presentation by Associate Prof. N. Nihei

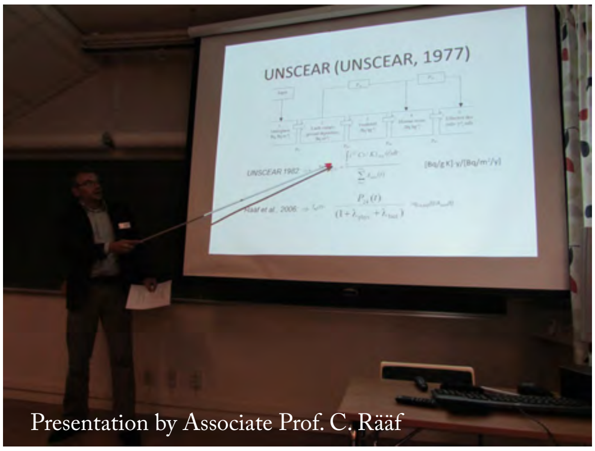

Presentation by Dr. G. Bengtsson

Presentation by Mr. O. Hashimoto



Presentation by Ms. M. Takada

Prof. E. Forssell-Aronsson and Project Associate Prof. S. Miura



Presentation by Associate Prof. C. Rääf


A group photo of participants of the workshop in Gothenburg


Japanese students at Gothenburg Central Station

Gothenburg Central Station

Arrival at Stockholm Central Station

Aula Magna, the venue of the workshop at Stockholm University

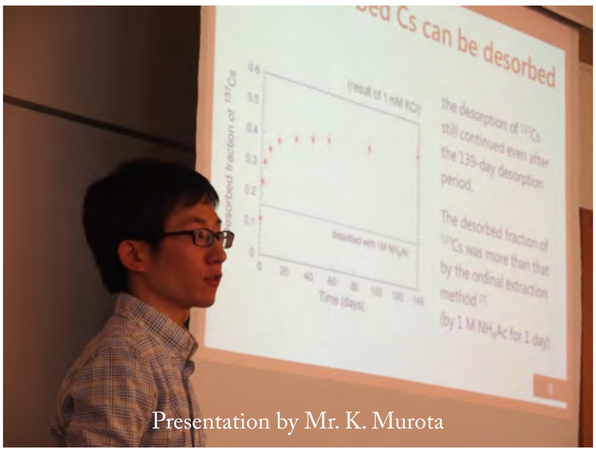
The meeting room of the workshop

Presentation by Mr. R. Weimer

Presentation by Associate Prof. N. Tanoi

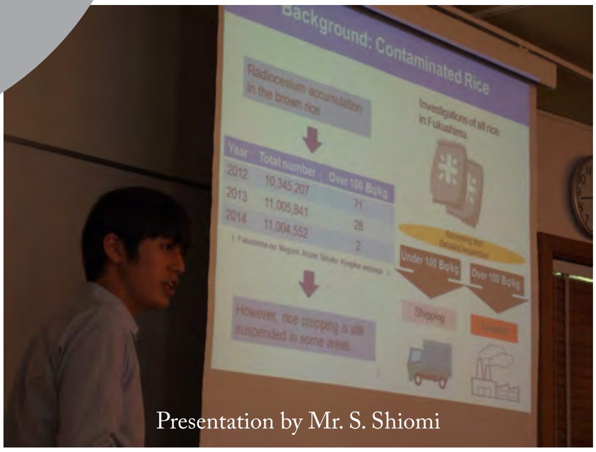
Presentation by Mr. T. Hori

Presentation by Mr. T. Suzuki



Presentation by Mr. K. Murota

Presentation by Dr. S. Bengtsson



Presentation by Mr. S. Shiomi

Presentation by Ms. N. Oshima

Presentation by Assistant Prof. N. I. Kobayashi


Presentation by Dr. U. Kautsky

The campus of Stockholm University

Prof. A. Wojcik was introducing the low dose rate (mGy/h) gamma incubator (Cs-137 source).

The mixed beam (alpha / X-ray) exposure facility

PhD theses accepted in the laboratory

Surströmming welcome party

Day

4

A coach ready to go to excursion for the final repository at Forsmark

The map of Forsmark foundry managed by VATTENFALL, an electric energy company

Explanation of history of Forsmark village's former steel industry

Nine Japanese students at Forsmark village

An old spruce-dominated forest within terrestrial monitoring sites in Forsmark, which is located above the underground final repository for radioactive waste of SKB

The old spruce-dominated forest

Understory of the old spruce-dominated forest

The workshop participants in the old spruce-dominated forest

A monitoring site of frogs and orchids in Labbo forest wetland in Forsmark

A pond in Labbo forest wetland

Day
4

Watching frogs or tadpoles?

Lingonberry, vaccinium vitis-idaea in Labbo forest wetland

Picking mushroom or lingonberry?

Another mushroom, edible or not?

An edible mushroom (funnel chanterelle; Cantharellus tubaeformis) in Labbo forest wetland

Tea break near lake Bolundsfjärden

Possible future wetlands study site in relation to hydrology and transport mechanisms of surface hydrology at lake Bolundsfjärden

A dragonfly

Common toad,

Arable land in Forsmark

Postscript

The present project, “Sweden-Japan Workshop of Radioecology for Students, 2015”, was co-organised by the Graduate School of Agricultural and Life Sciences, University of Tokyo (GSALS UTokyo) and the NPO Radiation Safety Forum. This project was also supported by the Watanabe Memorial Foundation for the Advancement of New Technology and GSALS UTokyo.

There are two main aims of this project. One is related to education, allowing students to become familiar with English presentations. In this context, the final report is also published in English, and all of the presentations given in Sweden were in English. English fluency is becoming increasingly important for everyone, not only researchers. Given this, Master’s and Diploma students, in addition to PhD students, attended the project.

The other aim is to develop a closer relationship between Sweden and Japan, focusing on radioecology, which has been a maturing topic in Sweden since the Chernobyl accident, and has been drawing increasing attention in Japan since the Fukushima Daiichi nuclear power plant accident in 2011. I was impressed by the attitude of the Swedish researchers in investigating and developing countermeasures to the contamination of fields and forests. I am also confident that the Japanese team were able to provide fundamental data about the agricultural situation in Fukushima to the Swedish researchers. I deeply appreciate the contribution of the Swedish participants. It is important to maintain contact and arrange the next workshop soon.

Through the two workshops in Sweden, I was really impressed by the students’ research related to Fukushima. In addition, all of the students were able to benefit from the activities, namely, presentations and discussions in English. In fact, I found that the students tended to focus too much on the English language, especially English pronunciation and fluency. I strongly recommend that the students look back on their presentations and subsequent discussions and check the following points:

- Did they really get the audience to understand what they were talking about? Did they give up on telling the story when they lost their way?
- Was their attitude towards the audience sincere and earnest? When they made a mistake, did they laugh the matter off? Alternatively, did they try to cover it up by speaking fast?
- Had they thoroughly prepared their presentation in advance?

The students who attended the project will have (or had already) noticed what is really important when they speak in front of an audience. Improving English skills is not the only solution to giving better presentations in English.

Lastly, I would like to thank the leader, Dr. Miura, for coordinating all of the activities in the present project. All of the participants were able to obtain valuable experience thanks to his consideration and care.

Keitaro Tanoi
The University of Tokyo
NPO Radiation Safety Forum

Appendix 1
Statens strålskyddsinstitut informerar om det radioaktiva nedfallet från kärnkraftsolyckan i Tjernobyl

(“Swedish Radiation Protection Authority News of the radioactive fallout from the Chernobyl nuclear accident”, a brochure introduced in p.245.)

Gruppinformation till hushållen i Uppsala. Västmanlands och Gävleborgs län.

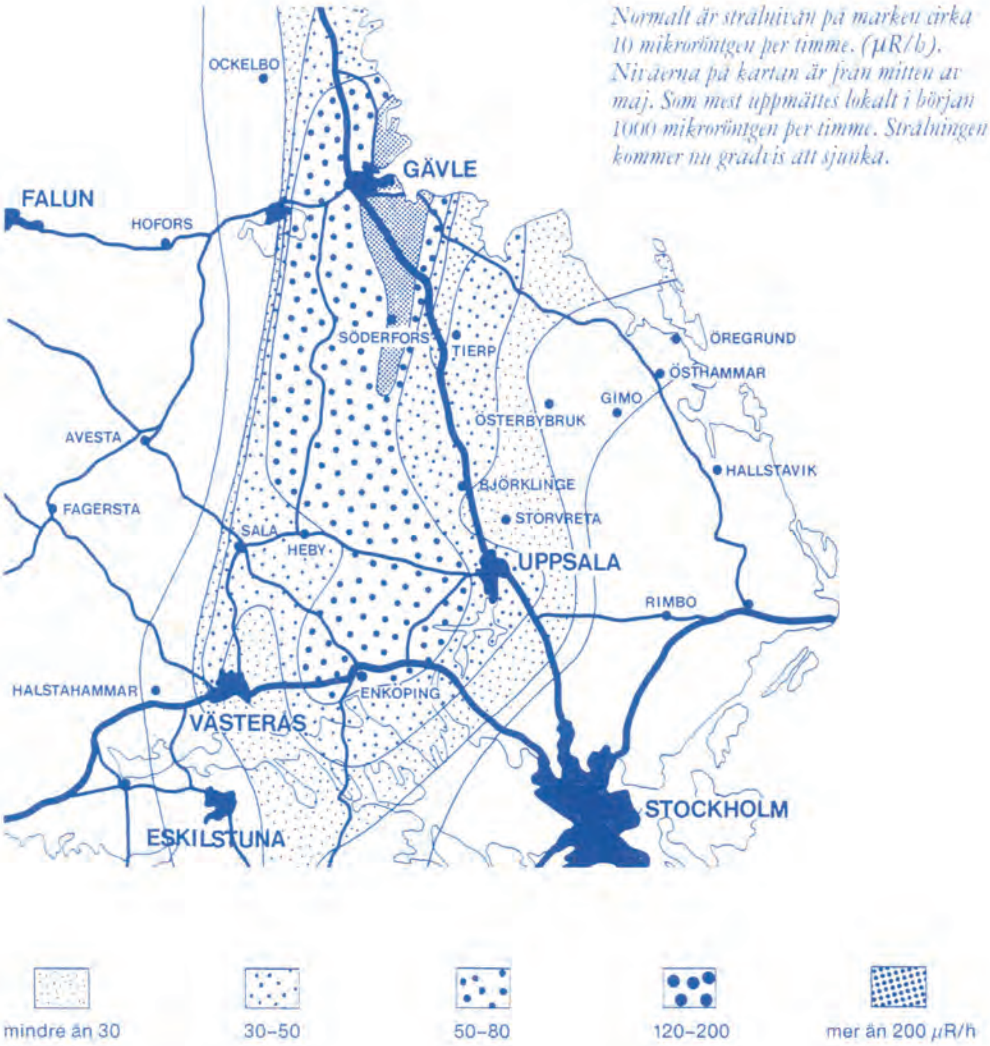
86-05-26

STATENS
STRÅLSKYDDSINSTITUT
BOX 60204 104 01 STOCKHOLM

Statens strålskyddsinstitut informerar om det radioaktiva nedfallet från kärnkraftsolyckan i Tjernobyl

I det område där du bor har mer radioaktiva ämnen från kärnkrafts-olyckan i Tjernobyl fallit ner än i övriga Sverige. Orsaken till detta är att det regnade när molnet med de radioaktiva ämnena passerade. Kartan visar hur nedfallet på marken fördelar sig.

Normalt är strålnivån på marken cirka 10 mikroröntgen per timme. (μR/h). Nivåerna på kartan är från mitten av maj. Som mest uppmättes lokalt i början 1000 mikroröntgen per timme. Strålningen kommer nu gradvis att sjunka.



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Många är oroliga för riskerna med strålningen

Det finns många frågor de flesta har ställt sig de senaste dagarna.
Några är:

- Vågar jag dricka mjölk och vatten?
- Kan jag sätta och så?
- Kan barnen vara ute och leka?
- Hur stor är hälsorisken för mig och min familj?

Många frågor har vi försökt besvara i tidningar, radio och TV. I detta brev vill vi sammanfatta den information som gäller dig och din familj.

Risken de första dagarna

De första dagarna efter det att de radioaktiva ämnena nått Sverige fanns en stor del i luften. Det mesta var jod och cesium, som vi andades in.

Joden samlas i sköldkörteln. Gävle sjukhus har nu undersökt ett hundratal personer. Resultaten visar att halterna radioaktivt jod i sköldkörteln varit låga. Värdena för 90 av de hundra personerna låg under 50 Bq. Övriga hade värden mellan 50 och 100 Bq. Den stråldos man får av dessa halter är mycket liten.

Cesium går främst ut i musklerna. Där omsätts det och hälften försvinner ut ur kroppen på tre månader. Några cesiummätningar har ännu inte gjorts på människor efter olyckan, men erfarenheterna från provsprängningar av kärnladdningar säger oss att stråldosen från inandat cesium är liten.

Markbeläggningen

Ett stort antal mätningar har gjorts inom det område som kartan visar. Vi har funnit så stora mängder radioaktiva ämnen i gräset, att mjölkkorna ännu inte får släppas ut. Anledningen är att korna får i sig för stor del jod och cesium, som sedan förs vidare till mjölken. Vi har på detta sätt kunnat hålla nere halten radioaktiva ämnen i mejerimjölken och vi mäter varje dag mjölken från mejerierna.

Vi har också mätt kommunalt vatten och vatten från brunnar, och endast funnit låga halter av radioaktiva ämnen. Våra kontroller av mjölk och vatten kommer att pågå länge. Du kan därför utan oro dricka både mjölk och vatten. Men du ska undvika att dricka stillastående vatten.

Endast de grönsaker som vuxit upp före olyckan kan innehålla så höga halter av radioaktiva ämnen att du bör undvika att äta dem. Livsmedelsverket föreslår ändå att du avstår från nässlor, persilja, gräslök och murklor. När området blir friklassat är det åter fritt fram. Men skölj gärna grönsakerna väl.

Du kan så och sätta som vanligt i din trädgård. De grönsaker som växer upp och ska skördas i höst har inte fått något nedfall på sig. Den mängd som kommit in i växten genom rotsystemet är mindre än en procent av nedfallet.

Ända sedan atombombsprängningarna på 50- och 60-talet har bl a lantbruksuniversitetet i Uppsala studerat hur de radioaktiva ämnena tas upp i växter och djur. Vi vet därför idag hur de uppträder i naturen och i våra livsmedel. Vi kommer att noggrant kontrollera livsmedel, som mjölk, kött, grönsaker och spannmål. Även viltkött ska kontrolleras.

Lev som vanligt

Alla kan trots nedfallet leva som vanligt. Du kan gå i skog och mark, sköta din trädgård, bada i sjön osv. Barnen kan vara ute som vanligt, gräva i sandlådan och leka sina lekar.

Riskerna i framtiden

Hur stor är då risken med de radioaktiva ämnena du blivit bestrålade av? Den stråldos du högst kommer att få är 3 millisievert. Det är den totala dosen för all framtid från olyckan. Den motsvarar 3 års stråldos från den naturliga strålningen.

Denna stråldos ligger långt under de doser som ger akuta skador. Stråldosen från olyckan ger dig en något ökad risk för cancer och genetiska skador. I det område kartan visar kan det gälla fem cancerfall med dödlig utgång under en tid av 35 år. Samtidigt kommer ca 100 000 människor i området att dö i cancer av andra orsaker. Det kommer därför att vara omöjligt att peka ut vilka cancerfall som förorsakats av kärnkraftsolyckan. De genetiska skadorna har uppskattats till hälften så många som cancerfallen. Även dessa blir så få att man inte kan påvisa dem.

Den uppskattade risken att dö i cancer efter en stråldos av 1 millisievert kan jämföras med:

- en röntgenundersökning av t ex magen
- en veckas vistelse i ett hus som har en radonhalt vid gränsvärdet 400 Bq/m^3
- arbete en vecka i högsta tillåtna strålmiljön

Risken är alltså ganska liten att skadas av stråldoserna från kärnkraftsolyckan även i ditt område. Att vi ändå försöker att minska verkningarna beror på att vi vill hålla all onödig bestrålning så liten, som det är praktiskt möjligt.

Det är vår förhoppning att du fått svar på några av de frågor som oroat dig. Vi kommer även i fortsättningen att göra vårt bästa för att minska riskerna och hålla dig informerad om den aktuella situationen.

Mer information kan du få om du vänder dig till din kommun, din länsstyrelse eller strålskyddsinstitutet.

Med vänliga hälsningar
Statens strålskyddsinstitut

Gunnar Bengtsson

Några exempel på uppmätta värden

Mejerimjölk

		jod-131	cesium-137
Gränsvärde		2 000 Bq/l	300 Bq/l
Gävle	3 maj	56 Bq/l	2 Bq/l
"	15 maj	7 Bq/l	2 Bq/l
Uppsala	3 maj	48 Bq/l	2 Bq/l
"	15 maj	2 Bq/l	2 Bq/l

Som synes ligger värdena för mjölk långt under gränvärdena. Detta beror på att mjölkkorna hålls inne.

För dricksvatten ligger värdena på ungefär samma nivå.

Gräs

	jod-131	cesium-137
Gränsvärde	10 000 Bq/m²	(1 000 Bq/m²) ej fastställt
Gävle	23 000–316 000 Bq/m²	90 000–120 000 Bq/m²
Furuvik	258 000 Bq/m² (mark)	137 000 Bq/m²
Sandviken	44 000–63 000 Bq/m²	22 000–37 000 Bq/m²
Uppsala	8 000–20 000 Bq/m²	3 000 Bq/m²
Tärnsjö	9 000 Bq/m²	10 000–16 000 Bq/m²

För gräs ligger ännu värdena långt över gränsvärdena och är skälet till att mjölkkorna hålls inne.

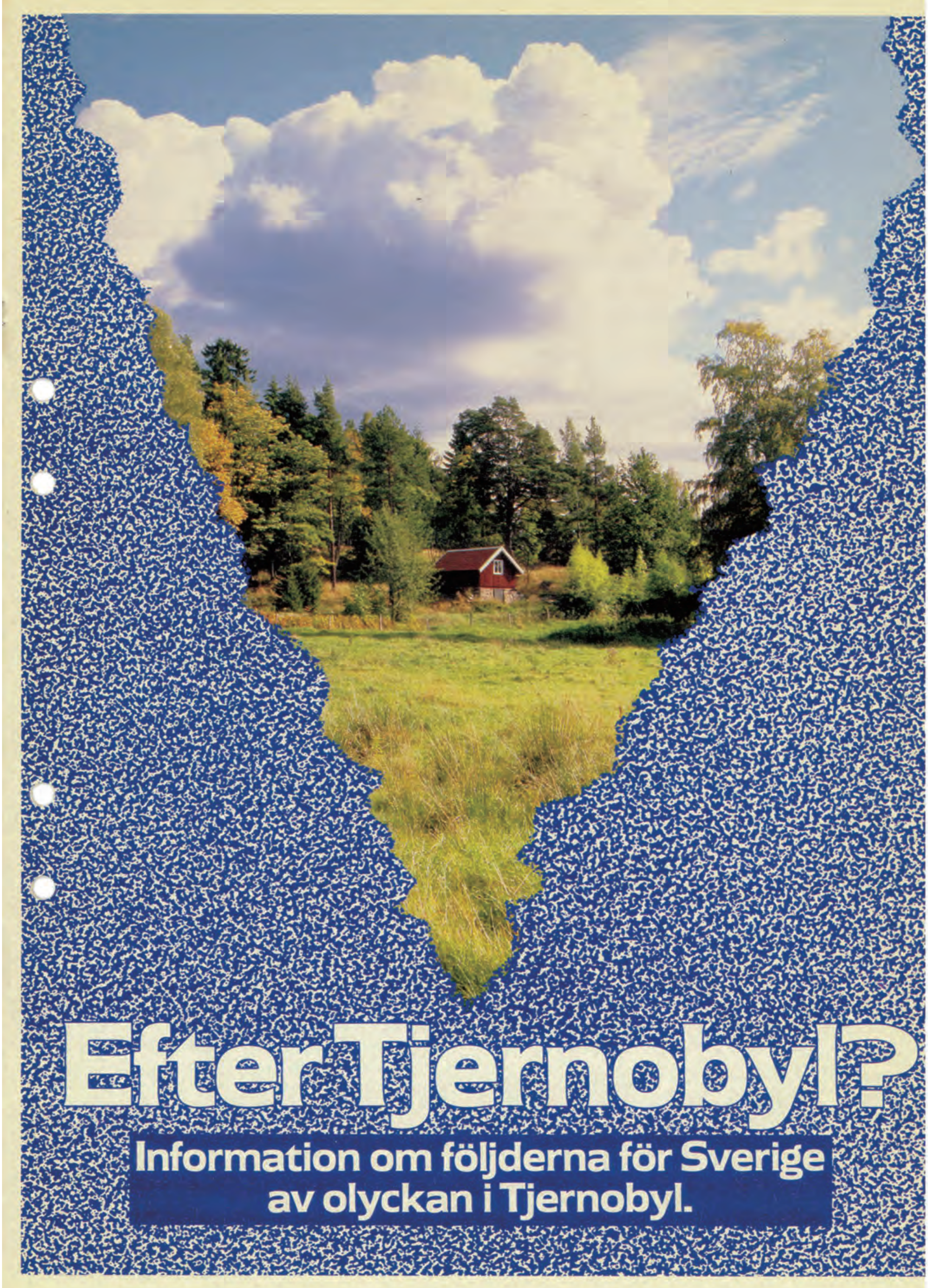
Jod-131 förekommer normalt inte i naturen, men cesium-137 finns i små mängder, vilka kommer från atombombssprängningarna. Jod-131 minskar till hälften på 8 dygn. Motsvarande tid för cesium-137 är 30 år.

När man tar hänsyn till stralningens biologiska verkan, anges straldosen i millisievert (mSv). Av 100000 personer som fått 1 millisievert beräknas två personer avlida i cancer och en få en genetisk skada.

Radioaktivt sönderfall mäts i becquerel (Bq). En becquerel anger att en atom sönderfaller per sekund.

Appendix 2
Efter Tjernobyl?

(“After Chernobyl?”,
 a brochure introduced in p.246.)



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Reaktorolyckan i Tjernobyl var en katastrof som skakade hela världen. Vi vet nu att följderna är oerhörda för människorna runt olycksplatsen. De sovjetiska myndigheterna ser inte ut att planera för någon återflyttning till staden Pripjat. Även för övrigt är följderna för Sovjets befolkning mycket stora.

Naturligtvis blev vi alla oroade när det stod klart att Sverige var ett av de mest utsatta länderna utanför Sovjetunionen.

Allteftersom vi fick mätvärden klarnade bilden. Fortfarande vet vi inte allt. Vi kommer att få ytterligare detaljer genom den forskning som kommer att hålla på i många år framåt. Omfattande åtgärder har satts in framför allt för att hindra onödigt höga intag av radioaktivt cesium från mat och dryck.

Ingen i Sverige väntas få annat än ett litet tillskott från Tjernobyl till den stråldos som vi alla får från naturliga källor. Lika stora eller större stråldoser kommer från andra källor, t ex röntgenundersökningar och strålningen i bostäder.

Oron för stora risker kan stillas. De flesta behöver inte göra några stora ändringar i sin livsföring. Sådana ändringar kan till och med ibland öka den ovälkomna risken. Barn behöver till exempel allsidigt sammansatt mat, och naturligtvis ska man låta dem dricka mjölk.

I denna broschyr rekommenderar vi framför allt följande:

- *storkonsumenter av renkött ska planera sin konsumtion noga*
- *gravida kvinnor i de mest utsatta områdena ska noga följa livsmedelsverkets kostråd, om de äter mycket av vad skog och sjöar ger*

I den här broschyren får Du fakta direkt från oss på myndigheterna. Den sammanfattar den information som nått Dig genom tidningar, radio och TV.

Jag ber Dig läsa broschyren. Den kan hjälpa Dig och Din familj att se på Tjernobylolyckan med befogad respekt men utan onödig oro.

Gunnar Bengtsson
Generaldirektör Strålskyddsinstitutet

Skilj mellan aktivitet och stråldos.

Aktivitet mäts i becquerel

Atomerna i ett radioaktivt ämne faller sönder. Då sänder de ut strålning. Hur snabbt ämnet faller sönder, aktiviteten, mäts i en enhet som kallas becquerel. Den förkortas Bq.

Om aktiviteten är 1 Bq betyder det att en atom faller sönder per sekund. Bq är en mycket liten enhet. Därför brukar man uttrycka aktivitet i kilobecquerel. Den förkortas kBq. 1 kBq = 1000 Bq.

Aktiviteten i mjölk, vatten och andra livsmedel anges i becquerel per liter (Bq/l) eller becquerel per kilogram (Bq/kg).

Aktiviteten på marken anges i becquerel per kvadratmeter (Bq/m^2) och i luft med becquerel per kubikmeter (Bq/m^3).

Aktiviteten av ett radioaktivt ämne minskar i den takt atomerna faller sönder. Hur snabbt aktiviteten avtar anger man med ämnets halveringstid. Det är den tid det tar tills aktiviteten gått ner till hälften. Mer om halveringstid finns på sid 11.

Stråldos mäts i sievert

När en människa bestrålas tar kroppen upp energi. Den strålenergi per kilogram kroppsvikt man tar emot kallas stråldos.

Stråldos mäts i enheten sievert, som förkortas Sv. Det är en mycket stor enhet. Därför brukar man uttrycka stråldoser i millisievert, som förkortas mSv. 1 Sv = 1000 mSv.

Ju större aktivitet man utsätter sig för desto större stråldos tar man emot.

Sambandet mellan aktivitet och stråldos är komplicerat. Vid omräkningar måste man ta hänsyn till flera fysikaliska och biologiska faktorer.

Det radioaktiva nedfallet i Sverige.

När olyckan inträffade fanns det ett kraftigt högtryck över Ukraina, där Tjernobyl ligger. Vädret var vackert, och vinden blåste mot Skandinavien.

De radioaktiva ämnena fördes mot Sverige och Finland. De nådde Sverige på eftermiddagen söndagen den 27 april 1986.

I utsläppet fanns ädelgaser, som inte reagerar med andra ämnen, och som snabbt späddes ut i luften. Utsläppet innehöll också till exempel jod, cesium och en mycket liten del strontium.

Av de olika radioaktiva ämnen som fallit ner på marken i Sverige är det bara några få som har givit nämnvärda stråldoser till människan. Det var jod, som nu försvunnit, eftersom jod har kort halveringstid. Cesium finns fortfarande kvar i naturen, eftersom cesium har lång halveringstid. Även strontium bidrar till stråldosen med någon procent.

Jod som inte är radioaktiv finns naturligt i våra sköldkörtlar. Dit sökte sig också den radioaktiva jod som kom in i våra kroppar.

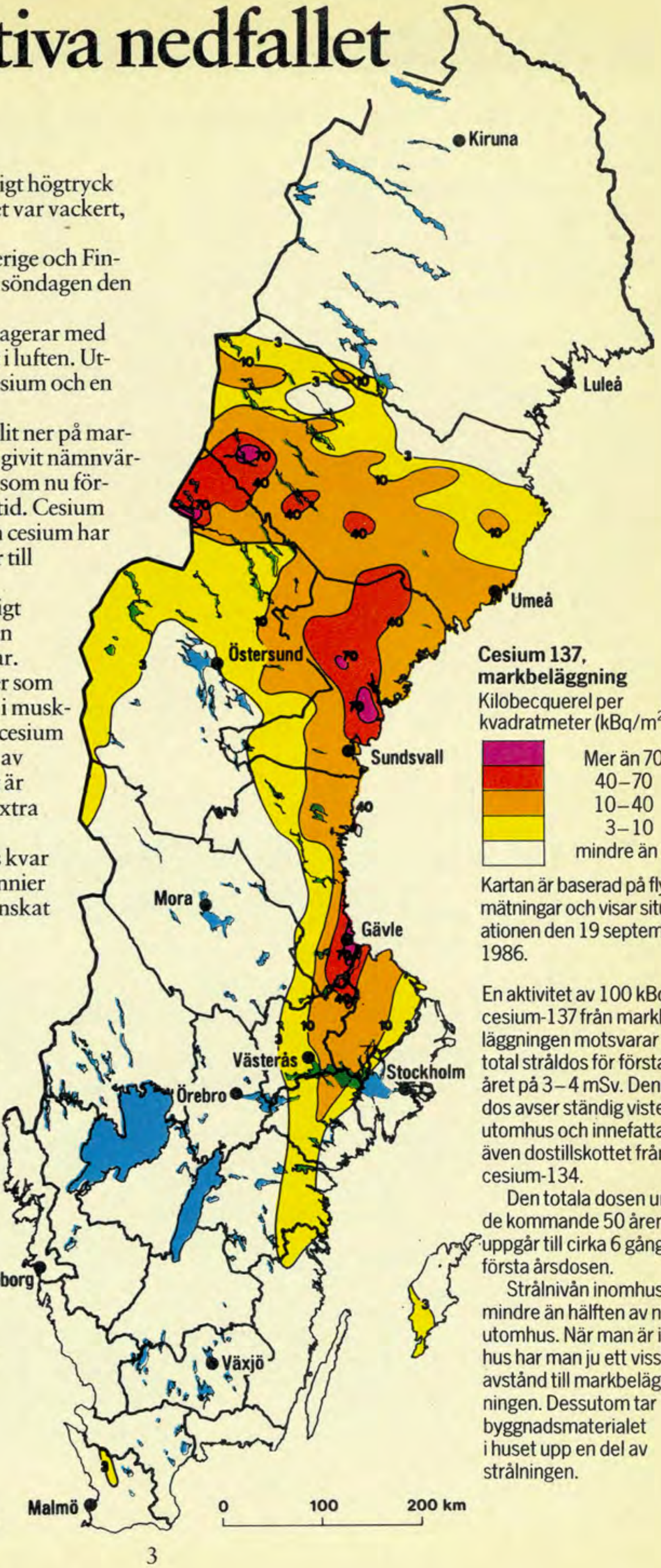
Cesium har ungefär samma egenskaper som kalium, som finns i alla celler och särskilt i musklerna. Därför söker sig också radioaktivt cesium dit. I nedfallet finns två radioaktiva typer av cesium, cesium-137 och cesium-134. Det är dessa som svarar för större delen av den extra stråldos vi får.

Radioaktivt cesium kommer att finnas kvar i naturen under lång tid. Efter några decennier kommer dess roll för stråldosen att ha minskat betydligt.

Strontium-90 finns också med i nedfallet men i mycket mindre mängd än cesium. Strontium liknar kalcium och samlas därför bland annat i skelettet. Strontium kommer att finnas kvar länge i naturen.

Plutonium, som är mycket långlivat, finns i ytterligt små mängder i nedfallet. De fem ton plutonium som spreds över jorden vid kärnvapenproven i atmosfären under femtio- och sextiotalen dominerar helt över det tillskott vi fått från Tjernobyl.

I vikt räknat var det mycket små mängder radioaktiva ämnen i det moln utsläppet bildade. Över Sverige spreds några gram jod och cirka 1,5 kg cesium. Trots de små mängderna finns radioaktiva atomer överallt.



Kartan är baserad på flygmätningar och visar situationen den 19 september 1986.

En aktivitet av 100 kBq/m² cesium-137 från markbeläggningen motsvarar en total stråldos för första året på 3–4 mSv. Denna dos avser ständig vistelse utomhus och innefattar även dostillskottet från cesium-134.

Den totala dosen under de kommande 50 åren uppgår till cirka 6 gånger första årsdosen.

Strålnivån inomhus är mindre än hälften av nivån utomhus. När man är inomhus har man ju ett visst avstånd till markbeläggningen. Dessutom tar byggnadsmaterialet i huset upp en del av strålningen.

SVERIGES GEOLOGISKA AB

3

Du kan äta allt som säljs i handeln..

Kan vi äta våra grönsaker? Vågar vi dricka mjölk? Sådana frågor ställde sig många oroligt efter olyckan i Tjernobyl.

Några dagar efter haveriet rekommenderade myndigheterna att korna skulle hållas inne. Man ville skydda mjölken mot för höga halter radioaktiv jod.

Mätningar inleddes omedelbart för att kartlägga hur mycket radioaktiva ämnen det fanns i våra livsmedel.

Myndigheterna fastställde ett riktvärde, som ligger till grund för kontrollen av handel och import, det vill säga vilken högsta halt cesium-137 mat och dryck får innehålla vid försäljning. Det är också underlag för de kostråd som livsmedelsverket utarbetar.

Kassarna innehåller en genomsnittlig dagskonsumtion av livsmedel, cirka 2 kg för en person. De är inköpta i Gävle och Malmö under september 1986. I båda fallen ligger aktiviteten långt under riktvärdet.

Undersökningar visar att den som livnär sig på ett varierat sortiment ur butikerna hamnar långt under en årlig stråldos på 1 mSv. Du kan alltså köpa och äta allt som finns i handeln.

Det är bara om Du äter mycket livsmedel från områden där nedfallet varit kraftigt som Du behöver

tänka på att begränsa konsumtionen av en del produkter. Det gäller om Du äter

– mycket kött som inte kontrollerats vid slakten, t ex av ren, får och lamm eller älg och annat vilt
– mycket insjöfisk
– mycket bär och svamp från skogen

Riktvärdet för aktivitet i livsmedel.

Strålskyddsinstitutet och livsmedelsverket har som mål att stråldosen från livsmedel bör hållas under 1 mSv i genomsnitt per år, utslaget på en längre följd av år. Detta gäller också för de mest utsatta grupperna. Inget år bör tillskottet från livsmedel överstiga 5 mSv.

För barn och vuxna motsvaras 1 mSv av 75 000 Bq cesium-137 eller 50 000 Bq cesium-134 per år. Ett dagligt kostintag av 100 Bq cesium-137 ger en årlig dos på cirka 1 mSv, om man också räknar in andra radioaktiva ämnen.

För att stråldosen ska hållas under denna nivå har myndigheterna satt ett riktvärde för handeln på 300 Bq cesium-137 per kilogram eller liter livsmedel. Varor med halter över denna nivå får inte säljas. Halterna i de flesta livsmedel ligger för närvarande långt under detta riktvärde.

Riktvärdet är ingen gräns mellan farligt och ofarligt. Därför kan Du äta livsmedel med halter över riktvärdet. Du kan också enstaka gånger äta livsmedel med halter som mångfalt överstiger riktvärdet. Det är inte enstaka höga halter utan det totala intaget under längre tid som avgör vilken extra stråldos Du får.

Kontroll av livsmedel

I samarbete med bl a kommunerna har livsmedelsverket genomfört ett omfattande analysprogram för att kontrollera aktiviteten i mat och dryck.

På slakterierna tas prov på allt kött som man misstänker kan innehålla för höga halter.

På mejerierna övervakar man noga mjölkens halt av radioaktiva ämnen.

Livsmedelsverket kontrollerar att riktvärdet respekteras av handeln. Det gör man genom att ta stickprov i affärerna och på importerade livsmedel.

Samma kontroll görs av råvaror som ska användas i storkök eller på restaurang.

...också där nedfallet varit stort.

Livsmedlen har tagit upp olika mycket radioaktiva ämnen. Halten varierar från livsmedel till livsmedel och från område till område.

De flesta livsmedel i Sverige har låga halter. I hela landet ligger halterna cesium-137 klart under riktvärdet i följande livsmedel:
- konsumtionsmjölk, smör och ost
- dricksvatten
- odlade bär och frukter
- potatis, grönsaker och rotfrukter
- mjöl och gryn
- griskött
- fisk från fiskodlingar och från havet

I de län som fått kraftigt nedfall har man funnit halter över riktvärdet i
- insjöfisk, ren, får och lamm
- vilt, till exempel hare och rådjur
- svamp och vilda bär, till exempel hjortron

Du kan dock lugnt äta också sådana livsmedel, om Du köper dem i handeln.

Det här kan du göra själv.

Du som jagar, fiskar eller plockar bär och svamp i något av de områden som drabbats hårdast av nedfallet kan fråga kommunens miljö- och hälsoskyddsnämnd om råd när det gäller strålmiljön. Där finns kunskap om de lokala förhållandena, och där finns också livsmedelsverkets råd, analysresultat och kostrekommendationer.

Om Du vill ha en analys utförd kan Du få hjälp med detta hos kommunen. Några kommuner har egen analysutrustning. Andra kan hänvisa Dig till lämpligt laboratorium. I en del fall får Du själv betala kostnaden, cirka hundra kronor.

Att skölja bär och svamp kan vara bra, även om det inte längre minskar halterna radioaktiva ämnen så mycket. När du kokar bitar av kött eller fisk i vatten löses en del cesium, men också vissa näringsämnen, ut i vattnet. Försök har visat att halten cesium i svamp kan minska betydligt om svampen förvälls i rikligt med vatten som sedan hälls bort. När Du steker eller fryser livsmedel minskas däremot inte halten av cesium nämnvärt.

Strålningen från ett livsmedel gör naturligtvis inte andra livsmedel radioaktiva. Strålning kan inte "smitta"!

5

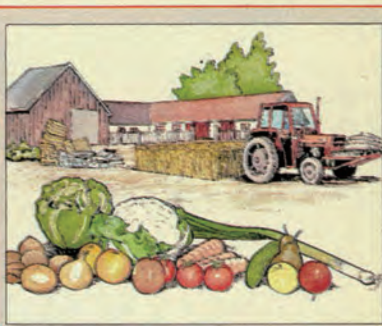
Så här sprids radioaktiva ämnen till l

En del av de radioaktiva ämnen som spreds över Sverige föll sakta ner på marken. I de områden där det regnade och snöade blev nedfallet störst. Mycket av detta cesium har nu spolats bort av regn och finns några millimeter ner i marken, i våtmarker och i vattendrag. Trots att det finns cesium i naturen är det inget som hindrar att Du och Din familj vistas i skog och mark.

Det tar flera år för cesium att vandra i naturen och genom livsmedel till människan. Halten av cesium kan sjunka i en del livsmedel men fortsätta att stiga i andra. Så småningom minskar halterna i alla livsmedel.

MJÖLK
Kor betar av stora ytor gräs. Av det cesium som finns i gräs eller foder överförs en del via kon till mjölken.

BÄR OCH SVAMP
Vilda bär och svampar växer ofta på näringsfattig mark. Detta gör att de lättare tar upp cesium än odlade växter, som gödslas. Lokalt kan det finnas bär och svamp med halter över riktvärdet.



VÄXTER
Spannmål, potatis och grönsaker växer på gödslad och kalkad jord och tar endast upp en liten del av det cesium som finns i marken.

VATTEN
Dricksvattnet har bara obetydliga halter av cesium-137, i regel under 2 Bq/l.

6

ivsmedel.

KÖTT
Bara hos nötkreatur som betat där nedfallet varit kraftigt har man funnit halter över riktvärdet.

Svin äter foder som innehåller litet cesium. Det är därför som grisköttet har låg aktivitet.

Lamm och får från områden där det radioaktiva nedfallet varit stort har i många fall haft halter över riktvärdet. Det beror på att de betar tätt intill marken, där cesiumhalten är högre.

RENAR OCH VILT
Rådjur och småvilt äter marknära växter och betar på stora ytor. I de områden som fått mest nedfall kan därför aktiviteten i viltet vara hög.

Älgar har som regel lägre halter än rådjur och harar, men halterna i älg stiger när den går över på vinterbete.

Renar äter mycket lavar, som är fleråriga växter utan rötter. Lav har speciell förmåga att ta upp och behålla radioaktiva ämnen. Därför får renar höga cesiumhalter.

Det cesium ett djur får i sig utsöndras med tiden ur kroppen. Halva mängden försvinner på 1–2 månader. Mängden cesium i ett djur påverkas därför både av hur mycket cesium det får i sig och hur mycket som utsöndras.

FISK
Havsfisk har påverkats endast obetydligt av nedfallet.

I insjöar och vattendrag i de områden som fått mest nedfall finns lokalt halter över riktvärdet hos fisken. Alger och plankton tog upp radioaktiva ämnen som genom växtätande fiskar fördes över till rovfiskar. Fisk har låg ämnesomsättning, och problemen kan därför vara kvar i flera år.

7

Så här påverkades arbetsmiljön.

I en del fall samlades betydande mängder radioaktivt stoft från nedfallet i luftfilter för stora luftflöden, till exempel i industrianläggningar, samt stora kontors- och hyresfastigheter.

När man byter sådana luftfilter är det skydd man normalt använder mot damm och mycket små partiklar tillräckligt.

Strålningsnivåerna i rötslam från reningsverk för avloppsvatten har även mätts.

I enstaka fall har strålningsnivåerna varit sådana att man inte bör arbeta i direkt anslutning till sådant slam under mer än några timmar per dag.

Hur vår hälsa påverkas.

Det görs mycket för att hindra onödigt stora intag av radioaktiva ämnen. Det kan betyda stora ingrepp i vardagen för en del grupper. Samernas kultur är t ex starkt berörd, eftersom renkött på många håll har höga halter av cesium. Den som huvudsakligen lever på renkött kan därför bli tvungen att i flera år ändra sina levnadsvanor så att stråldosen hålls nere. Även den som till stor del lever av vad skog, fjäll och sjö ger kan behöva se över sina matvanor.

Stråldoserna från nedfallet är så låga att ingen i Sverige kan ha fått akuta skador, till exempel strålsjuka.

Strålning kan orsaka cancer, men i Sverige är stråldoserna från nedfallet så låga att de inte nämnvärt kommer att påverka den totala cancerrisken. Detta gäller också i de områden som har fått mest nedfall.

Vi kan vänta oss att de stråldoser vi får från nedfallet kommer att orsaka något hundratal dödsfall i cancer under de närmaste 50 åren i Sverige. Under samma tid väntas cirka 1 miljon människor i vårt land avlida i cancer av andra orsaker.

De extra cancerfallen kommer därför inte att kunna spåras i statistiken. Detta får dock inte hindra oss från att göra vad vi kan för att hålla stråldoserna nere.

Foster och spädbarn

Allvarliga fosterskador kan uppstå vid höga stråldoser. Inga fosterskador är kända vid så låga stråldoser som Tjernobylolyckan gett.

Gravida kvinnor bör, som en försiktighetsåtgärd, följa givna kostråd så att deras och därmed fostrets stråldos från maten under graviditeten inte uppgår till 5 mSv. Motsvarande stråldoser förekommer i andra sammanhang, till exempel i bostäder och anses inte leda till någon nämnvärd riskökning.

Kostråd kan man få hos mödra- och barnhälsovården.

Bröstmjölk har låga halter av radioaktiva ämnen. Därför bör man amma som vanligt.

Ärftliga skador

Strålning kan påverka könsceller. Om en skadad könscell ger upphov till ett barn kan detta få en ärftlig skada. Denna risk bedöms vara mindre än risken för cancer på grund av nedfallet.

Du behöver inte oroa Dig

Du behöver inte göra någon hälsoundersökning på grund av olyckan i Tjernobyl. Det finns ingen i Sverige som har fått så stor extra dos att det finns skäl att göra en sådan undersökning.

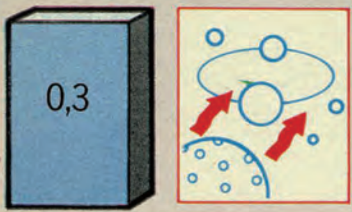
Kärnkraftsolyckan har emellertid orsakat oro, en oro som i sig kan vara ett hälsoproblem.

Om man är orolig behöver man någon att tala med. Familjen, släktingar, grannar och goda vänner kan vara ett bra stöd.

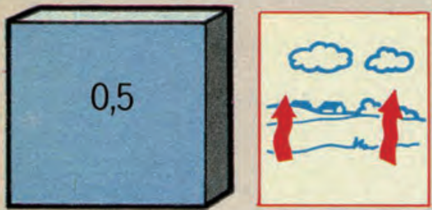
Inom hälso- och sjukvården finns det människor som har särskild utbildning i att hjälpa. Ta kontakt med dem om Du är mycket orolig.

Vår strålmiljö.

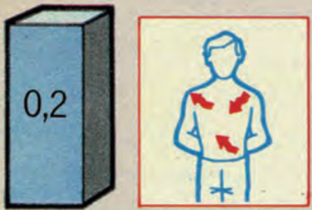
Strålning av det slag som kan skada levande celler finns överallt i vår miljö. En person i Sverige får i genomsnitt en stråldos av cirka 5 mSv varje år. Större delen av den kommer från naturliga strålkällor. Resten kommer från källor som vi själva skapat.



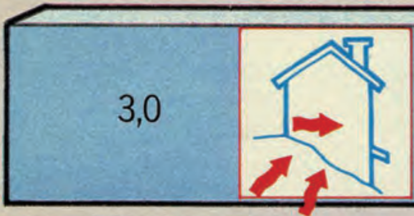
Från världsrymden och solen
Större delen av denna strålning tas upp av atmosfären runt jorden. Stråldosen är dubbelt så stor på 1 500 meters höjd som vid havsytan. På ungefär 10 km höjd är stråldosen cirka 20 mSv per år.



Från marken
Strålning kommer också från radioaktiva ämnen som förekommer naturligt i marken. Stråldoserna varierar mellan 0,2 mSv och 0,9 mSv per år, beroende på hur berggrunden är sammansatt.

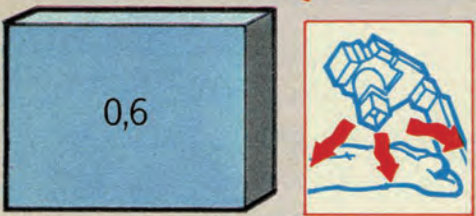


I Din kropp
Människokroppen innehåller flera radioaktiva ämnen, bland annat kalium-40 och kol-14. Aktiviteten av dessa ämnen i människokroppen är cirka 100 Bq/kg, dvs cirka 7000 Bq i hela kroppen.

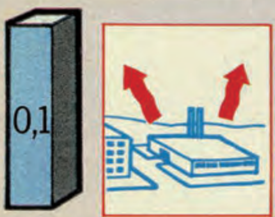


Från radon i hus
Radon är en radioaktiv gas. Den bildas när radium, som finns i marken, faller sönder. Radon från marken och från byggnadsmaterial kan samlas i hus som är dåligt ventilerade.

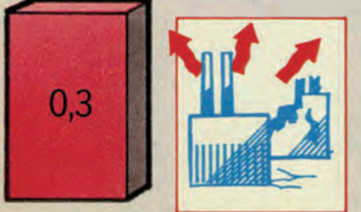
Den genomsnittliga stråldosen i svenska bostäder kan ligga mellan 2 och 7 mSv per år.



Inom sjukvården
Var tredje person i Sverige går varje år genom någon form av röntgenundersökning. En magröntgen ger en stråldos på cirka 1 mSv. En vanlig tandröntgenbild ger cirka 0,03 mSv.



Från andra konstgjorda källor
Det finns många andra konstgjorda källor, till exempel radioaktiva ämnen som används inom industrin och utsläpp från kärnkraftverk i normal drift.



Efter Tjernobyl
Det nedfall vi fick efter olyckan ger år 1986 ett extra bidrag på cirka 0,3 mSv i genomsnitt, livsmedlen inräknade. I de mest utsatta områdena kan det dock finnas människor som får upp till 5 mSv i extra dos. Du kan själv påverka den del som kommer från livsmedel.

Det här hände i Tjernobyl.

Enligt rapporter från Sovjet gjorde teknikerna natten mellan den 25 och 26 april 1986 ett experiment vid reaktor nr 4 i Tjernobyl innan reaktorn skulle ställas av för den årliga översynen. Då effekten var låg gjorde de ett prov med en elgenerator.

De som gjorde provet bröt mot säkerhetsföreskrifterna. System som automatiskt ska stoppa reaktorn om något går fel hade kopplats bort. Följden blev att man tappade kontrollen över reaktorn.

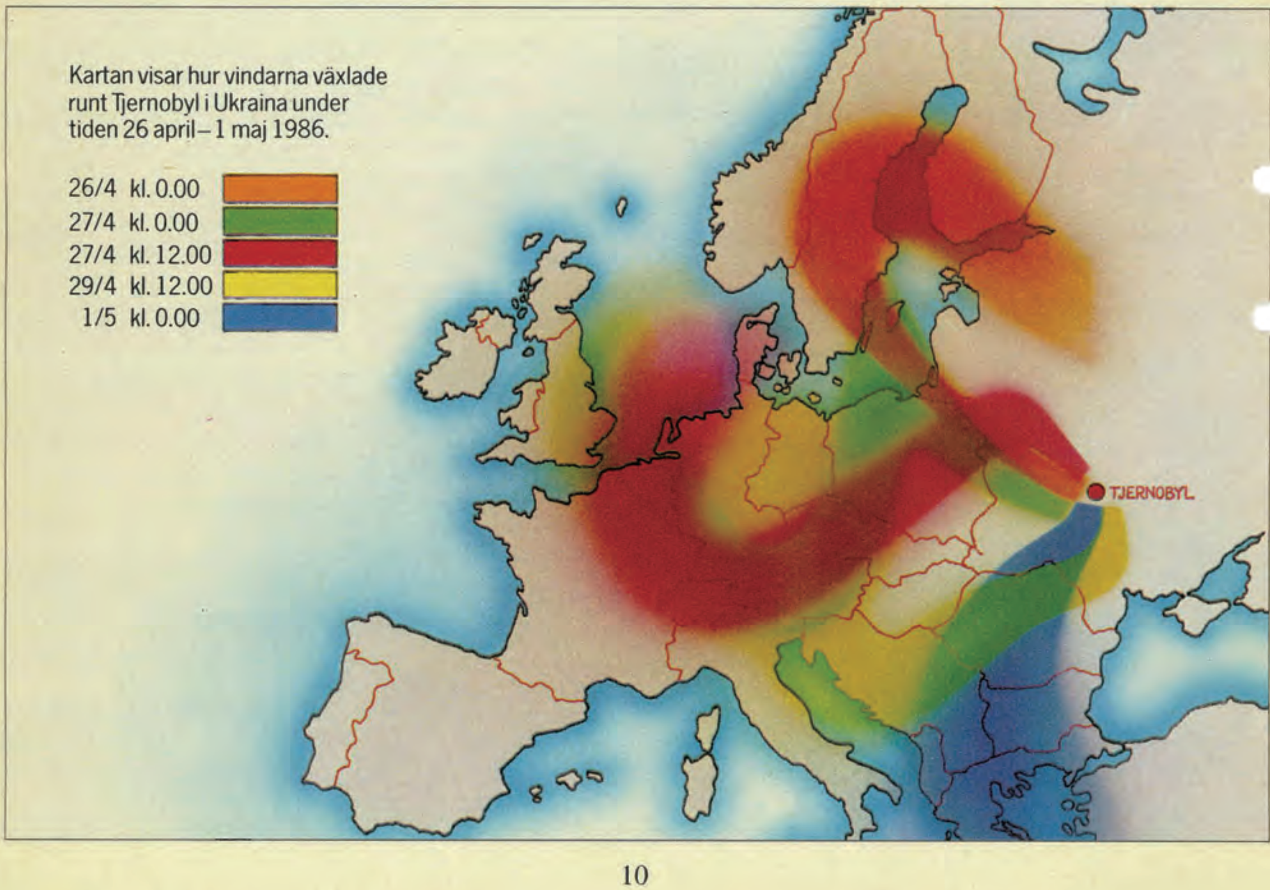
Reaktorn skenade, och på några få sekunder hade för mycket och för het ånga bildats. Av trycket sprängdes reaktorhärden sönder. Explosioner förstörde reaktorbyggnaden. Delar av den förstörda härden kastades upp i luften. Det mesta av de radioaktiva ämnena föll ned i närheten av reaktorn. Av hettan lyftes en del radioaktiva ämnen cirka 1200 meter upp i luften.

I reaktorer av denna typ finns grafit. Denna fattade eld. Grafitbranden spred ytterligare radioaktiva ämnen till omgivningen. Först efter tio dagar hade man kontroll över utsläppen. Man räknar med att några procent av reaktorns totala innehåll av radioaktiva ämnen släpptes ut i luften. Den havererade reaktorn byggs nu in i betong.

Enligt den ryska haveriutredningen utlöstes olyckan av flera oförsvarliga brott mot säkerhetsbestämmelserna. Det snabba och våldsamma olycksförloppet hängde i hög grad samman med reaktorns konstruktion. Kärnkraftverk med denna reaktorkonstruktion finns endast i Sovjetunionen. I de flesta andra länder är reaktorerna inneslutna i byggnader av betong och stål.

Följderna för Sovjets del blev stora. Ett trettiotal människor har hittills avlidit. Över 200 människor blev allvarligt strålskadade. Cirka 135 000 människor var tvungna att lämna sina hem. Det är osäkert om de kan flytta tillbaka.

Olyckan får också följder på sikt. Man räknar i Sovjet med att få flera tiotusentals extra dödsfall i cancer under de närmaste 50 åren.



Så här mäter vi aktivitet och stråldos.

Strålskyddsinstitutet och Försvarets forskningsanstalt, FOA, har mätstationer som sedan lång tid tillbaka fortlöpande registrerar strålning. FOA har dessutom i många år gjort reguljära mätningar av radioaktiva ämnen i luften med hjälp av Lansenplan från flygvapnet. Vid kärnkraftverken har man ständigt mätningar av strålningen i omgivningen. Mätningar av det här slaget gav oss en tidig bild av omfattningen av nedfallet.

Så fort det blev klart att strålnivån ökat

Strålningen från nedfallet mättes av många och på flera sätt. Mätningarna utfördes bland annat av Sveriges Geologiska AB, FOA, Studsvik Energiteknik AB, kärnkraftverken, de radiofysiska institutionerna, lantbruksuniversitetet och strålskyddsinstitutet.

startade strålskyddsinstitutet speciella mätningar. De gjordes med hjälp av flygplan, helikoptrar och bilar. De olika typer av kvalificerade instrument vi använde är mycket känsliga och noggranna, och det växte fram en tydlig bild av läget.

Efter några dagar visste vi både vilka ämnen som ingick i nedfallet och vilka mängder det handlade om.

Mätningar av aktivitet i luft, från marken och i livsmedel kommer att ske fortlöpande framöver. Hur mycket aktivitet det finns i livsmedel mäts med speciell utrustning.

Det går också att mäta hur mycket radioaktiva ämnen det finns i en människa. Då använder man så kallade helkroppsmätare.

I många år kommer vi att följa hur vår strålmiljö har förändrats efter olyckan. Vi kommer också att noggrant följa de radioaktiva ämnenas vandring i naturen.

Mer om halveringstid

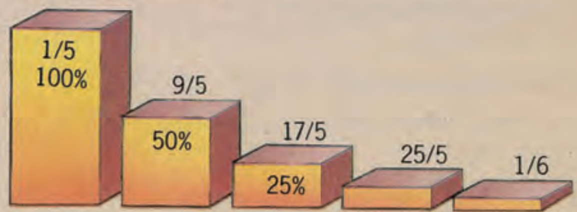
Halveringstiden för ett radioaktivt ämne är den tid det tar tills hälften av aktiviteten finns kvar.

Radioaktiv jod-131 har halveringstiden 8 dygn. Efter ytterligare 8 dygn är det kvar hälften av hälften, alltså en fjärdedel.

Cesium-137 har 30 års och cesium-134 två års halveringstid.

De flesta ämnen omsätts fortlöpande i kroppen. Så sker också med kalium och kalcium. Mängden cesium, som följer kalium, halveras i en människa på ungefär 3 månader. Denna omsättning kallas biologisk halveringstid. Om inte nytt cesium kommer in i kroppen minskar halten ganska snabbt.

Strontium, som följer kalcium, omsätts mycket långsamt. Den biologiska halveringstiden är något tiotal år. Strontium stannar därför mycket längre i kroppen än cesium.



Radioaktiv jod har halveringstiden 8 dygn. Den aktivitet som fanns den 1 maj 1986 var i stort sett försvunnen efter ett par månader.

Vår beredskap mot kärnkrafts-olyckor.

Information till hushållen
Broschyren finns i Invandrartidningens novemberspecial på engelska, tyska, franska, spanska, polska, serbokroatiska, grekiska, arabiska, italienska, finska, turkiska samt på lätt svenska. På invandrarbyrån finns dessutom en förkortad version på isländska, kurdiska, persiska, rumänska, tigrinja, ungerska och vietnamesiska.

Räddningsverket leder och bygger ut räddningstjänsten för hela landet. I den ingår också beredskap mot kärnkraftsolyckor. Den är särskilt utbyggd i de fyra län där det finns kärnkraftverk. Det är i Malmöhus län, Kalmar län, Hallands län och Uppsala län.

Runt varje svenskt kärnkraftverk finns det en inre beredskapszon. Den sträcker sig 12–15 km ut från verket. Om det inträffar något som kan ge stora utsläpp av radioaktiva ämnen larmas befolkningen inom denna zon med sirener och telefoner.

Sirenerna ger signalen "Viktigt meddelande – lyssna på P3!" Information om vad som hänt och vad man bör göra lämnas av länsstyrelsen i P3.

Länsstyrelsen leder räddningstjänsten där bland annat brandförsvaret, polisen, kommunen, sjukvården och kustbevakningen medverkar.

Strålskyddsinstitutet och kärnkraftinspektionen, som är statliga tillsynsmyndigheter, medverkar i denna organisation. De har en utbildad och samtränad organisation, som var basen för verksamheten efter Tjernobylolyckan.

Signalen "Viktigt meddelande – lyssna på P3!" kan ges i de flesta städer och samhällen över hela landet.

7 sek	14 sek	7 sek	14 sek

Signalen provas kl 15.00 den första måndagen i mars, juni, september och december.

Olyckan i Tjernobyl har visat att vi behöver öka vår beredskap mot kärnkraftsolyckor i Sverige.

Därför kommer den nuvarande beredskapsorganisationen att ses över, och viss beredskap mot kärnkraftsolyckor kommer att införas i alla län. Det landsomfattande system för mätning av strålning som redan finns ska byggas ut.

Det ska träffas internationella överenskommelser om snabb spridning av information om en kärnkraftsolycka inträffar.

Har du idéer eller frågor?

Denna broschyr ger svar på frågor som många har ställt. Om Du har idéer eller frågor kan Du vända Dig bland annat till:

Länsstyrelsen
Beredskapen vid olyckor. Användning av jodtabletter. Jakt och fiske. Länsveterinärerna svarar på frågor om livsmedelshygien och djurhållning

Miljö- och hälsoskyddsnämnden i kommunen
Strålning i yttre miljö, bostad och livsmedel

Mödra- och barnhälsovården
Medicinska frågor om graviditet och barn

Vårdcentraler och sjukhus
Medicinska frågor

Lantbruksnämnden
Frågor om jordbruk, yrkesmässig trädgårdsodling och renskötsel

Yrkesinspektionen
Frågor om arbetsmiljö

Statens strålskyddsinstitut
Box 60204
104 01 STOCKHOLM

I samarbete med Arbetarskyddsstyrelsen, Invandrarverket, Kärnkraftinspektionen, Lantbruksstyrelsen, Livsmedelsverket, Länsstyrelsen i Hallands län och Kalmar län, Naturvårdsverket, Räddningsverket och Socialstyrelsen.

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