CHERNOBYL - 20 YEARS AND BEYOND

In commemoration of the Chernobyl accident 20 years ago, the French Society for Radiation Protection (SFRP) and the Belgian Society for Radiation Protection (BVSABR) organise jointly a one day colloquium in Brussels.

DATE :
Friday 24th March 2006

LIEU :
Brussels

COLLOQUIUM PROGRAMME

Session 1: technical and organisational aspects
Chairman : J.F. Lacronique, President of the Board of Directors IRSN, F

Chernobyl, the accident scenario and its global impact
F. Deconinck, President of the Board of Directors SCK • CEN, B
(in memoriam P. Govaerts, General Manager of the SCK • CEN Research centre)

International environmental radioactivity information exchange: the Chernobyl experience
M. De Cort, Institute for Environment and Sustainability, DG JRC, EC

The EU assistance to mitigate the Chernobyl accident consequences
JP. Joulia, Head of the Nuclear Safety Unit, Europaid Co-operation Office, EC

Crisis communication, crisis management: lessons learned
Dr. A.H. Dal, former Crisis Management Director for the Min. of Housing, Spat. Pl. and Env., NL

Session 2: medical and humanitarian aspects
Chairman : C. Eggermont, Programme for Integration of Social Aspects (PISA), SCK•CEN, B

The Chernobyl Forum: findings and recommendations –

Prof. M. Balonov, Head of the Radioactive Discharges Unit, International Atomic Energy Agency

Thyroid cancer after Chernobyl accident
Prof. J. Kenigsberg, Nat. Commission on Radiation Protection, Council of Ministry, Belarus

Health effects in the European Union
Dr. E. Hindié, Maître des Conférences des Universités, Paris, F

Psychological factors affecting health after the Chernobyl disaster
J.M. Havenaar, psychiatrist at the Vrije Universiteit of Amsterdam, Med. Centre, Dpt. Of Psychiatry, NL,

Chernobyl

The accident scenario and its global impact

Frank Deconinck

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Chernobyl reactor 4

- graphite moderated light water reactor (RBMK) with an output of 1000 MWe
- pressure tubes boiling water reactor with direct steam feed to the turbines
- positive void coefficient at low power: emergency cooling pumps required in case of a power failure
- control bars have voids

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The accident

- planned test
- Friday 25 April
- Saturday 26 April
- the explosion
- main causes

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The test

- in case of a power failure, emergency generators start after a few seconds
- the test was to check if the inertia of the turbines provides enough power to keep the cooling pumps operational during the time required to start the emergency generators
- this required the emergency cooling system to be disconnected

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Friday April 25

- 01.00 a.m.: the operators decrease the power of the reactor
- 02.00 p.m.: the reactor runs at half power
- 11.00 p.m.: decision to start the test. Due to an error, the power is much lower than normal. The operators try to increase the power by lifting many more control bars than allowed (only 6-8 remain, rather than an absolute minimum of 30 out of 211).

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Saturday April 26 1/2

- 01.22 a.m.: start of the test. The reactor operates in non-authorised conditions. The operators switch off the safety mechanism that should stop the reactor in case of loss of steam supply to the turbine
- 01.23.04 a.m.: turbines shut down, cooling pumps stop. The steam content in the tubes increases. The reactor power increases rather than decreases due to the positive void coefficient

Saturday April 26 2/2

- 01.23.40 a.m.: attempt to manually stop the reactor by releasing the control bars. The control bars take about 20 s to reach the core, and their design is such that reactivity increases during the first seconds (voids). Fuel elements start breaking apart.
- Power in fuel increases from 200 MW to 300.000 MW in seconds

The explosion

- 01.23.47 a.m.: shocks felt and explosions heard: steam explosions destroy the reactor core and blow the roof off the reactor building. Fires start all over the place. The worst civil nuclear accident just occurred.
- 01.28 a.m.: the first fireman arrive
- 02.30 a.m.: the largest fires are under control
- 05.00 a.m.: the graphite fire starts...

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Main causes

- unsafe and unstable reactor design
- suitable for Pu production: restricted safety mechanisms
- political and military context in the former Soviet Union
- no safety culture
- chronic lack of training and knowledge by operators
- accidents officially unthinkable and secret

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Health (radiation induced)

Reducing human suffering to a number of deaths is much too restrictive, but that number is on everyone's mind

- number of casualties
  - certainly due to the accident among people who received high radiation doses
  - highly probable among people initially suffering from radiation sickness
  - estimated among rescue workers and 'liquidators'
  - estimated among the general population
- other effects

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Casualties: 'certain'

- 2 due to explosion
- in total 134 people suffered from radiation sickness
- high radiation doses: 28 within 4 months, certain;
- 19 between 1987 and 2004: highly probable (had radiation sickness)
- thyroid cancer among children: 10 (out of > 4000)
- Total: 59

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Question

- 134 people suffer from acute radiation sickness
- 28 die shortly afterwards
- remain: 106 people, of whom only 19 die over 15 y: normal death rates

How come ?

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Rescue workers, liquidators

- number between 200.000 and 600.000
- about 1000 receive doses of a few hundred mSv
- average dose around 100 mSv
- > 150 mSv: 21 cases of leukaemia: 2 x normal occurrence
- cancer increase = most probably screening effect

Estimates

- Based on best knowledge: 2000 radiation induced cancers expected over life-time
- *Question: In the model used, which normal life expectancy was assumed for the workers ? The current numbers in Ukraine or Belarus are now as low as 60 – 65 y for adult males. Many solid cancers may not have the time to develop before those ages.*

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The general population

- increase of thyroid cancer among children (I + Cs contamination): most probably not a screening effect: correlation with soil contamination (Belgium > 40% thyroid cancer upon autopsy)
- cataract

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Estimates

- probably based on LNT model: 2000 extra cancer deaths = 3 % of normal incidence (Chernobyl forum)

- x 33 gives ± 65.000
- normal incidence 25 % gives a population group of 250.000
- forum report: 200.000 liquidators + 116.000 evacuees + 270.000 residents = 600.000 people, not 250.000

Question

- *Question: Why the discrepancy between 250.000 and 600.000 ? Was a radiation threshold taken into account to limit the number of 'extra' exposed people?*

- If not, then even a small threshold level would strongly decrease the expected number of 2000 cancer cases.
- If yes, it would be an acknowledgement that a threshold should be taken into account.

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More questions

- *Question: is it reasonable to speak about 'extra cancer deaths' as if those people would not have died without radiation ? Would it not be better to speak about 'early cancer deaths'?*
- *Question: does an increase in cancer deaths necessarily mean a decreased life expectancy in general, or may it be that survivors live (much) longer ? Is cancer the best indicator ?*

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Social

- evacuation
- resettlement
- mental health
- privileges

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Evacuation

- April 27, 11.00 a.m.: population of Pripyat informed about evacuation. 2h30 later: farewell forever to house, friends, neighbours, cats, dogs, ...
- later extended to radius of 30 km around Chernobyl: 116.000 people
- following years: total grew to 350.000

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Psychological drama

- forced relocation gave rise to mental health problems, alcohol and tobacco abuse etc..., in what the Chernobyl forum reports as **"the largest public health problem unleashed by the accident today"**.
- resettlements: exclusion of 'contaminated strangers'

- *Question: If we can understand that the first evacuations had to be decided in a situation of emergency, what other reasons led to the evacuation, months or years after the accident of an extra 200.000 residents ?*

Privileges, disabled status

- 7.000.000 people receive some privileges
- 100.000 are considered disabled
- 5 - 7 % of public spending in Ukraine, Belarus

- *Question: how many people are objectively entitled to specific support, and how many have obtained this through less acceptable channels, or simply to survive as their poverty is unbearable ?*

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Environment

- geographical aspects
- countermeasures
- wildlife
- water

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Geographical aspects

- 4300 km^2 forbidden zone
- 7000 km^2 rather strongly Cs contaminated
- in inhabited zones: remaining radioactivity responsible for < 1mSv/y/person

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Countermeasures

- many other factors than public health (economics, politics,...)
- Becquerel versus Curie !
- decision taking process: difficulty for experts to communicate with authorities, and for authorities to know to which expert to listen

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Wildlife

- malformations in first generation
- no obvious hereditary effects
- blooming biodiversity: no human predators !

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Water and ecosystems

- contamination of groundwater and downstream water eco-systems, on top of industrial pollution

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Regulations

- IAEA, EURATOM, ICRP, ...
- major change in safety approach. The world is much safer now (nuclear and non-nuclear)
- public perception: strong regulations = great danger !

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Nuclear power 1970 - 2005

- Club of Rome (1972): in 2000, 900.000 nuclear MW in US...
- TMI, Chernobyl changed the scene
- green movements: nuclear = evil
- nuclear stop in West, expansion in East

Nuclear power 2006 - ?

- more objective reading
- economics
- security of supply
- CO_2

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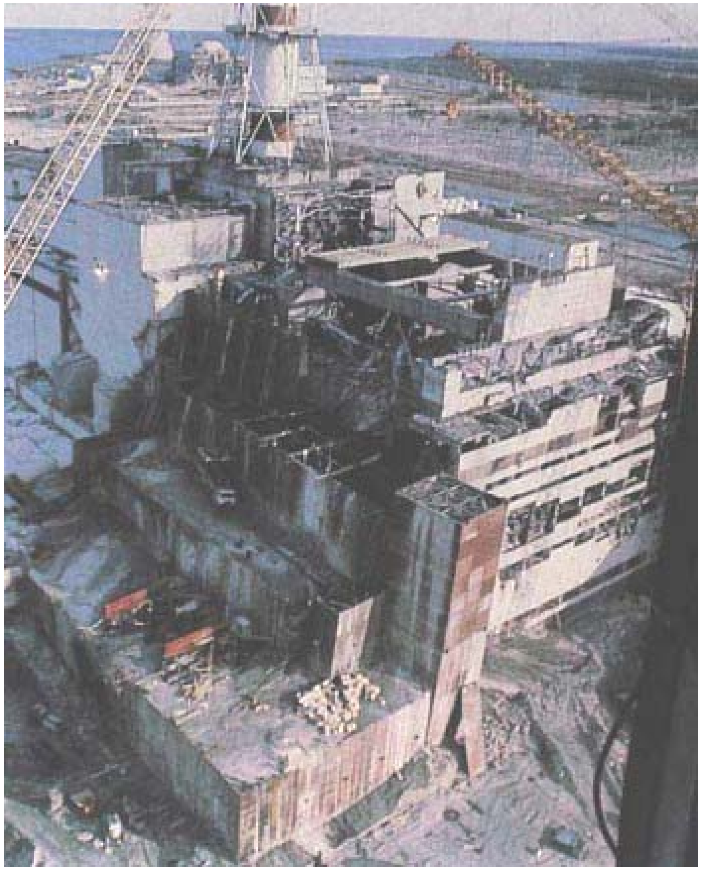
Perception

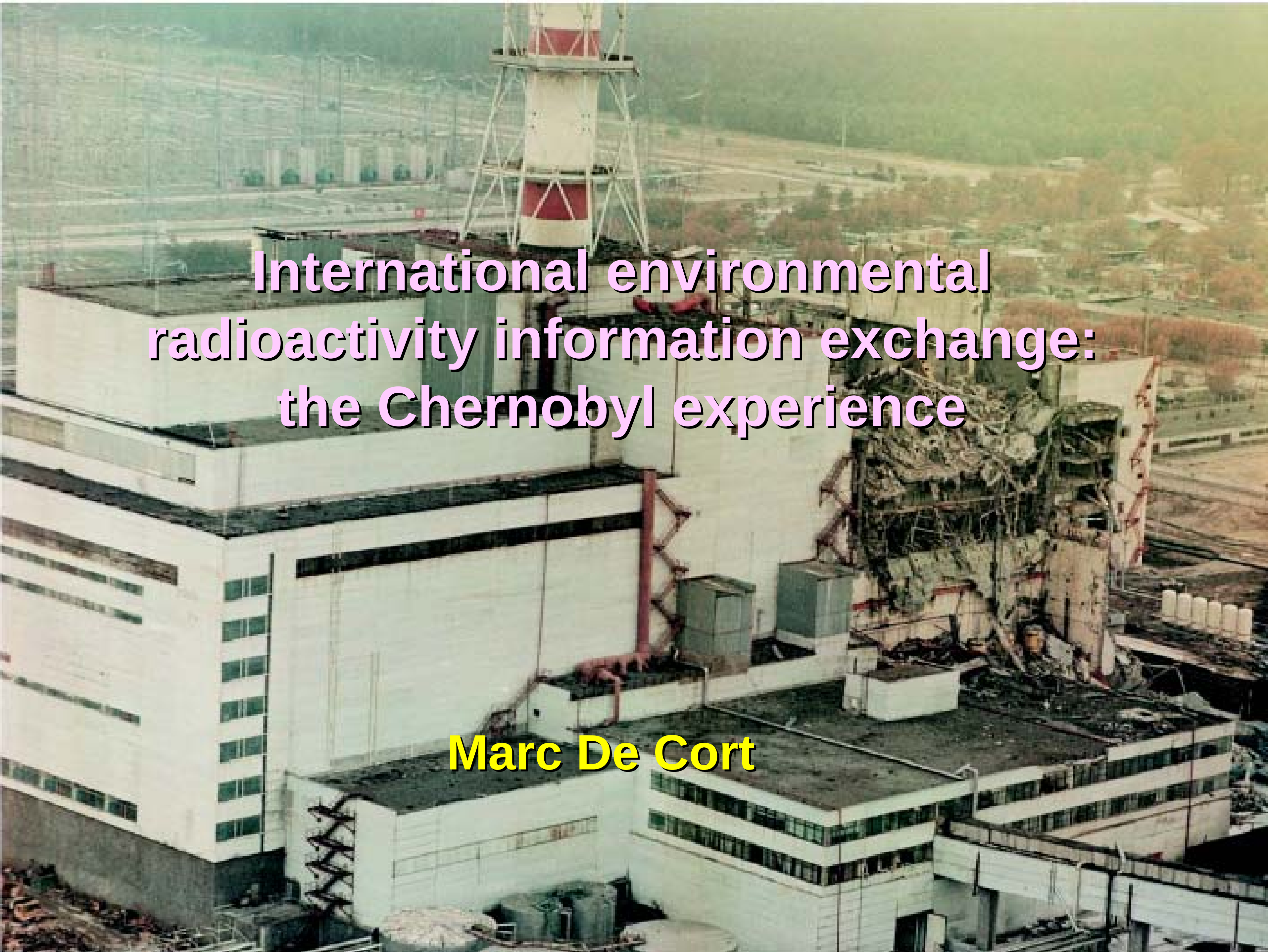
- no accident since twenty years: maturity, safety or amnesia?
- comparisons by number of casualties: public perception = feelings, not numbers
- one major accident: bye nuclear

Political

- Chernobyl allowed (or forced ?) Gorbatchov to impose glasnost. It was a catalyst in starting the chain reaction that led to the disintegration of the Soviet Union.

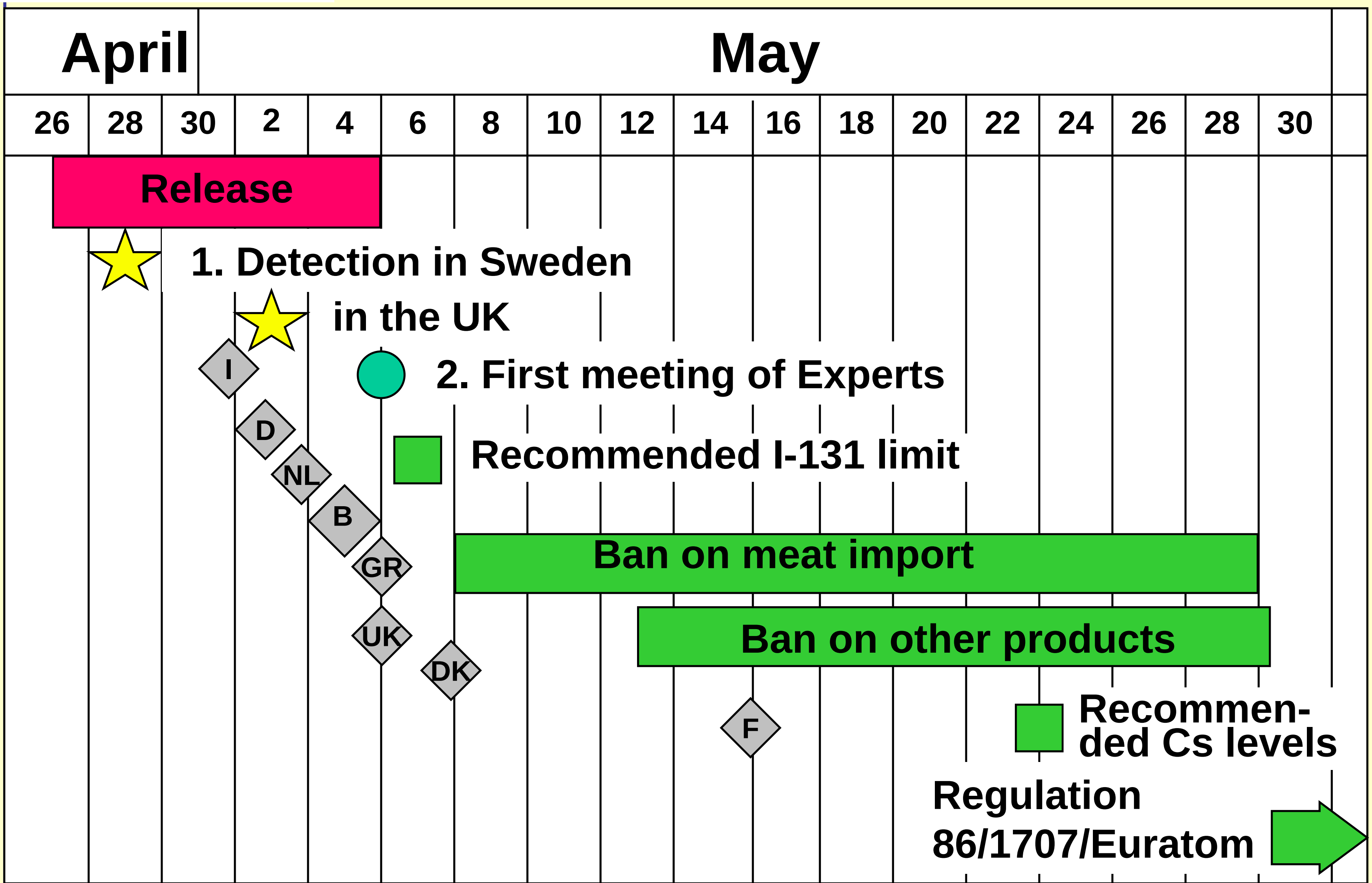
Thank you





International environmental radioactivity information exchange: the Chernobyl experience

Marc De Cort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Release
1. Detection in Sweden
in the UK
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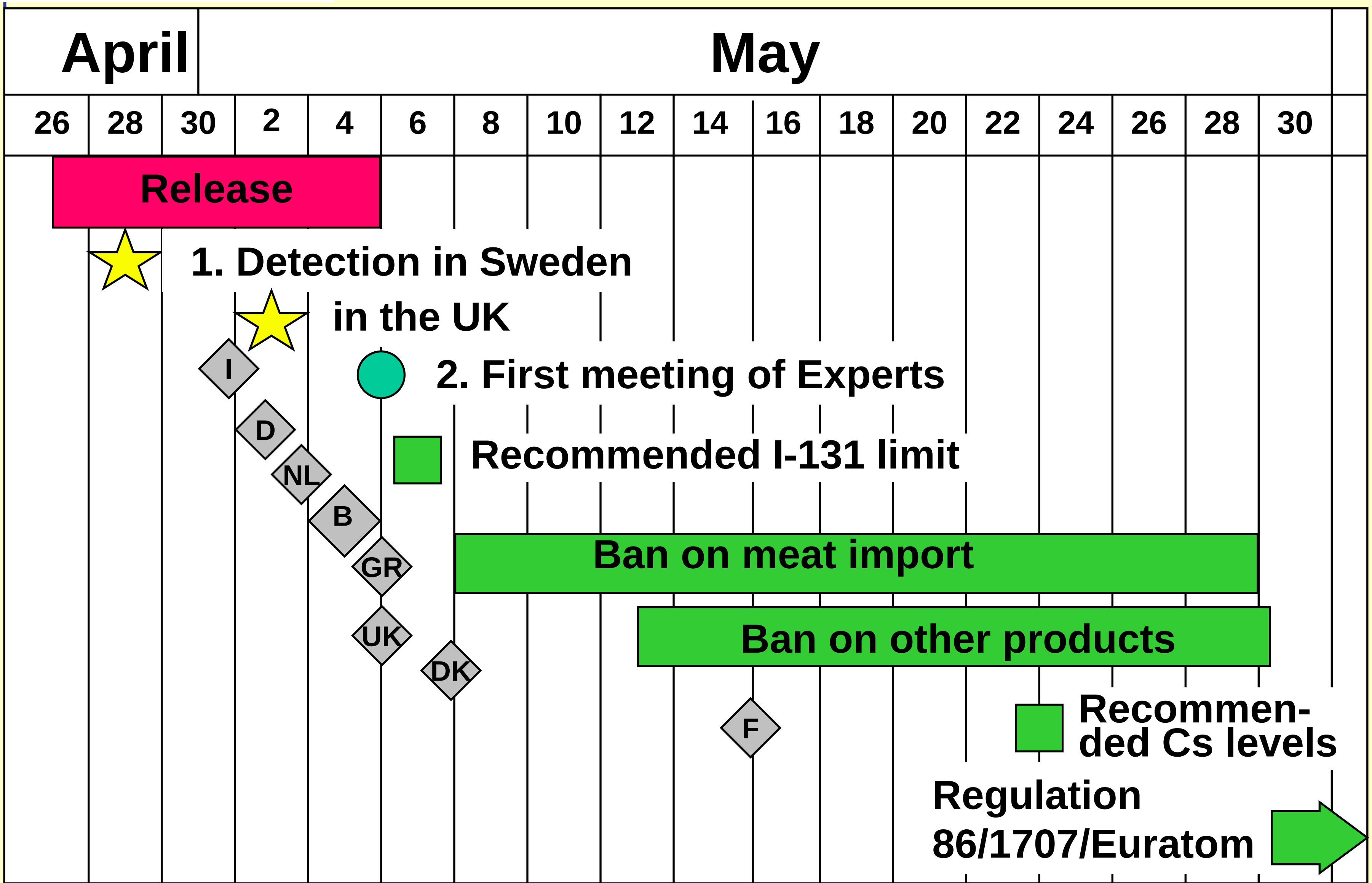
GR
UK
DK
F
2. First meeting of Experts
Recommended I-131 limit
Ban on meat import
Ban on other products
Recommen-
ded Cs levels
Regulation
86/1707/Euratom

National control measures	BE	DE	DK	ES	FR	GR	IE	IT	LU	NL	PT	UK
wash vegetables	*		*			*		*		*		
avoid vegetables						*			*	*		
250 Bq/kg vegetables		*										
1000 Bq/kg vegetables	*											
prohibit vegetables								*				
storage of food					*	*						
do not drink rainwater						*						*
500 Bq/l I Milk	*	*				*				*		
prohibit sheep and goats milk						*				*		
prohibit sheep and goats meat						*						*
no fresh fodder	*		*					*		*		
frequent washing						*						

Joint Research Centre



Institute for Environment and Sustainability

Chernobyl Regulation

- **30 May 1986**
- **Cesium isotopes**
  - **370 Bq/kg for dairy produce/babyfood**
  - **600 Bq/kg for other foodstuffs**
- **extended till 31 March 2010**

http://europa.eu.int/comm/energy/nuclear/radioprotection/index_en.htm

The role of the European Community since the Chernobyl accident

- ECURIE-Decision (87/600/Euratom)
- Information Directive (89/618/Euratom)
- Basic Safety Standards (96/29/Euratom)
- Foodstuff legislation
  - Post Chernobyl
  - In case of a future accident

http://europa.eu.int/comm/energy/nuclear/radioprotection/index_en.htm

Commission Recommendation

COMMISSION RECOMMENDATION

of 14 April 2003

on the protection and information of the public with regard to exposure resulting from the continued radioactive caesium contamination of certain wild food products as a consequence of the accident at the Chernobyl nuclear power station

(notified under document number C(2003) 510)

(2003/274/EC)

- **On health protection from certain wild food products contaminated as a result of the Chernobyl accident**
  - **game, mushrooms, berries**
  - **information to local population**
  - **restriction on placing on the market**
    - **600 Bq/kg**

http://europa.eu.int/comm/energy/nuclear/radioprotection/index_en.htm

EU maximum permitted levels in foodstuffs (future accident)

Nuclide	Reconstituted FOODSTUFFS			
	Baby food	Dairy produce	Other	Beverage
Sr-90	75	125	750	125
I-131	150	500	2000	500
Pu-239	1	20	80	20
Cs-134/137	400	1000	1250	1000

http://europa.eu.int/comm/energy/nuclear/radioprotection/index_en.htm

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Basic EC legislation

Euratom Treaty, chapter III: Health and Safety

- **Art 35:** Each MS shall establish the facilities necessary to carry out continuous monitoring of the level of radioactivity in the air, water and soil and to ensure compliance with the basic standards.

  The Commission shall have the right of access to such facilities, it may verify their operation and efficiency.

- **Art 36:** The appropriate authorities shall periodically comunicate information on the checks referred to in art. 35 to the Commission so that it is kept informed of the level of radioactivity to which the public is exposed.

http://europa.eu.int/comm/energy/nuclear/radioprotection/index_en.htm

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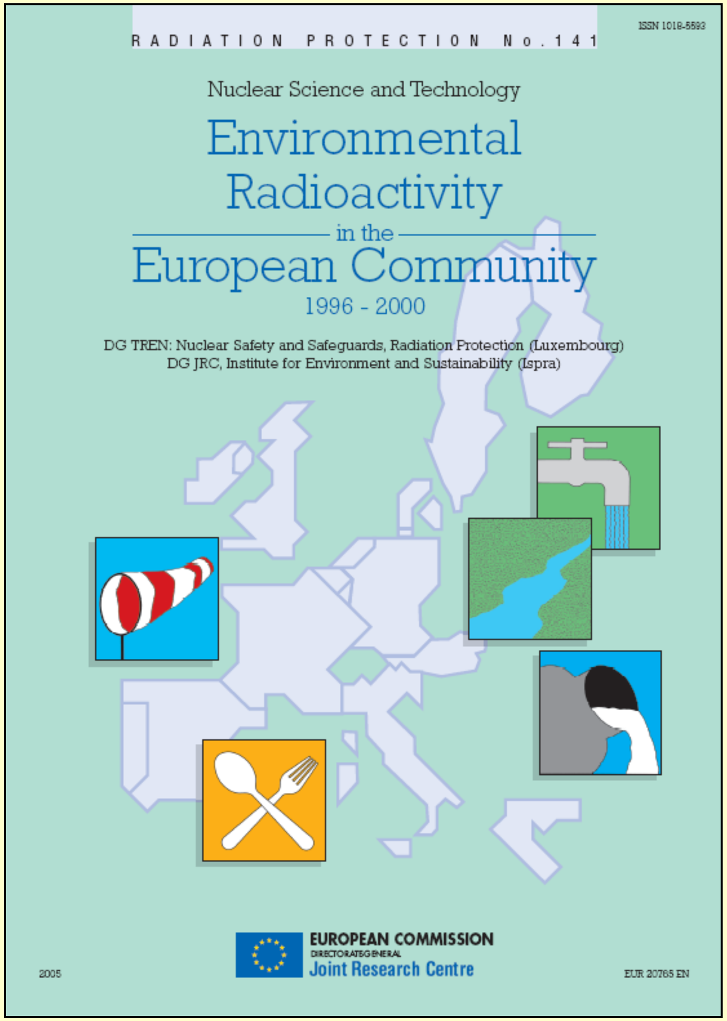
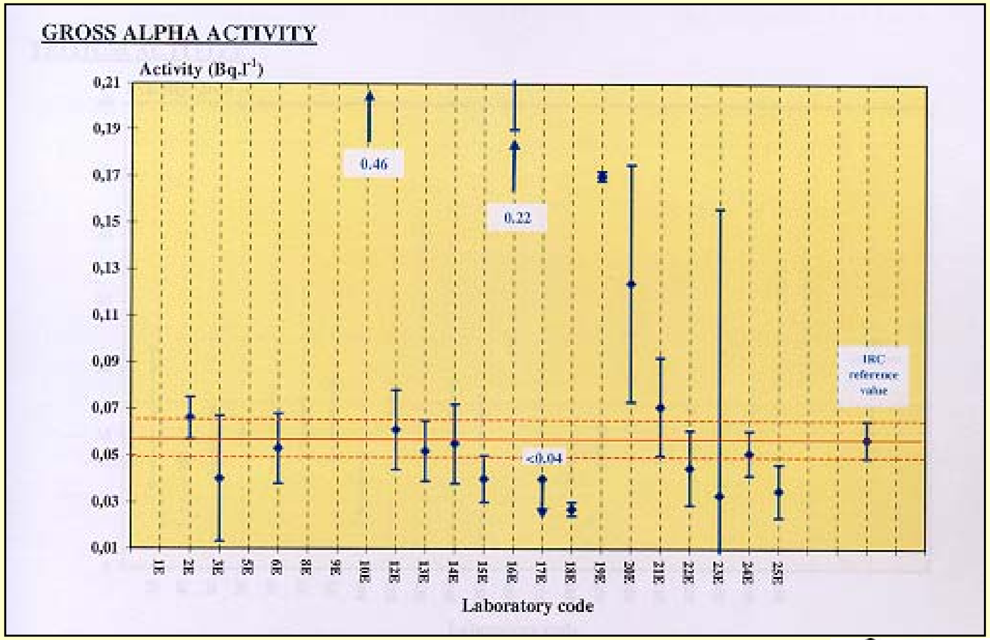
REM db + reporting:



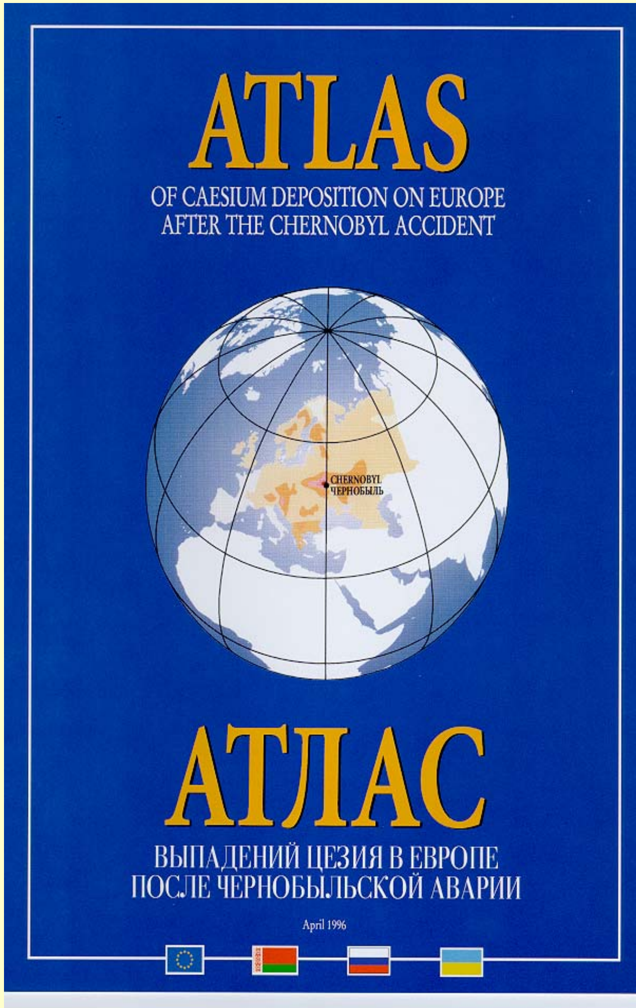
- **REMdb: > 1.8 M records from 1984 onwards**
- **On-line access *(http://rem.jrc.cec.eu.int)***
- **Standardisation of data-input**
- **input processing software (EasyProteo)**
- **Use of reporting levels**
- **international inter-comparison exercises**



Chernobyl Atlas

Objectives

- collection and harmonised storage of ^{137}Cs deposition data (± 400,000) in 31 European countries
- describe ^{137}Cs deposition patterns: use of GIS and development of spatial data analysis / geo-statistical techniques for data interpolation and presentation
- estimation of total amount of deposited ^{137}Cs
- training of CIS scientists



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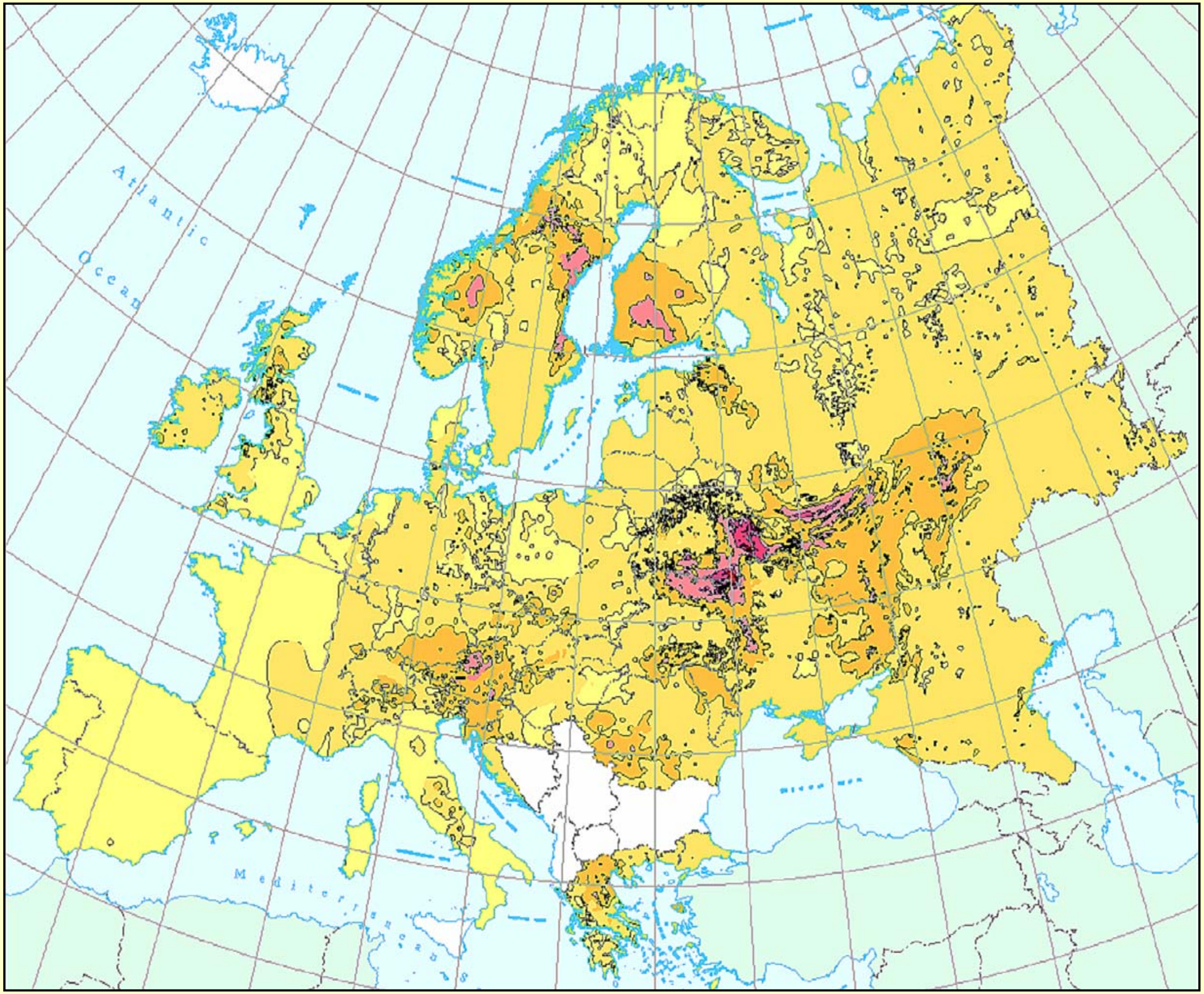
Atlantic
Ocean
Mediterranean Sea

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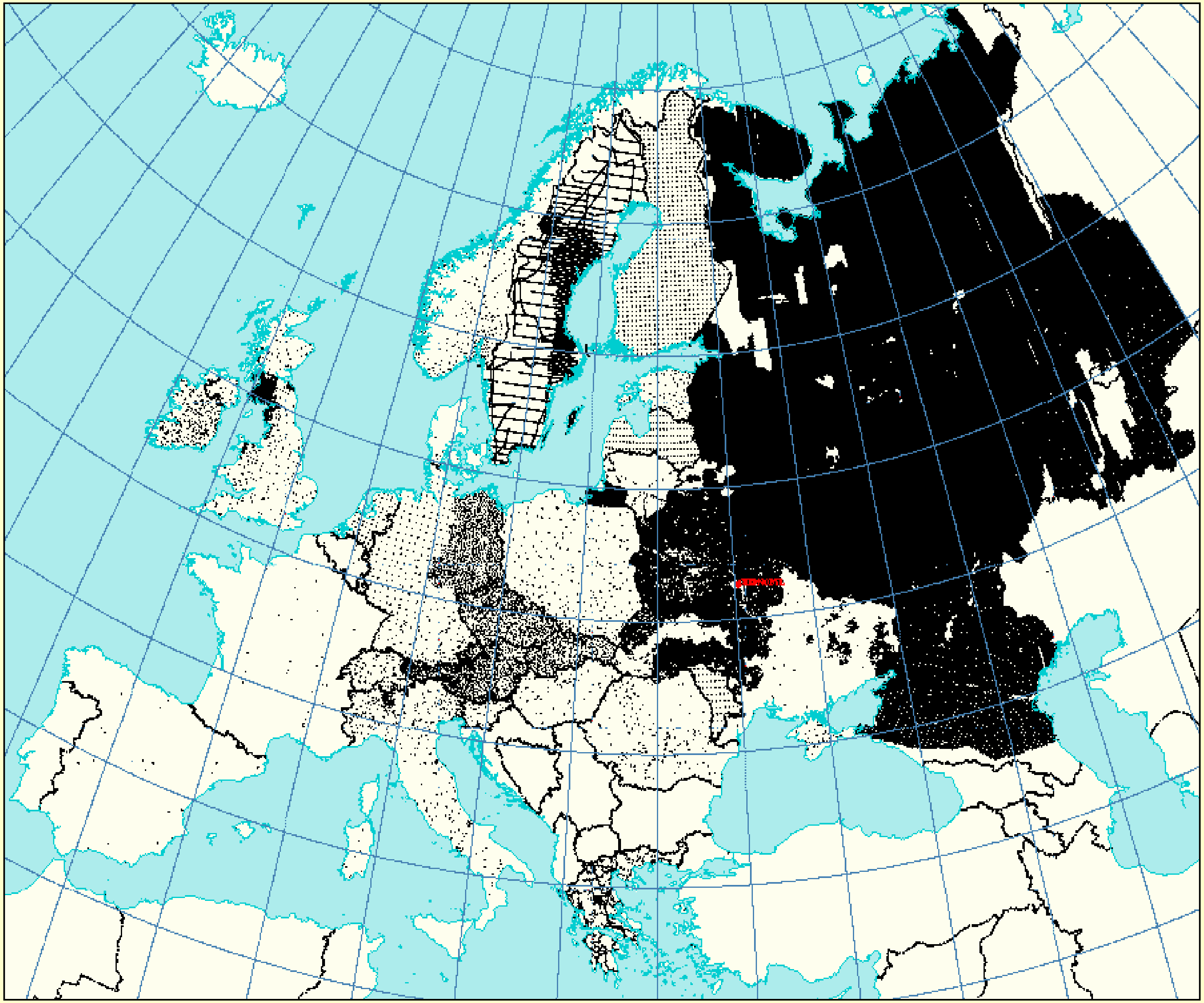


Emergency response

- **short term:**
  - immediate application of pre-established levels
  - immediate countermeasures
    - animals
    - vegetables
  - prompt communication with public
  - envisage need for correction of the levels
- **intermediate term:**
  - rapid assessment of the contaminated area (GIS)
  - evaluation of the economic impact/FAO
  - establishment of adequate restrictions
- **long term:**
  - foodstuff monitoring
  - agricultural countermeasures/food processing
  - stakeholder /consumer involvement
  - return normal

ECURIE

EC - Euratom Treaty - art 35-36
- Basic Safety Standards Directive - art. 45

IAEA - Early Notification Convention (27/10/86)
- Early Assistance Convention (26/2/87)

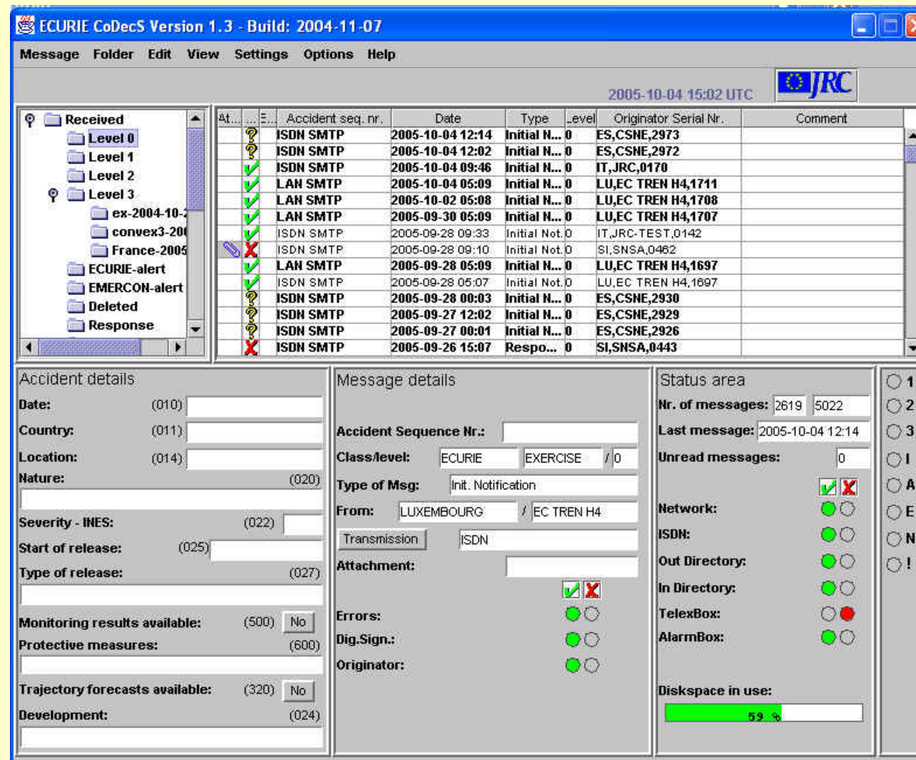
EC - Council Decision 87/600 (14/12/87)

⇩

European Commission Urgent Radiological Information Exchange (ECURIE)

European Community Urgent Radiological Information Exchange (ECURIE)

- **Early Notification system for Nuclear accidents, based on 87/600 Council Decision;**
- **24h Contact Points (EU25 + CH)**
- **Transmission of Notifications, Information and Data.**
- **Notifications are created, sent and received by the CoDecS software in use at the CP's and CA's;**
- **compatibility with IAEA**
- **Developed by REM, operated by DG TREN H.4 in Luxembourg.**



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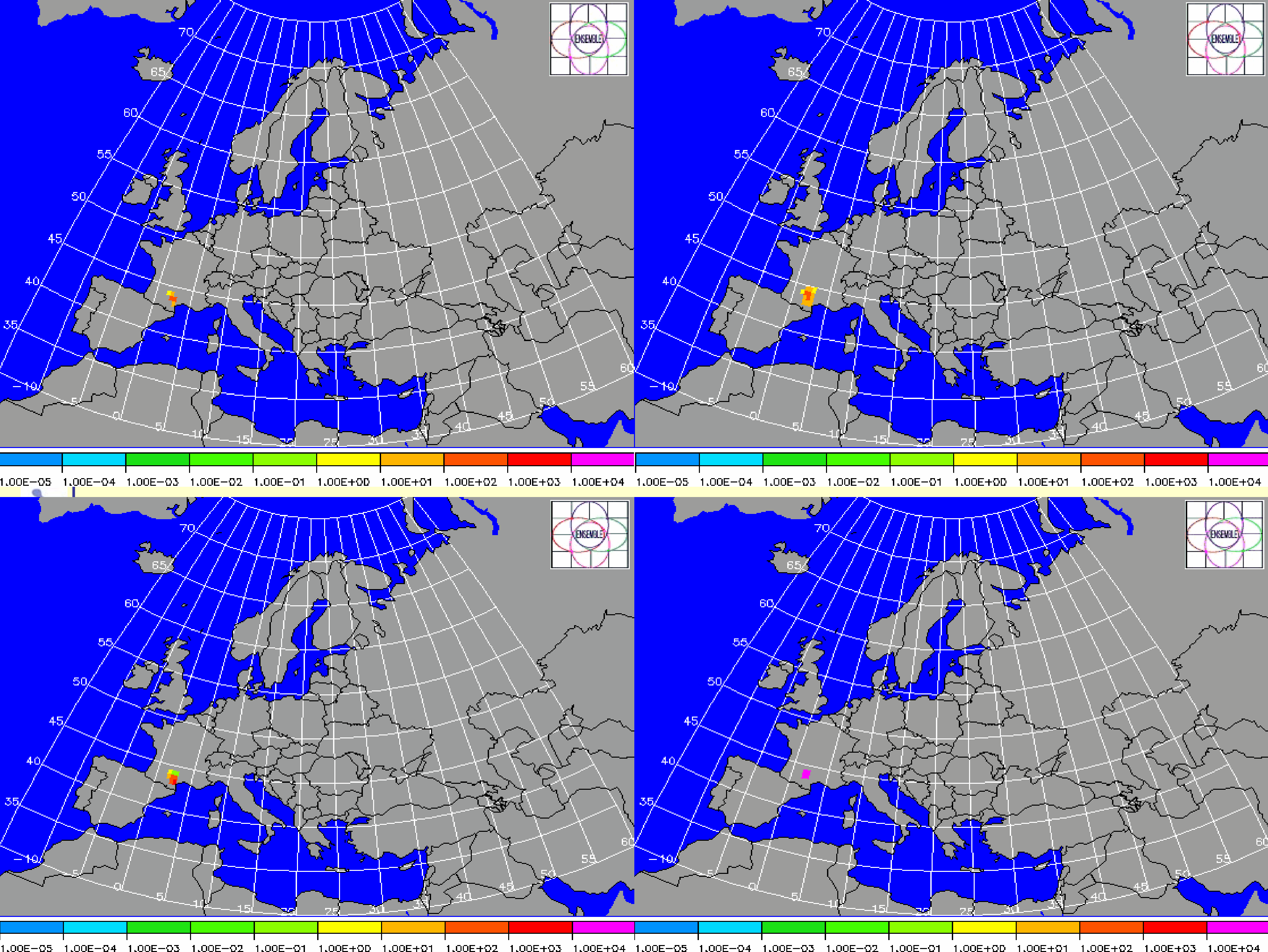
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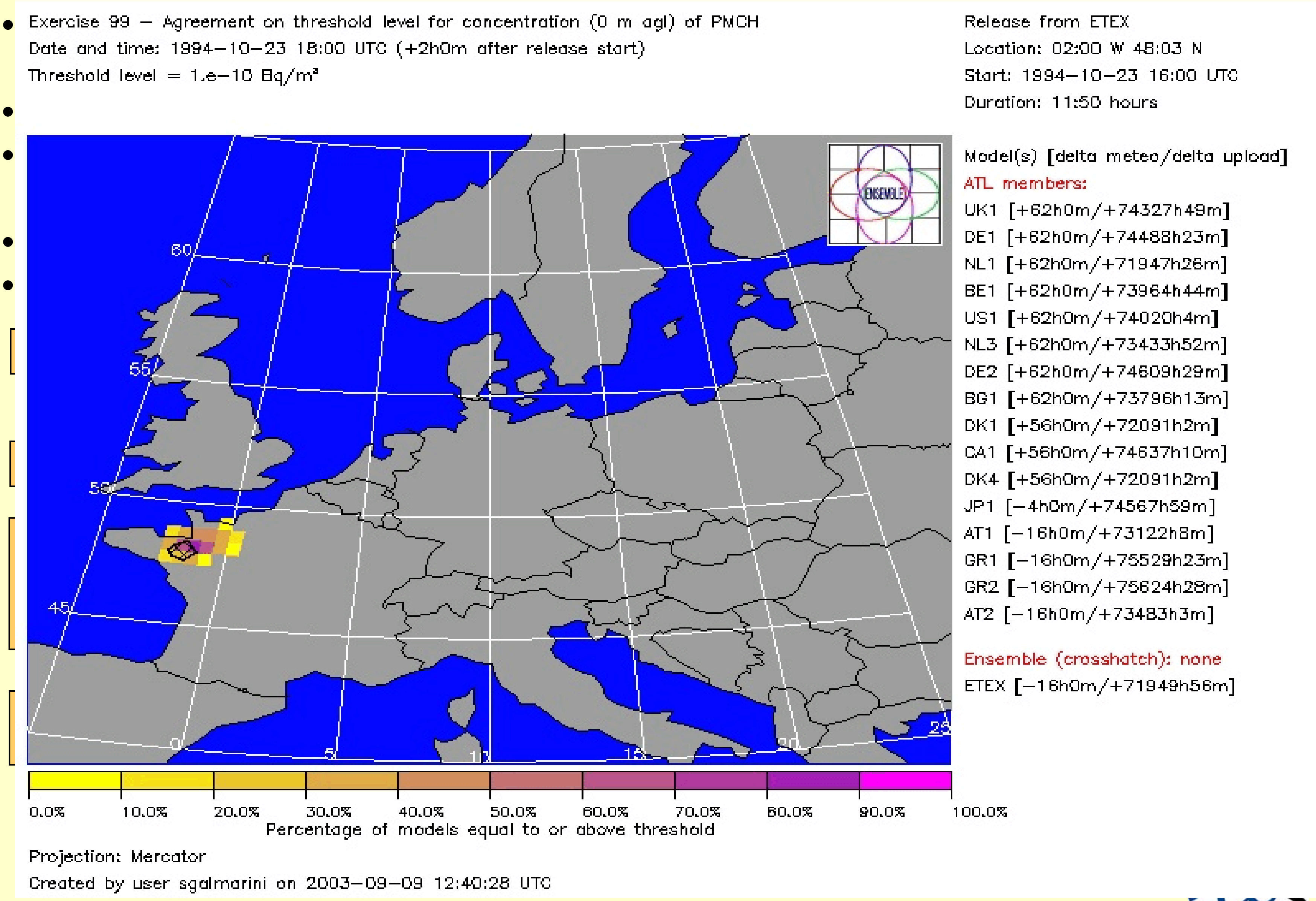
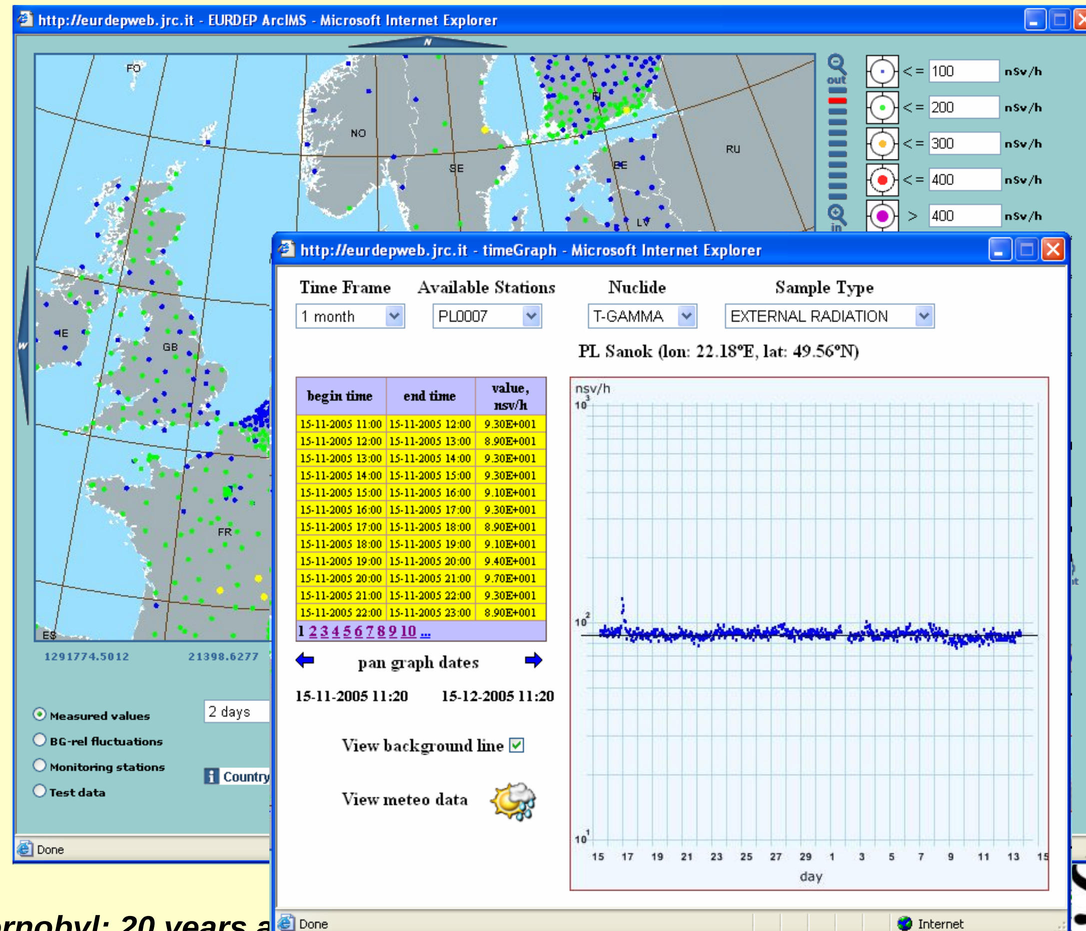
What is ENSEMBLE?



EUropean Radiological Data Exchange Platform (EURDEP)

Timely, free and continuous exchange with European countries of information relevant to the radiological situation to support nuclear emergency

- **Internationally recognized standard format for radiological data;**
- **Network (30 European countries participate);**
- **Routine (daily transmissions) and emergency (2-hourly transmissions) mode;**
- **Currently mostly γ-dose rates;**
- **Data-exchange by Email, FTP and mirroring of directories;**
- **Web-site to view and download data.**



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15-11-2005 13:00	15-11-2005 14:00	9.30E+001
15-11-2005 14:00	15-11-2005 15:00	9.30E+001
15-11-2005 15:00	15-11-2005 16:00	9.10E+001
15-11-2005 16:00	15-11-2005 17:00	9.30E+001
15-11-2005 17:00	15-11-2005 18:00	8.90E+001
15-11-2005 18:00	15-11-2005 19:00	9.10E+001
15-11-2005 19:00	15-11-2005 20:00	9.40E+001
15-11-2005 20:00	15-11-2005 21:00	9.70E+001
15-11-2005 21:00	15-11-2005 22:00	9.30E+001
15-11-2005 22:00	15-11-2005 23:00	8.90E+001

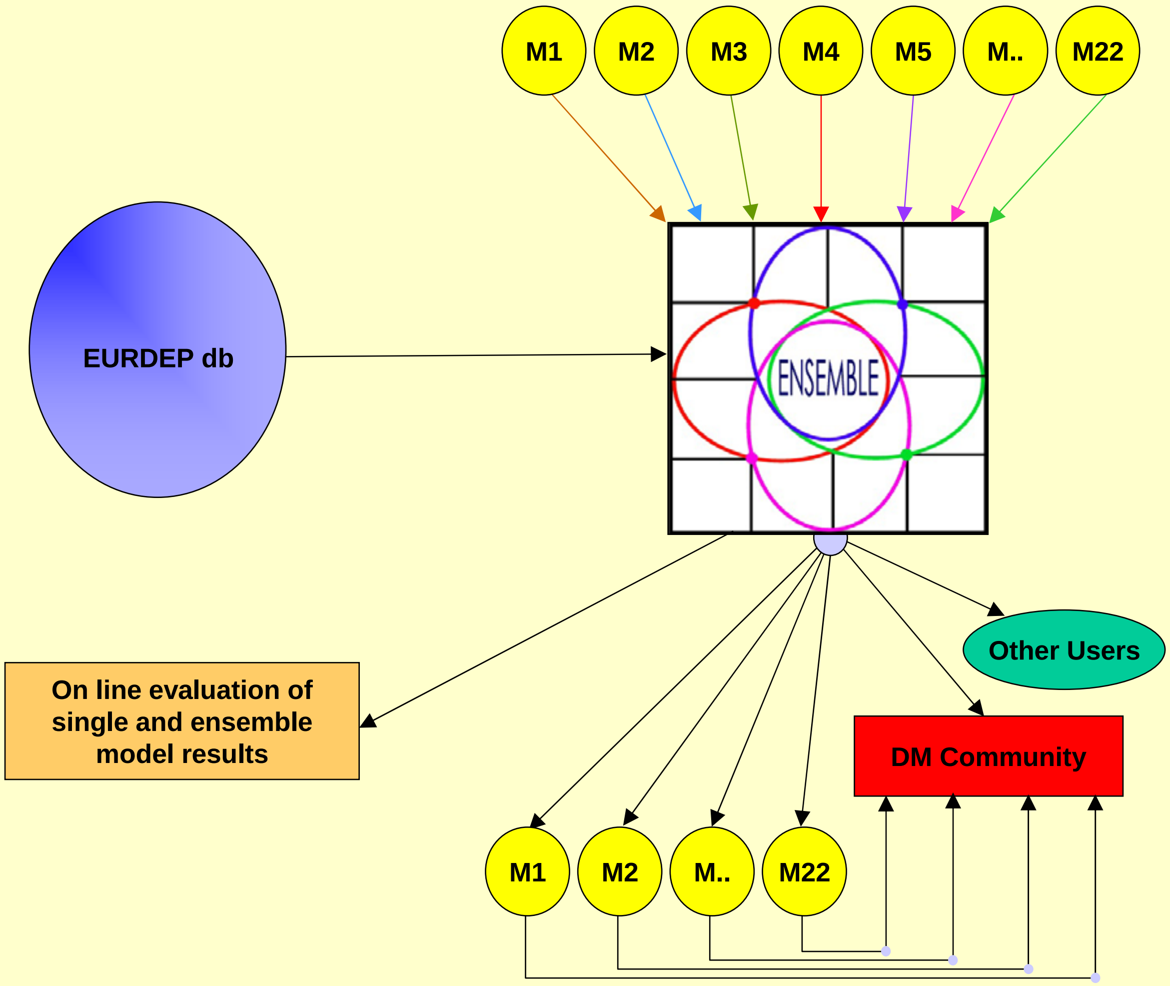
Coupling of ENSEMBLE and EURDEP

Ensemble connection to EURDEP database established and running

Model results will be presented on a geo-referenced framework including thematic layers

Web facility redesigned to accommodate new features and to a general applicability (variable domain size and positioning)

Multi-users features with varying privileges depending on the involvement



http://rem.jrc.cec.eu.int

EuropeAid Co-operation Office

Tacis Nuclear Safety

The EU assistance to mitigate the Consequences of the Chernobyl Accident

JP Joulia
Head of Unit “Nuclear Safety”
Directorate General “AIDCO
European Commission

Contents

- Past and present effort
- **Lessons Learnt**
- Conclusion

Introduction

- As the 20th anniversary of Chernobyl accident approaches the European Commission (EC) is pleased to communicate on EU efforts in relation to the Chernobyl accident.
- The Commission attaches also great importance to the efforts being made in order that the Ukrainian Nuclear Plants meet nuclear safety standards internationally recognized
- Assistance delivered through many EC Directorates: AIDCO, DEV, ECHO, ENV and RTD

EC Assistance to Ukraine 1991 -2004

EC largest donor to Ukraine

- **Total EC assistance** ~ 2.1 billion €
- **Total TACIS Assistance** 1.256 billion €

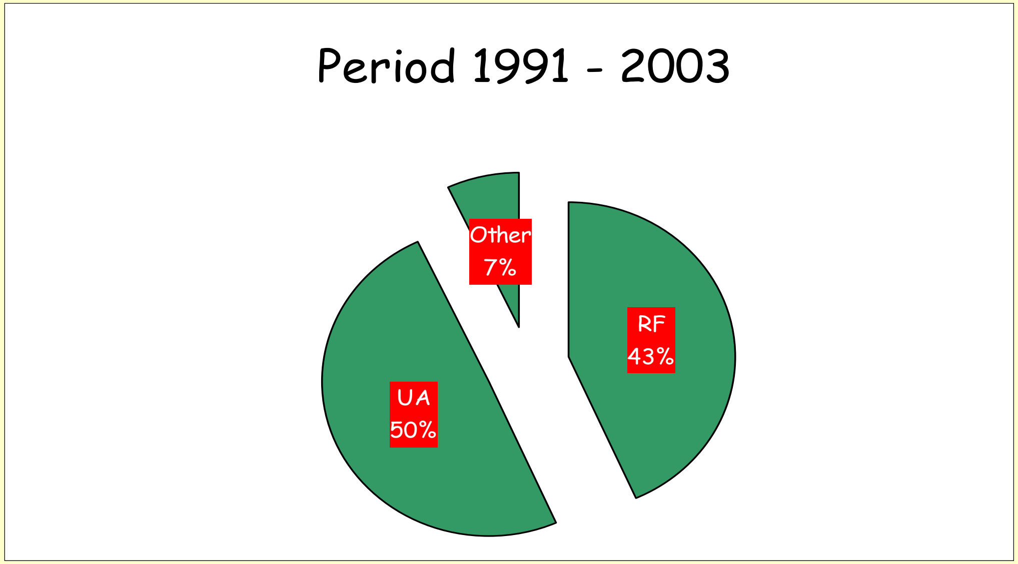
➔ Tacis National Programme: 704 M €

➔ Nuclear Safety

incl. Chernobyl and UA action Plan G7: 552 M €

TACIS Nuclear Safety Programme

Russian Federation	43,3%
Ukraine	49,7%
Other countries	7,0%



Ukraine TACIS Nuclear Safety 1991 - 2006

Total allocated funds: 552 M€

48 % to Chernobyl – 52 % to NPPs Safety

➔ Chernobyl Shelter Fund (CSF)	196 (+49)
➔ Waste Facilities in Chernobyl	20+47 (+24)
➔ Social impact of Chernobyl	12.5
➔ Assistance to the Nuclear Power Plants	167
➔ Assistance to Regulators and Design Safety	96
➔ Support to K2R4 NPPs	40

EU contributions to Chernobyl Shelter Fund

➔ **Chernobyl Shelter Fund (CSF) – International donors fund managed by the EBRD**

- Shelter Implementation Plan - initial stages and tasks: **5 M €**
- New safe Confinement (NSC): international pledging conferences of New York (11/1997) and Berlin (07/2000) for : **191 M €**
- Additional resources required (05/2005): **+ 49 M €**
- Targeted completion date: end 2008 (likely 2011)

EU Contribution to the Nuclear Safety Account

➔ **Nuclear Safety Account (NSA)**
Managed by the EBRD - EU contribution 20 M € - 2 projects

- Liquid Radioactive Treatment Facility (LRTP) - To be commissioned in 2006
- Interim Spent Fuel Storage Facility 2 (ISF 2) - Delays due to technical and contractual reasons

TACIS supported Project projects

→ Support to the closure of Chernobyl : Memorandum of Understanding 20 December 1995 – UA – EU - G7 initiative

- Assistance for the decommissioning of the Units 1 and 3: Industrial Complex for Solid Radwaste Management (ICSRM):
  - **47 M €** with co-financing of UA – Completion expected mid 2007
  - **24 M €** Support to other facilities (2002-2004)

TACIS supported Project projects

→Other facilities for decommissioning of Unit 1 to 3

Automated systems for the monitoring of the radiological situation in Chernobyl exclusion zone

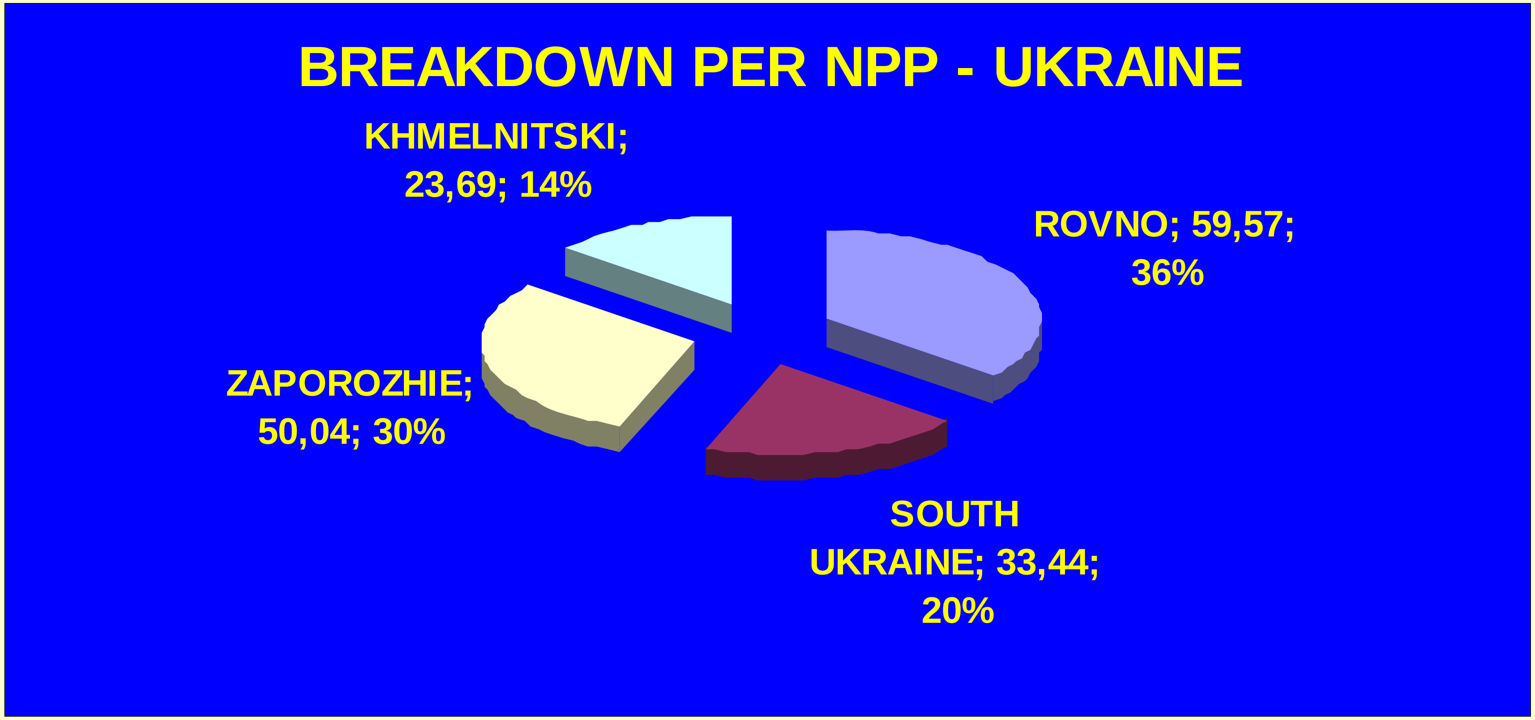
Construction of a facility for the production of concrete containers

Construction of a facility for the production of steel containers

Construction of a facility for cutting long pieces.

To be implemented in the next 3 years

Support to Ukrainian NPPs



Other EU contributions for Chernobyl

- **Completion of K2-R4**

  Preparatory works for the completion of these 2 units including Euratom loans

- **Support for the reform of the power sector - 35M €**

  Non nuclear energy projects in Ukraine

- **Energy supply : 65 M €**

  energy supply until K2-R4 units' production)

Environmental and Health impacts

- ***Agreement for International Collaboration on the Consequences of the Chernobyl Accident 1991 – 1995 (EU, Ukraine, Belarus and Russian Federation)***

→ **23 M€** - 40 % spent in the 3 Republics
→ 16 research projects – Up to 200 research groups of which 80 in the 3 Republics
→ 10 Environment-related and 6 Health-related projects

Environmental and Health impacts

- Technical assistance : medical staff, drug manufacturing, emergency management centers
- Humanitarian Assistance: medical equipment (thyroid), drugs, medical infrastructure
- Impact : mitigation of environment and health consequences

Environmental and Health impacts

- Projects ETHOS 1 and 2 for 5 settlements in Belarus

→ ETHOS had a decentralised approach with local populations leading to numerous initiatives: education (radiological culture), agriculture (farming), health (professionals)

Social impact

Addressing the social impact of the closure of Chernobyl 3.5 M€

Project EDUR 9804 “Social Impact of closing Chernobyl”

- On-site trained job counsellors, tools for job evaluation
- Coordination of business development activities
- Creation of a “business “Nursery”
- Establishment of an “Initiative Business Fund”
- Development of a long-term strategy for business development

CORE Program (Belarus)

TACIS support to specific projects (Atomremont, rehabilitation project)

Future – Period 2007 - 2013

- **European Neighbourhood and Partnership Instrument (ENPI)**

➔ Under negotiations with EU Council
➔ To replace the TACIS and other thematic programmes. Not limited to Technical Assistance
➔ To have a very clear policy content with key-policies (ex. Development)
➔ To be comprehensive and flexible
➔ To emphasise coherence and coordination with ownership and impact

- **New Instrument Nuclear Safety**

Lessons learnt for Chernobyl implementation

- **Chernobyl related projects are COMPLEX**
  Three levels of coordination

➔ Coordination at the level of the international or national organizations: Minister of Emergencies, Ministry of Economy, Fund Managers: EBRD, EC.

➔ Coordination at the level of the beneficiary / project stakeholder: Chernobyl NPP, local authorities.

➔ Coordination at the level of the project Teams: beneficiary / Regulatory Authorities / project stakeholders / EU and Ukrainian local contractors. Important role of The Project Monitoring Unit

Lessons learnt for Chernobyl implementation

- **Conditions required to reduce difficulties and delays**

➔ A stable Institutional and Managerial environment (licensing, certification, conformity assessment) with a move towards the harmonisation which would be beneficial to all actors.

➔ To develop "Common Ownership" of the projects for achieving better outputs and efficiency. A project failure is always detrimental to all parties.

➔ To master the impact of the Ukrainian economic conditions (availability of manpower, competition between sectors)

Impact for the whole nuclear sector

◆ Fundamental role of the Regulator

TACIS placed emphasis on the reinforcement of the regulator and the coupling of industrial and regulatory projects

◆ Increased knowledge of reactor technology

Impact for the whole nuclear sector

◆Increased attention to the waste issue

➔TACIS placed emphasis on the development of strategies for waste both in Chernobyl and in Nuclear Power plants

Beneficiary countries put increased focus to this issue

Conclusion

Chernobyl is a major catastrophe having strong impact on the relation between civil society and industrial production

Although there is still a lot to implement, the international Community has been able to react facing the difficulties and the complexity of the tasks.

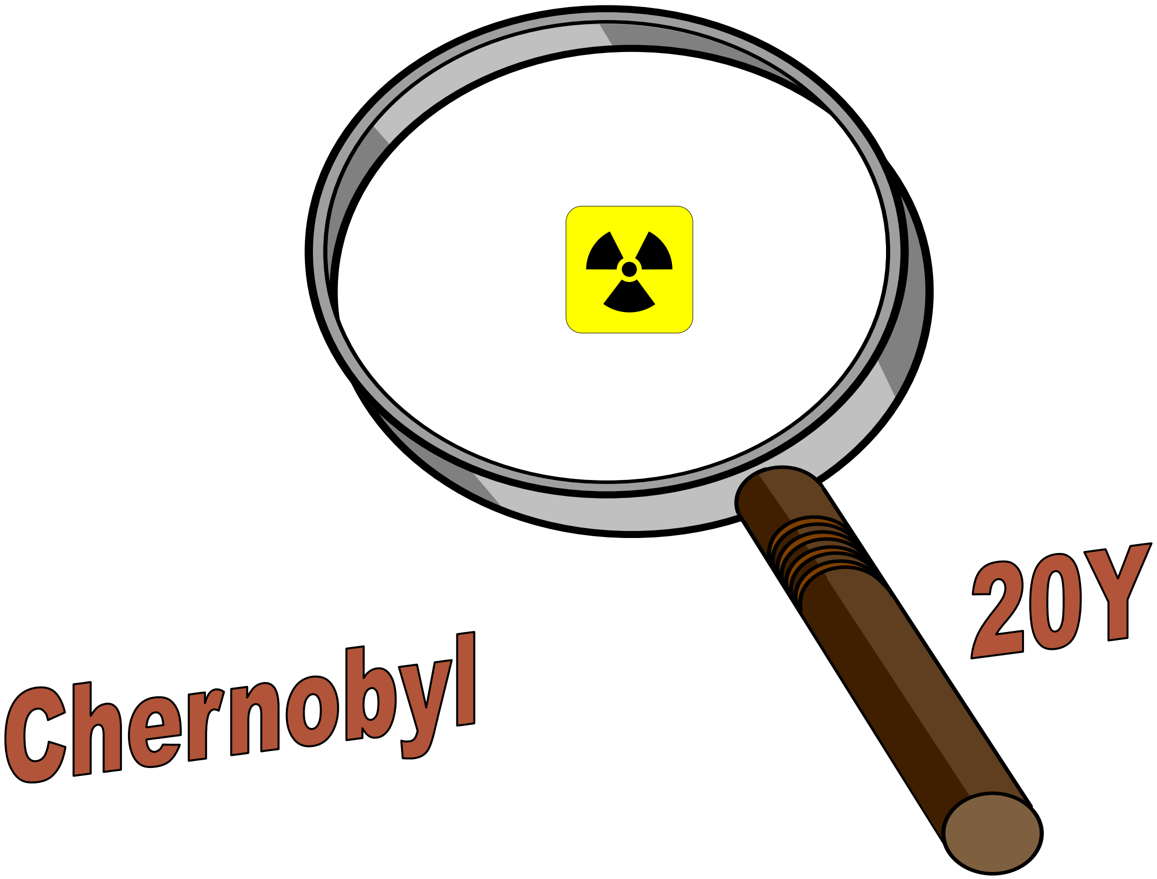
Chernobyl accident induced a process of adaptation in the nuclear industry in the concerned countries and had an impact in the EU as well.

The Commission has actively participate to this evolution

Chernobyl 20Y Colloquium
Brussels 24.3.06.

Crisis Management, Crisis Communication

Lessons Learned



Bart Dal

Inspectorate of the Ministry of Housing,

Spatial Planning & Environment (VROM)

Nuclear Regulatory Body

Topics

- The Chernobyl Experience
- National Nuclear Emergency Plan
- Revision project RNPK
- Technical and public information
- National Staff Exercise

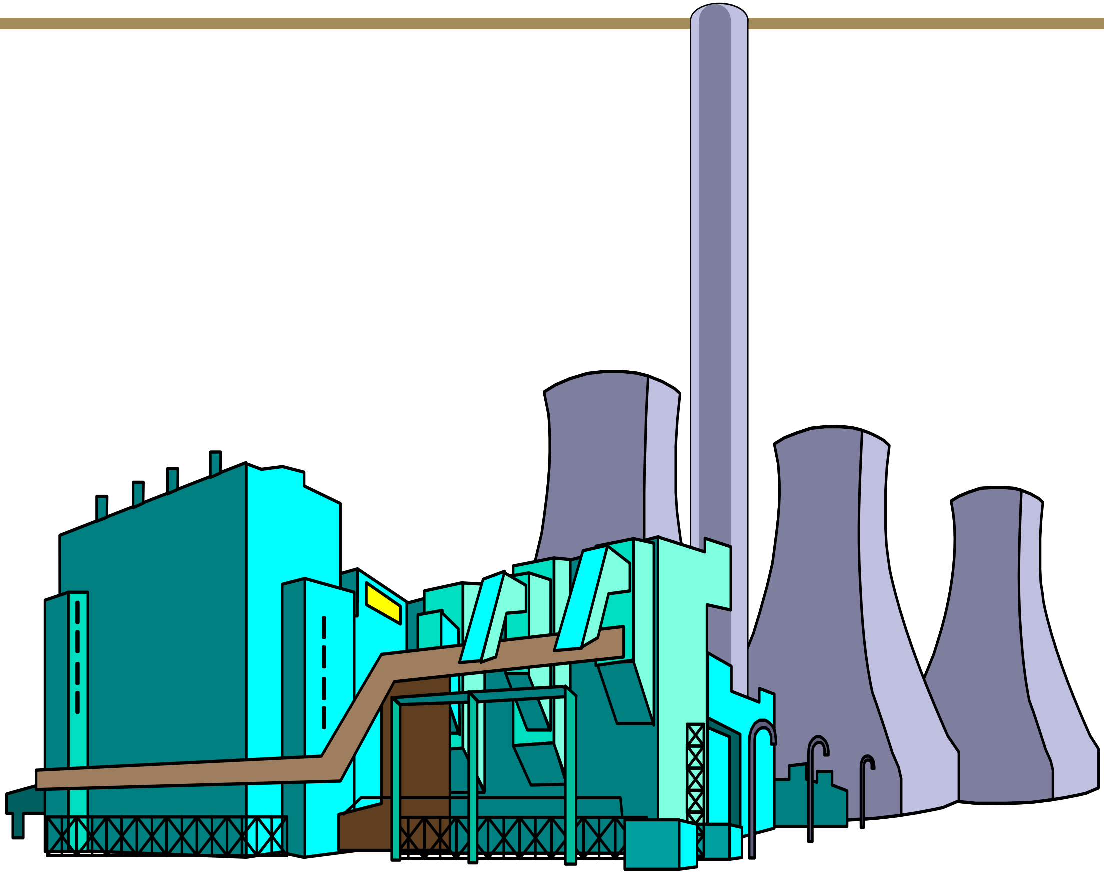
Chernobyl, lessons learned

(Inter)national approach

Allocation of tasks

Emergency Planning Zones

Information Management



Public Information?

International Agreements

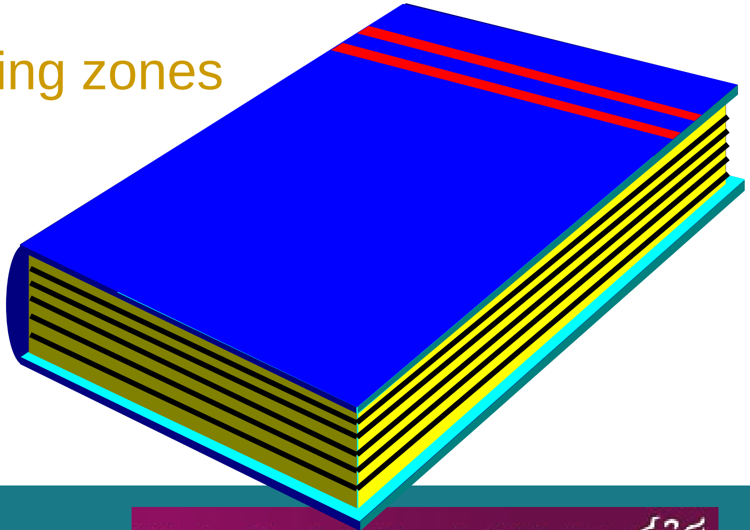
IAEA conventions

European directives

Memoranda of understanding

National Nuclear Emergency Plan (NPK)

- All nuclear objects and activities
- National and local organisation
- Organisation for technical information
- Protective measures and intervention levels
- Emergency classification and planning zones



Categorization of Nuclear Objects

Category A

- Nuclear Installations,
- Nuclear propelled ships,
- Nuclear defense material
- Satellites, etc

National

Category B

- Transports,
- Laboratories,
- Uranium enrichment,
- Storage facilities radioactive waste, etc.

Regional / Local

Developments 1986-2006

- Chemical accidents
- Plane crash A'dam
- Fireworks Enschede
- Power failures

↓

National Handbook on crisis management decision-making

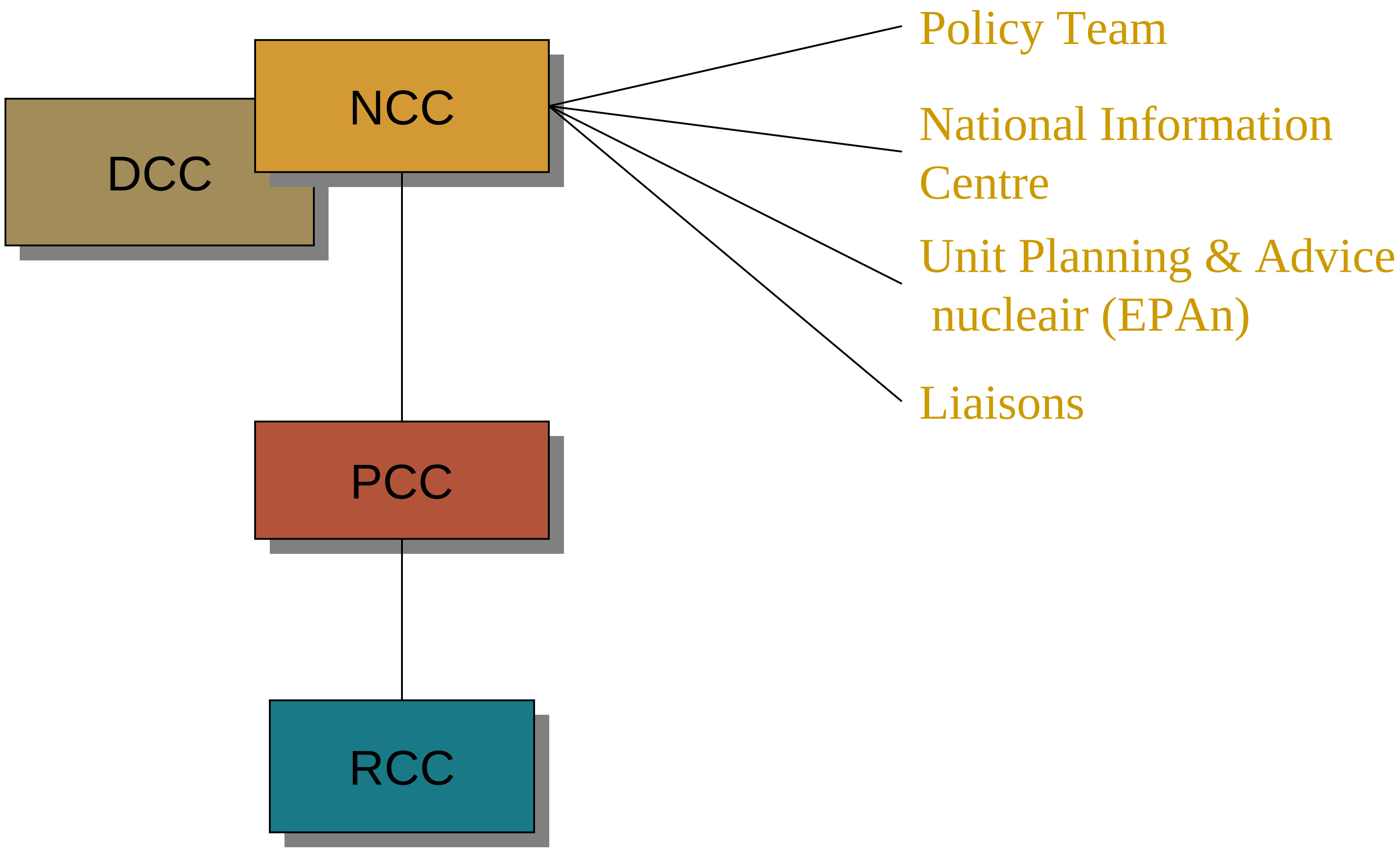
Nationaal Handboek Crisisbesluitvorming

• Each minister is responsible for preparation and response on crises situations concerning the own policy fields

• Each ministry has a Departmental Coordination Centre

• In case of a crisis concerning more than one policy field, coordination will take place in the National Coordination Centre (NCC) of the ministry of the Interior and Kingdom relations (BZK)

National Response Organisation



Revision project for nuclear accidents (RNPK)

Objectives:

- Transparency in roles and responsibilities
- Merging NPK in regular system for crisis management
- Connecting with developments in emergency organisations
- improving public information and technical advice
- Better cross-border harmonization of response
- measurable operational readiness (exercises)
- introducing quality assurance
- Maintenance and supervision

What makes the NPK special

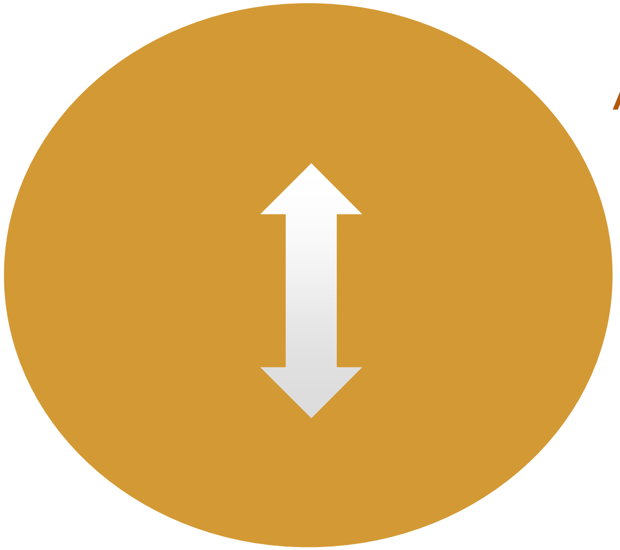
- Potential scope of accidents
- Necessary radiological expertise
- Public Information
- Specific legislation

Technical Information and Advice

Decision-Makers

Integral advice

Achievable measures

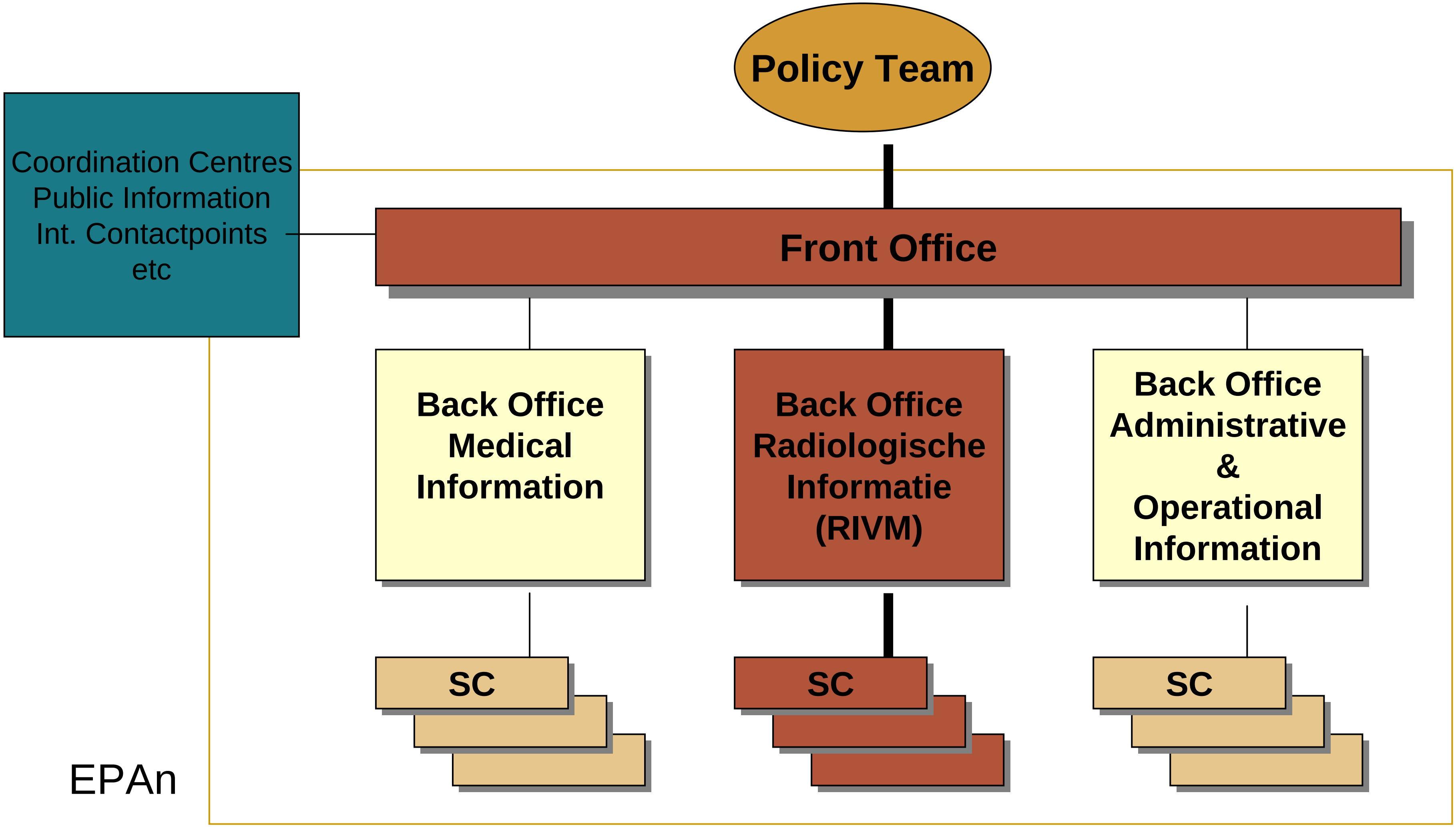


Timely

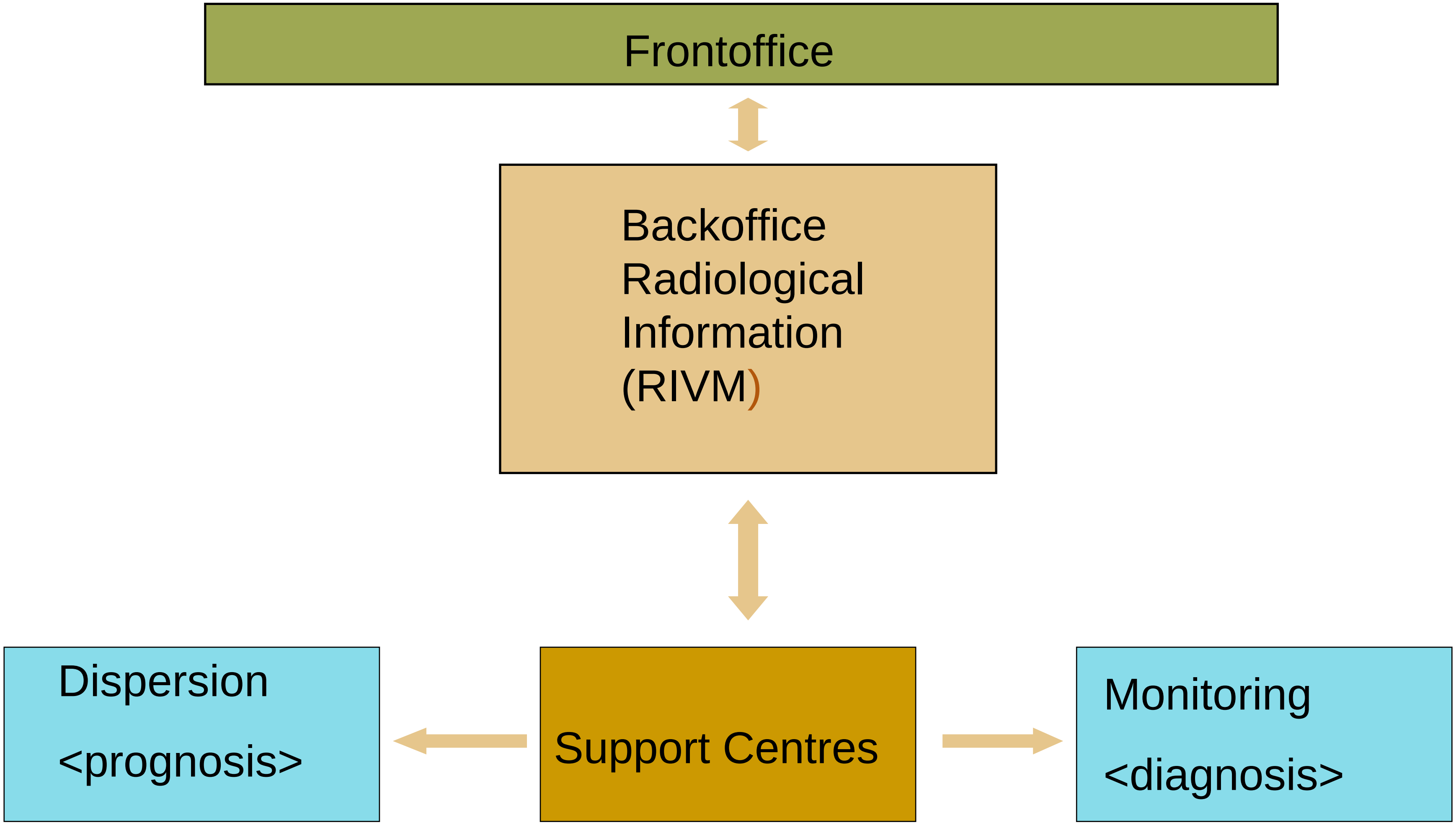
Flexible organisation

Radiation hygiene

The Unit Planning & Advise nuclear (EPAn)



Backoffice Radiological Information



The Decision-makers Labyrinth

• Direct Measures	---	Indirect Measures
• Actual Situation	---	Expected Situation
• Intervention levels	---	ALARA
• Proactive	---	Reactive
• Prognosis	---	Diagnosis

Communication: lessons learned

National Information Center

↓

Expertisecentre Risk and Crisis communication (2005):

1) Expertise
2) Communication policy and advice
3) Operations

Communication file on nuclear events

Dossier containing:

- Communication strategy
- Standard press releases
- Questions and answers
- Fact sheets Nuclear-installations
- Societal consequences nuclear incidents
- Names and Coordinates

Testing the system?

- Checking the motto "**measurable preparedness**"
- Checking new technical means, handbooks, guidelines
- Last national exercise in 1991

↓

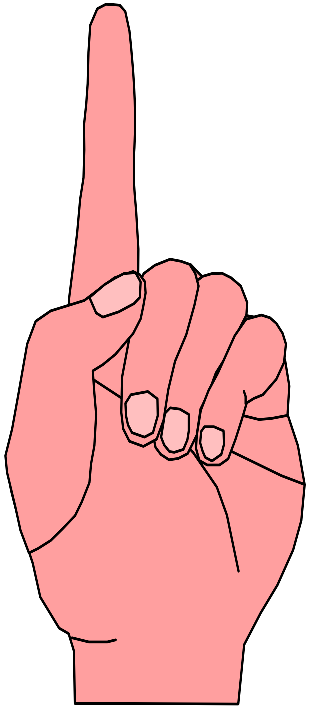
National Nuclear Full Scale Exercise 2005 (NSOn)

The National Staff Exercise (NSOn)2005

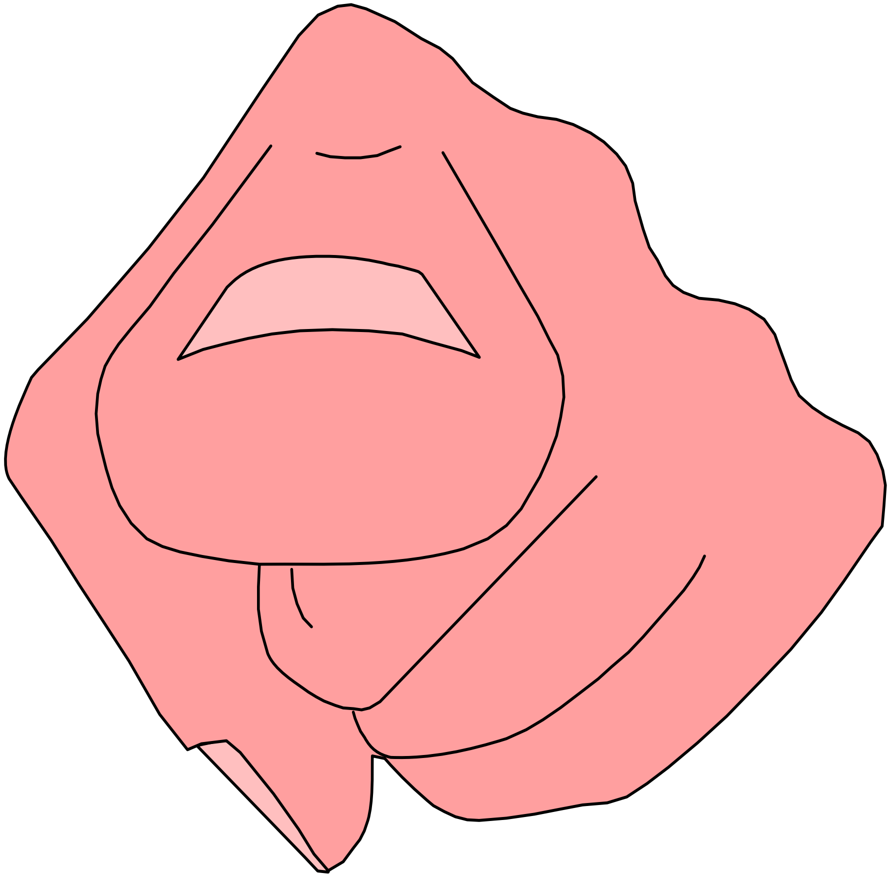
The international perspective

STATEMENT:

A lack of international coordination
in dealing with incidents or
implementing protective measures,
may add considerably to public anxiety



Questions, no questions......???



Questions...... ???

Contactpoint VROM 070-3832425

BZK / NCC 070-3454400

International points of contact for

Early Notification and Mutual Assistance

Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts

and

Recommendations to the Governments of Belarus, the Russian Federation and Ukraine

The Chernobyl Forum: 2003–2005

Second revised version

The Chernobyl Forum

IAEA

WHO

UNDP

FAO

UNEP

UN-OCHA

UNSCEAR

WORLD BANK GROUP

Belarus

the Russian Federation

Ukraine

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Table of Contents

Summary

The accident at the Chernobyl nuclear power plant in 1986 was the most severe in the history of the nuclear power industry, causing a huge release of radionuclides over large areas of Belarus, Ukraine and the Russian Federation. Now, 20 years later, UN Agencies and representatives of the three countries have reviewed the health, environmental and socio-economic consequences.

The highest radiation doses were received by emergency workers and on-site personnel, in total about 1000 people, during the first days of the accident, and doses were fatal for some of the workers. In time more than 600 000 people were registered as emergency and recovery workers ('liquidators'). Although some received high doses of radiation during their work, many of them and the majority of the residents of areas designated as 'contaminated' in Belarus, Russia and Ukraine (over 5 million people) received relatively low whole-body doses of radiation, not much higher than doses due to natural background radiation. The mitigation measures taken by the authorities, including evacuation of people from the most contaminated areas, substantially reduced radiation exposures and the radiation-related health impacts of the accident. Nevertheless, the accident was a human tragedy and had significant environmental, public health and socio-economic impacts.

Childhood thyroid cancer caused by radioactive iodine fallout is one of the main health impacts of the accident. Doses to the thyroid received in the first few months after the accident were particularly high in those who were children at the time and drank milk with high levels of radioactive iodine. By 2002, more than 4000 thyroid cancer cases had been diagnosed in this group, and it is most likely that a large fraction of these thyroid cancers is attributable to radioiodine intake.

Apart from the dramatic increase in thyroid cancer incidence among those exposed at a young age, there is no clearly demonstrated increase in the incidence of solid cancers or leukaemia due to radiation in the most affected populations. There was, however, an increase in psychological problems among the affected population, compounded by insufficient communication about radiation effects and by the social disruption and economic depression that followed the break-up of the Soviet Union.

It is impossible to assess reliably, with any precision, numbers of fatal cancers caused by radiation exposure due to the Chernobyl accident — or indeed the impact of the stress and anxiety induced by the accident and the response to it. Small differences in the assumptions concerning radiation risks can lead to large differences in the predicted health consequences, which are therefore highly uncertain. An international expert group has made projections to provide a rough estimate of the possible health impacts of

the accident and to help plan the future allocation of public health resources. The projections indicate that, among the most exposed populations (liquidators, evacuees and residents of the so-called 'strict control zones'), total cancer mortality might increase by up to a few per cent owing to Chernobyl related radiation exposure. Such an increase could mean eventually up to several thousand fatal cancers in addition to perhaps one hundred thousand cancer deaths expected in these populations from all other causes. An increase of this magnitude would be very difficult to detect, even with very careful long term epidemiological studies.

Since 1986, radiation levels in the affected environments have declined several hundred fold because of natural processes and countermeasures. Therefore, the majority of the 'contaminated' territories are now safe for settlement and economic activity. However, in the Chernobyl Exclusion Zone and in certain limited areas some restrictions on land-use will need to be retained for decades to come.

The Governments took many successful countermeasures to address the accident's consequences. However, recent research shows that the direction of current efforts should be changed. Social and economic restoration of the affected Belarusian, Russian and Ukrainian regions, as well as the elimination of the psychological burden on the general public and emergency workers, must be a priority. Additional priorities for Ukraine are to decommission the destroyed Chernobyl Unit 4 and gradually remediate the Chernobyl Exclusion Zone, including safely managing radioactive waste.

Preservation of the tacit knowledge developed in the mitigation of the consequences is essential, and targeted research on some aspects of the environmental, health and social consequences of the accident should be continued in the longer term.

This report, covering environmental radiation, human health and socio-economic aspects, is the most comprehensive evaluation of the accident's consequences to date. About 100 recognized experts from many countries, including Belarus, Russia and Ukraine, have contributed. It represents a consensus view of the eight organizations of the UN family according to their competences and of the three affected countries.

Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts

Highlights of the Chernobyl Forum Studies

Nearly 20 years after the accident at the Chernobyl nuclear power plant (NPP), people in the countries most affected had yet to obtain a clear scientific consensus on the health, environmental, and socio-economic consequences of the accident and authoritative answers to outstanding questions. To help fill this void and to promote better understanding and improved measures to deal with the impacts of the accident, the Chernobyl Forum was established in 2003.

The Chernobyl Forum is an initiative of the IAEA, in cooperation with the WHO, UNDP, FAO, UNEP, UN-OCHA, UNSCEAR, the World Bank[1] and the governments of Belarus, the Russian Federation and Ukraine. The Forum was created as a contribution to the United Nations' ten-year strategy for Chernobyl, launched in 2002 with the publication of *Human Consequences of the Chernobyl Nuclear Accident — A Strategy for Recovery*.

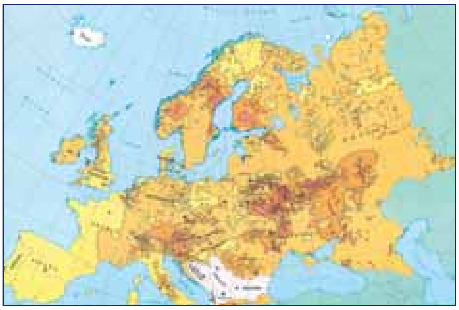
To provide a basis for achieving the goal of the Forum, the IAEA convened an expert working group of scientists to summarize the environmental effects, and the WHO convened an expert group to summarize the health effects and medical care programmes in the three most affected countries. These expert groups reviewed all appropriate scientific information that related to health and environmental consequences of the accident in Belarus, the Russian Federation and Ukraine. The information presented here and in the two full expert group reports has been drawn from scientific studies undertaken by the IAEA, WHO, UNSCEAR and numerous other authoritative bodies. In addition, UNDP has drawn on the work of eminent economists and policy specialists to assess the socio-economic impact of the Chernobyl accident, based largely on the 2002 UN study cited above.

---

[1] International Atomic Energy Agency (IAEA), World Health Organization (WHO), United Nations Development Programme (UNDP), Food and Agriculture Organization (FAO), United Nations Environment Programme (UNEP), United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA), United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

Preface: The Chernobyl Accident

On 26 April 1986, the most serious accident in the history of the nuclear industry occurred at Unit 4 of the Chernobyl nuclear power plant in the former Ukrainian Republic of the Soviet Union. The explosions that ruptured the Chernobyl reactor vessel and the consequent fire that continued for 10 days or so resulted in large amounts of radioactive materials being released into the environment.



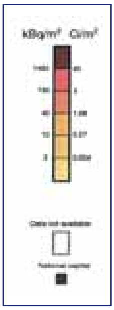


FIG. 1. Deposition of ^{137}Cs throughout Europe as a result of the Chernobyl accident (De Cort et al. 1998).

The cloud from the burning reactor spread numerous types of radioactive materials, especially iodine and caesium radionuclides, over much of Europe. Radioactive iodine-131, most significant in contributing to thyroid doses, has a short half-life (8 days) and largely disintegrated within the first few weeks of the accident. Radioactive caesium-137, which contributes to both external and internal doses, has a much longer half-life (30 years) and is still measurable in soils and some foods in many parts of Europe, see Fig. 1. The greatest deposits of radionuclides occurred over large areas of the Soviet Union surrounding the reactor in what are now the countries of Belarus, the Russian Federation and Ukraine.

An estimated 350 000 emergency and recovery operation workers, including army, power plant staff, local police and fire services, were initially involved in containing and cleaning up the accident in 1986–1987. Among them, about 240 000 recovery operation workers took part in major mitigation activities at the reactor and within the 30-km zone surrounding the reactor. Later, the number of registered “liquidators” rose to 600 000, although only a small fraction of these were exposed to high levels of radiation.

More than five million people live in areas of Belarus, Russia and Ukraine that are classified as ‘contaminated’ with radionuclides due to the Chernobyl accident (above 37 kBq m^{-2} of ^{137}Cs)[2]. Amongst them, about 400 000 people lived in more contaminated areas — classified by Soviet authorities as areas of strict radiation control (above 555 kBq m^{-2} of ^{137}Cs). Of this population, 116 000 people were evacuated in the spring

[2] Becquerel (Bq) is the international unit of radioactivity equal to one nuclear decay per second.

and summer of 1986 from the area surrounding the Chernobyl power plant (designated the "Exclusion Zone") to non-contaminated areas. Another 220 000 people were relocated in subsequent years.

Unfortunately, reliable information about the accident and the resulting dispersion of radioactive material was initially unavailable to the affected people in what was then the Soviet Union and remained inadequate for years following the accident. This failure and delay led to widespread distrust of official information and the mistaken attribution of many ill health conditions to radiation exposure.

Forum Expert Group Report: Health Consequences

The report of the Expert Group provides a summary on health consequences of the accident on Belarus, the Russian Federation and Ukraine and responds to five of the most important health-related questions concerning the impact of the Chernobyl accident.

How much radiation were people exposed to as a result of the Chernobyl nuclear accident?

Three population categories were exposed from the Chernobyl accident:

— Emergency and recovery operation workers who worked at the Chernobyl power plant and in the exclusion zone after the accident;

— Inhabitants evacuated from contaminated areas; and

— Inhabitants of contaminated areas who were not evacuated.

With the exception of the on-site reactor personnel and the emergency workers who were present near the destroyed reactor during the time of the accident and shortly afterwards, most of recovery operation workers and people living in the contaminated territories received relatively low whole-body radiation doses, comparable to background radiation levels accumulated over the 20 year period since the accident.

The highest doses were received by emergency workers and on-site personnel, in total about 1000 people, during the first days of the accident, ranging from 2 to 20 Gy, which was fatal for some of the workers. The doses received by recovery operation workers, who worked for short periods during four years following the accident ranged up to more than 500 mSv, with an average of about 100 mSv according to the State Registries of Belarus, Russia, and Ukraine.

Effective doses to the persons evacuated from the Chernobyl accident area in the spring and summer of 1986 were estimated to be of the order of 33 mSv on average, with the highest dose of the order of several hundred mSv.

Doses of Ionizing Radiation

Interaction of ionizing radiation (alpha, beta, gamma and other kinds of radiation) with living matter may damage human cells, causing death to some and modifying others. Exposure to ionizing radiation is measured in terms of absorbed energy per unit mass, i.e., absorbed dose. The unit of absorbed dose is the gray (Gy), which is a joule per kilogram (J/kg). The absorbed dose in a human body of more than one gray may cause acute radiation syndrome (ARS) as happened with some of the Chernobyl emergency workers.

Because many organs and tissues were exposed as a result of the Chernobyl accident, it has been very common to use an additional concept, that of *effective dose*, which characterizes the overall health risk due to any combination of radiation. The effective dose accounts both for absorbed energy and type of radiation and for susceptibility of various organs and tissues to development of a severe radiation-induced cancer or genetic effect. Moreover, it applies equally to external and internal exposure and to uniform or non-uniform irradiation The unit of effective dose is the sievert. One sievert is a rather large dose and so the millisievert or mSv (one thousandth of a Sv) is commonly used to describe normal exposures.

Living organisms are continually exposed to ionizing radiation from natural sources, which include cosmic rays, cosmogenic and terrestrial radionuclides (such as ^{40}K, ^{238}U, ^{232}Th and their progeny including ^{222}Rn (radon)). UNSCEAR has estimated annual natural background doses of humans worldwide to average 2.4 mSv, with a typical range of 1–10 mSv. Lifetime doses due to natural radiation would thus be about 100–700 mSv. Radiation doses to humans may be characterized as low-level if they are comparable to natural background radiation levels of a few mSv per year.

Ingestion of food contaminated with radioactive iodine did result in significant doses to the thyroid of inhabitants of the contaminated areas of Belarus, Russia, and Ukraine. The thyroid doses varied in a wide range, according to age, level of ground contamination with ^{131}I, and milk consumption rate. Reported individual thyroid doses ranged up to about 50 Gy, with average doses in contaminated areas being about 0.03 to few Gy, depending on the region where people lived and on their age. The thyroid doses to residents of Pripyat city located in the vicinity of the Chernobyl power plant, were substantially reduced by timely distribution of stable iodine tablets. Drinking milk from cows that ate contaminated grass immediately after the accident was one of the main reasons for the high doses to the thyroid of children, and why so many children subsequently developed thyroid cancer.

The general public has been exposed during the past twenty years after the accident both from external sources (^{137}Cs on soil, etc.) and via intake of radionuclides (mainly, ^{137}Cs) with foods, water and air, see Fig. 2. The average effective doses for the general population of 'contaminated' areas accumulated in 1986–2005 were estimated to be between 10 and 30 mSv in various administrative regions of Belarus, Russia and Ukraine. In the areas of strict radiological control, the average dose was around 50 mSv and more. Some residents received up to several hundred mSv. It should be noted that the average doses received by residents of the territories 'contaminated' by Chernobyl fallout are generally lower than those received by people who live in some areas of high natural background radiation in India, Iran, Brazil and China (100–200 mSv in 20 years).

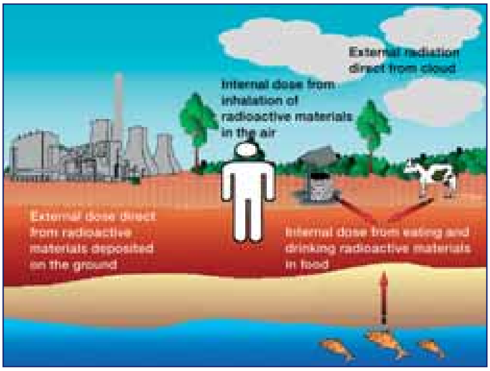


FIG. 2. Pathways of exposure to man from environmental releases of radioactive materials.

The vast majority of about five million people residing in contaminated areas of Belarus, Russia and Ukraine currently receive annual effective doses from the Chernobyl fallout of less than 1 mSv in addition to the natural background doses. However, about 100 000 residents of the more contaminated areas still receive more than 1 mSv annually from the Chernobyl fallout. Although future reduction of exposure levels is expected to be rather slow, i.e. of about 3 to 5% per year, the great majority of dose from the accident has already been accumulated.

The Chernobyl Forum assessment agrees with that of the UNSCEAR 2000 Report in terms of the individual and collective doses received by the populations of the three most affected countries: Belarus, Russia and Ukraine.

Summary of average accumulated doses to affected populations from Chernobyl fallout

Population category	Number	Average dose (mSv)
Liquidators (1986–1989)	600 000	~100
Evacuees from highly-contaminated zone (1986)	116 000	33
Residents of "strict-control" zones (1986–2005)	270 000	>50
Residents of other 'contaminated' areas (1986–2005)	5 000 000	10–20

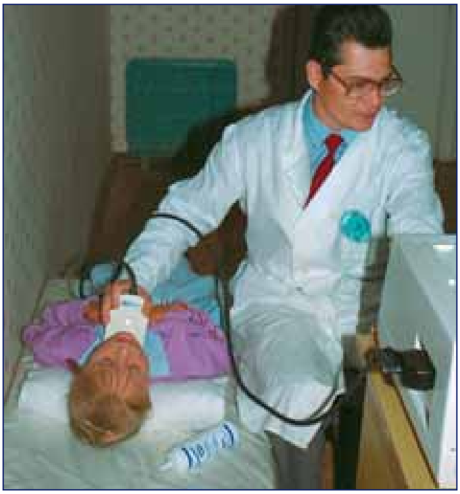
How many people died as a result of the accident and how many more are likely to die in the future?

The number of deaths attributable to the Chernobyl accident has been of paramount interest to the general public, scientists, the mass media, and politicians. Claims have been made that tens or even hundreds of thousands of persons have died as a result of the accident. These claims are highly exaggerated. Confusion about the impact of Chernobyl on mortality has arisen owing to the fact that, in the years since 1986, thousands of emergency and recovery operation workers as well as people who lived in 'contaminated' territories have died of diverse natural causes that are not attributable to radiation. However, widespread expectations of ill health and a tendency to attribute all health problems to exposure to radiation have led local residents to assume that Chernobyl-related fatalities were much higher.

Acute Radiation Syndrome mortality

The number of deaths due to acute radiation syndrome (ARS) during the first year following the accident is well documented. According to UNSCEAR (2000), ARS was diagnosed in 134 emergency workers. In many cases the ARS was complicated by extensive beta radiation skin burns and sepsis. Among these workers, 28 persons died in 1986 due to ARS. Two more persons had died at Unit 4 from injuries unrelated to radiation, and one additional death was thought to have been due to a coronary thrombosis. Nineteen more have died in 1987–2004 of various causes; however their deaths are not necessarily — and in some cases are certainly not — directly attributable to radiation exposure. Among the general population exposed to the Chernobyl radioactive fallout, however, the radiation doses were relatively low, and ARS and associated fatalities did not occur.

Cancer mortality



It is impossible to assess reliably, with any precision, numbers of fatal cancers caused by radiation exposure due to Chernobyl accident. Further, radiation-induced cancers are at present indistinguishable from those due to other causes.

An international expert group has made projections to provide a rough estimate of the possible health impacts of the accident and to help plan the future allocation of public health resources. These predictions were based on the experience of other populations exposed to radiation that have been studied for many decades, such as the survivors of the atomic bombing in Hiroshima and Nagasaki. However, the applicability of risk estimates derived from other populations with different genetic, life-style and environmental backgrounds, as well as having been exposed to much higher radiation dose rates, is unclear. Moreover small differences in the assumptions about the risks from exposure to low level radiation doses can lead to large differences in the predictions of the increased cancer burden, and predictions should therefore be treated with great caution, especially when the additional doses above natural background radiation are small.

The international expert group predicts that among the 600 000 persons receiving more significant exposures (liquidators working in 1986–1987, evacuees, and residents of the most 'contaminated' areas), the possible increase in cancer mortality due to this radiation exposure might be up to a few per cent. This might eventually represent up to four thousand fatal cancers in addition to the approximately 100 000 fatal cancers to be expected due to all other causes in this population. Among the 5 million persons residing in other 'contaminated' areas, the doses are much lower and any projected increases are more speculative, but are expected to make a difference of less than one per cent in cancer mortality.

Such increases would be very difficult to detect with available epidemiological tools, given the normal variation in cancer mortality rates. So far, epidemiological studies of residents of contaminated areas in Belarus, Russia and Ukraine have not provided clear and convincing evidence for a radiation-induced increase in general population mortality, and in particular, for fatalities caused by leukaemia, solid cancers (other than thyroid cancer), and non-cancer diseases.

However, among the more than 4000 thyroid cancer cases diagnosed in 1992–2002 in persons who were children or adolescents at the time of the accident, fifteen deaths related to the progression of the disease had been documented by 2002.

Some radiation-induced increases in fatal leukaemia, solid cancers and circulatory system diseases have been reported in Russian emergency and recovery operation workers. According to data from the Russian Registry, in 1991–1998, in the cohort of 61 000 Russian workers exposed to an average dose of 107 mSv about 5% of all fatalities that occurred may have been due to radiation exposure. These findings, however, should be considered as preliminary and need confirmation in better-designed studies with careful individual dose reconstruction.

What diseases have already resulted or might occur in the future from the Chernobyl radiation exposure?

Thyroid Cancer in Children

One of the principal radionuclides released by the Chernobyl accident was iodine-131, which was significant for the first few months. The thyroid gland accumulates iodine from the blood stream as part of its normal metabolism. Therefore, fallout of radioactive iodines led to considerable thyroid exposure of local residents through inhalation and ingestion of foodstuffs, especially milk, containing high levels of radioiodine. The thyroid gland is one of the organs most susceptible to cancer induction by radiation. Children were found to be the most vulnerable population, and a substantial increase in thyroid cancer among those exposed as children was recorded subsequent to the accident.

From 1992 to 2002 in Belarus, Russia and Ukraine more than 4000[3] cases of thyroid cancer were diagnosed among those who were children and adolescents (0–18 years) at the time of the accident, the age group 0–14 years being most affected; see Fig. 3. The majority of these cases were treated, with favourable prognosis for their lives. Given the rarity of thyroid cancer in young people, the large population with high doses to the thyroid and the magnitude of the radiation-related risk estimates derived from epidemiological studies, it is most likely that a large fraction of thyroid cancers observed to date among those exposed in childhood are attributable to radiation exposure from the accident. It is expected that the increase in thyroid cancer incidence from Chernobyl will continue for many more years, although the long term magnitude of risk is difficult to quantify.

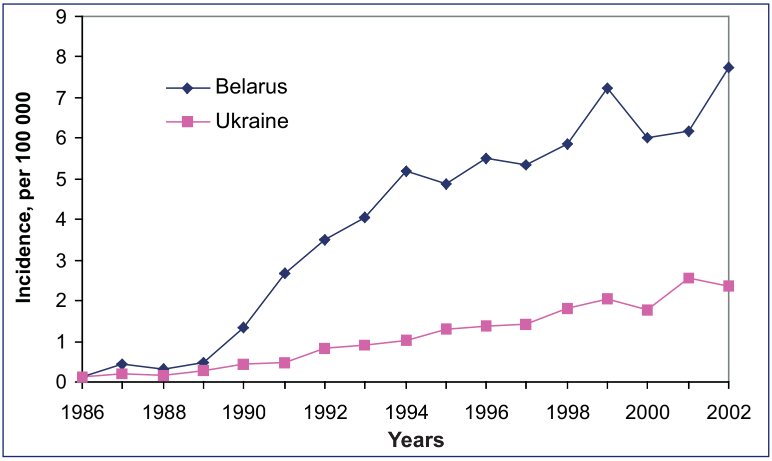


FIG. 3. Incidence rate of thyroid cancer in children and adolescents exposed to ^{131}I as a result of the Chernobyl accident (after Jacob et al., 2005).

It should be noted that early mitigation measures taken by the national authorities helped substantially to minimize the health consequences of the accident. Intake of stable iodine tablets during the first 6–30 hours after the accident reduced the thyroid dose of the residents of Pripyat by a factor of 6 on average. Pripyat was the largest city nearest to the Chernobyl nuclear plant and approximately 50 000 residents were evacuated within 40 hours after the accident. More than 100 000 people were evacuated within few weeks after the accident from the most contaminated areas of Ukraine and

[3] More recent statistics from the national registries of Belarus and Ukraine indicate that the total number of thyroid cancers among those exposed under the age of 18, is currently close to 5000. The numbers differ slightly depending on the reporting methods, but the overall number observed in the three countries is certainly well above 4000.

Belarus. These actions reduced radiation exposures and reduced the radiation related health impacts of the accident.

Leukaemia, Solid Cancers and Circulatory Diseases

A number of epidemiological studies, including atomic bombing survivors, patients treated with radiotherapy and occupationally exposed populations in medicine and the nuclear industry, have shown that ionizing radiation can cause solid cancers and leukaemia (except CLL[4]). More recent findings also indicate an increased risk of cardiovascular diseases in populations exposed at higher doses (e.g. atomic bombing survivors, radiotherapy patients).

An increased risk of leukaemia associated with radiation exposure from Chernobyl was, therefore, expected among the populations exposed. Given the level of doses received, however, it is likely that studies of the general population will lack statistical power to identify such an increase, although for higher exposed emergency and recovery operation workers an increase may be detectable. The most recent studies suggest a two-fold increase in the incidence of non-CLL leukaemia between 1986 and 1996 in Russian emergency and recovery operation workers exposed to more than 150 mGy (external dose). On going studies of the workers may provide additional information on the possible increased risk of leukaemia.

However, since the risk of radiation-induced leukaemia decreases several decades after exposure, its contribution to morbidity and mortality is likely to become less significant as time progresses.

There have been many post-Chernobyl studies of leukaemia and cancer morbidity in the populations of ‘contaminated’ areas in the three countries. Most studies, however, had methodological limitations and lacked statistical power. There is therefore no

[4] CLL is chronic lymphoid leukaemia that is not thought to be caused by radiation exposure.

convincing evidence at present that the incidence of leukaemia or cancer (other than thyroid) has increased in children, those exposed in-utero, or adult residents of the 'contaminated' areas. It is thought, however, that for most solid cancers, the minimum latent period is likely to be much longer than that for leukaemia or thyroid cancer — of the order of 10 to 15 years or more — and it may be too early to evaluate the full radiological impact of the accident. Therefore, medical care and annual examinations of highly exposed Chernobyl workers should continue.

The absence of a demonstrated increase in cancer risk — apart from thyroid cancer — is not proof that no increase has in fact occurred. Such an increase, however, is expected to be very difficult to identify in the absence of careful large scale epidemiological studies with individual dose estimates. It should be noted that, given the large number of individuals exposed, small differences in the models used to assess risks at low doses can have marked effects on the estimates of additional cancer cases.

There appears to be some recent increase in morbidity and mortality of Russian emergency and recovery operation workers caused by circulatory system diseases. Incidence of circulatory system diseases should be interpreted with special care because of the possible indirect influence of confounding factors, such as stress and lifestyle. These findings also need confirmation in well-designed studies.

Cataracts

Examinations of eyes of children and emergency and recovery operation workers clearly show that cataracts may develop in association with exposure to radiation from the Chernobyl accident. The data from studies of emergency and recovery workers suggest that exposures to radiation somewhat lower than previously experienced, down to about 250 mGy, may be cataractogenic.

Continued eye follow-up studies of the Chernobyl populations will allow confirmation and greater predictive capability of the risk of radiation cataract onset and, more importantly, provide the data necessary to be able to assess the likelihood of any resulting visual dysfunction.

Have there been or will there be any inherited or reproductive effects?

Because of the relatively low dose levels to which the populations of the Chernobyl-affected regions were exposed, there is no evidence or any likelihood of observing decreased fertility among males or females in the general population as a direct result of radiation exposure. These doses are also unlikely to have any major effect on the number of stillbirths, adverse pregnancy outcomes or delivery complications or the overall health of children.

Birth rates may be lower in ‘contaminated’ areas because of concern about having children (this issue is obscured by the very high rate of medical abortions) and the fact that many younger people have moved away. No discernable increase in hereditary effects caused by radiation is expected based on the low risk coefficients estimated by UNSCEAR (2001) or in previous reports on Chernobyl health effects. Since 2000, there has been no new evidence provided to change this conclusion.

There has been a modest but steady increase in reported congenital malformations in both ‘contaminated’ and ‘uncontaminated’ areas of Belarus since 1986; see Fig. 4. This does not appear to be radiation-related and may be the result of increased registration.

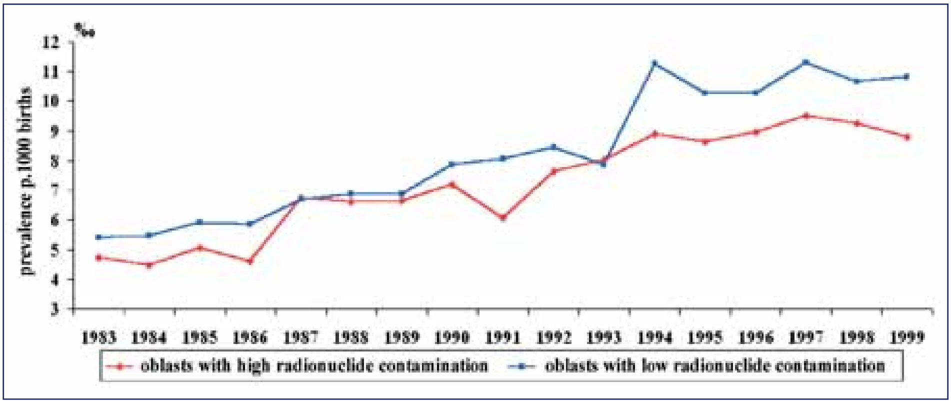


FIG. 4. Prevalence at birth of congenital malformations in 4 oblasts of Belarus with high and low levels of radionuclide contamination (Lasyuk et al., 1999).

The Chernobyl accident resulted in many people being traumatized by the rapid relocation, the breakdown in social contacts, fear and anxiety about what health effects might result. Are there persistent psychological or mental health problems?

Any traumatic accident or event can cause the incidence of stress symptoms, depression, anxiety (including post-traumatic stress symptoms), and medically unexplained physical symptoms. Such effects have also been reported in Chernobyl-exposed populations. Three studies found that exposed populations had anxiety levels that were twice as high as controls, and they were 3–4 times more likely to report multiple unexplained physical symptoms and subjective poor health than were unaffected control groups.

In general, although the psychological consequences found in Chernobyl exposed populations are similar to those in atomic bombing survivors, residents near the Three Mile Island nuclear power plant accident, and those who experienced toxic exposures at work or in the environment, the context in which the Chernobyl accident occurred makes the findings difficult to interpret because of the complicated series of events unleashed by the accident, the multiple extreme stresses and culture-specific ways of expressing distress.

In addition, individuals in the affected populations were officially categorized as "sufferers", and came to be known colloquially as "Chernobyl victims," a term that was soon adopted by the mass media. This label, along with the extensive government benefits earmarked for evacuees and residents of the contaminated territories, had the effect of encouraging individuals to think of themselves fatalistically as invalids. It is known that people's perceptions — even if false — can affect the way they feel and act. Thus, rather than perceiving themselves as "survivors," many of those people have come to think of themselves as helpless, weak and lacking control over their future.

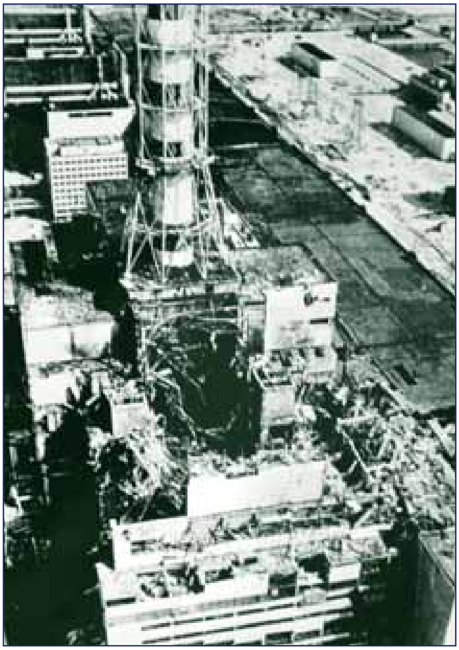
Renewed efforts at risk communication, providing the public and key professionals with accurate information about the health and mental health consequences of the disaster, should be undertaken.

Forum Expert Group Report: Environmental Consequences

The report of the Expert Group on environmental consequences covers the issues of radioactive release and deposition, radionuclide transfers and bioaccumulation, application of countermeasures, radiation-induced effects on plants and animals as well as dismantlement of the Shelter and radioactive waste management in the Chernobyl Exclusion Zone.

Release and Deposits of Radioactive Material

Major releases of radionuclides from unit 4 of the Chernobyl reactor continued for ten days following the April 26 explosion. These included radioactive gases, condensed aerosols and a large amount of fuel particles. The total release of radioactive substances was about 14 EBq[5], including 1.8 EBq of iodine-131, 0.085 EBq of ^{137}Cs, 0.01 EBq of ^{90}Sr and 0.003 EBq of plutonium radioisotopes. The noble gases contributed about 50% of the total release.



More than 200 000 square kilometres of Europe received levels of ^{137}Cs above 37 kBq m^{-2}. Over 70 percent of this area was in the three most affected countries, Belarus, Russia and Ukraine. The deposition was extremely varied, as it was enhanced in areas where it was raining when the contaminated air masses passed. Most of the strontium and plutonium radioisotopes were deposited within 100 km of the destroyed reactor due to larger particle sizes.

Many of the most significant radionuclides had short physical half-lives. Thus, most of the radionuclides released by the accident have decayed away. The releases of radioactive iodines caused great concern immediately after the accident. For the decades to come ^{137}Cs will continue to be of greatest importance, with secondary attention to ^{90}Sr. Over the longer term (hundreds to thousands of years) the plutonium isotopes and americium-241 will remain, although at levels not significant radiologically.

What is the scope of urban contamination?

Radionuclides deposited most heavily on open surfaces in urban areas, such as lawns, parks, streets, roads, town squares, building roofs and walls. Under dry conditions, trees, bushes, lawns and roofs initially had the highest levels, whereas under wet conditions horizontal surfaces, such as soil plots and lawns, received the highest levels. Enhanced ^{137}Cs concentrations were found around houses where the rain had transported the radioactive material from the roofs to the ground.

[5] 1 EBq = 10^{18} Bq (Becquerel).

The deposition in urban areas in the nearest city of Pripyat and surrounding settlements could have initially given rise to a substantial external dose. However, this was to a large extent averted by the timely evacuation of residents. The deposition of radioactive material in other urban areas has resulted in various levels of radiation exposure to people in subsequent years and continues to this day at lower levels.

Due to wind and rain and human activities, including traffic, street washing and cleanup, surface contamination by radioactive materials has been reduced significantly in inhabited and recreational areas during 1986 and afterwards. One of the consequences of these processes has been secondary contamination of sewage systems and sludge storage.

At present, in most of the settlements subjected to radioactive contamination as a result of Chernobyl, the air dose rate above solid surfaces has returned to the background level predating the accident. But the air dose rate remains elevated above undisturbed soil in gardens and parks in some settlements of Belarus, Russia and Ukraine.

.How contaminated are agricultural areas?

In the early months after the accident, the levels of radioactivity of agricultural plants and plant-consuming animals was dominated by surface deposits of radionuclides. The deposition of radioiodine caused the most immediate concern, but the problem was confined to the first two months after the accident because of fast decay of the most important isotope, ^{131}I.

The radioiodine was rapidly absorbed into milk at a high rate leading to significant thyroid doses to people consuming milk, especially children in Belarus, Russia and Ukraine. In the rest of Europe increased levels of radioiodine in milk were observed in some southern areas, where dairy animals were already outdoors.

After the early phase of direct deposit, uptake of radionuclides through plant roots from soil became increasingly important. Radioisotopes of caesium (^{137}Cs and ^{134}Cs) were the nuclides which led to the largest problems, and even after decay of ^{134}Cs (half-life of 2.1 years) by the mid-1990s the levels of longer lived ^{137}Cs in agricultural products from highly affected areas still may require environmental remediation. In addition, ^{90}Sr could cause problems in areas close to the reactor, but at greater distances its deposition levels were low. Other radionuclides such as plutonium isotopes and ^{241}Am did not cause real problems in agriculture, either because they were present at low deposition levels, or were poorly available for root uptake from soil.

In general, there was a substantial reduction in the transfer of radionuclides to vegetation and animals in intensive agricultural systems in the first few years after deposition, as would be expected due to weathering, physical decay, migration of radionuclides down the soil, reductions in bioavailability in soil and due to countermeasures, see Fig. 5. However, in the last decade there has been little further obvious decline, by 3–7 percent per year.

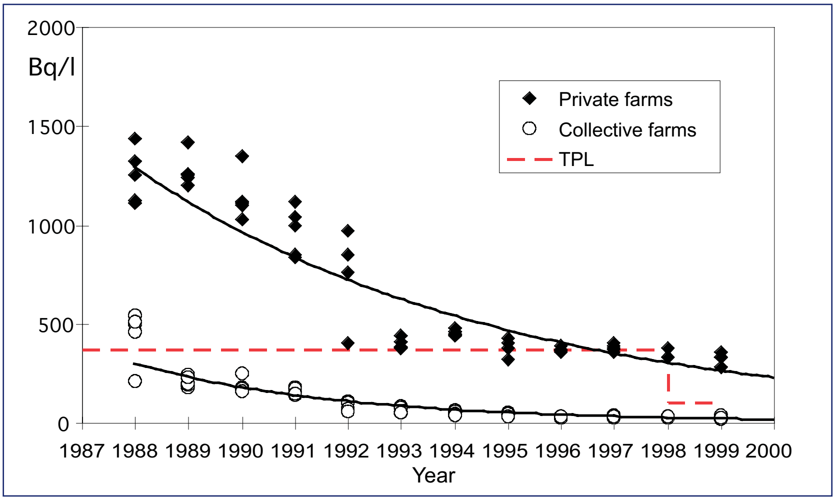


FIG. 5. Reduction with time of ^{137}Cs activity concentration in milk produced in private and collective farms of the Rovno region of Ukraine with a comparison to the temporary permissible level (TPL).

The radiocaesium content in foodstuffs was influenced not only by deposition levels but also by types of ecosystem and soil as well as by management practices. The remaining persistent problems in the affected areas occur in extensive agricultural systems with soils with a high organic content and animals grazing in unimproved pastures that are not ploughed or fertilized. This particularly affects rural residents in the former Soviet Union who are commonly subsistence farmers with privately owned dairy cows.

In the long term ^{137}Cs in milk and meat and, to a lesser extent, ^{137}Cs in plant foods and crops remain the most important contributors to human internal dose. As ^{137}Cs activity concentration in both vegetable and animal foods has been decreasing very slowly during the last decade, the relative contribution of ^{137}Cs to internal dose will continue to dominate for decades to come. The importance of other long lived radionuclides, ^{90}Sr, plutonium isotopes and ^{241}Am, in terms of the human dose will remain insignificant.

Currently, ^{137}Cs activity concentrations in agricultural food products produced in areas affected by the Chernobyl fallout are generally below national and international action levels. However, in some limited areas with high radionuclide contamination (parts of the Gomel and Mogilev regions in Belarus and the Bryansk region in Russia) or poor organic soils (the Zhytomir and Rovno regions in Ukraine) milk may still be produced with ^{137}Cs activity concentrations that exceed national action levels of 100 Bq per kilogram. In these areas countermeasures and environmental remediation may still be warranted.

What is the extent of forest contamination?

Following the accident vegetation and animals in forests and mountain areas have shown particularly high uptake of radiocaesium, with the highest recorded ^{137}Cs levels found in forest food products. This is due to the persistent recycling of radiocaesium particularly in forest ecosystems.

Particularly high ^{137}Cs activity concentrations have been found in mushrooms, berries, and game, and these high levels have persisted for two decades. Thus, while the magnitude of human exposure through agricultural products has experienced a general decline, high levels of contamination of forest food products have continued and still exceed permissible levels in some countries. In some areas of Belarus, Russia and Ukraine, consumption of forest foods with ^{137}Cs dominates internal exposure. This can be expected to continue for several decades.

Therefore, the relative importance of forests in contributing to radiological exposures of the populations of several affected countries has increased with time. It will primarily be the combination of downward migration in the soil and the physical decay of ^{137}Cs that will contribute to any further slow long term reduction in contamination of forest food products.

The high transfer of radiocaesium in the pathway lichen-to-reindeer meat-to-humans has been demonstrated again after the Chernobyl accident in the Arctic and sub-Arctic areas of Europe. The Chernobyl accident led to high levels of ^{137}Cs of reindeer meat in Finland, Norway, Russia and Sweden and caused significant difficulties for the indigenous Sami people.

How contaminated are the aquatic systems?

Radioactive material from Chernobyl resulted in levels of radioactive material in surface water systems in areas close to the reactor site and in many other parts of Europe. The initial levels were due primarily to direct deposition of radionuclides on the surface of rivers and lakes, dominated by short lived radionuclides (primarily ^{131}I). In the first few weeks after the accident, high activity concentrations in drinking water from the Kyiv Reservoir were of particular concern.

Levels in water bodies fell rapidly during the weeks after fallout through dilution, physical decay and absorption of radionuclides to catchment soils. Bed sediments are an important long term sink for radioactivity.

Initial uptake of radioiodine to fish was rapid, but activity concentrations declined quickly, due primarily to physical decay. Bioaccumulation of radiocaesium in the aquatic food chain led to significant activity concentrations in fish in the most affected areas, and in some lakes as far away as Scandinavia and Germany. Because of generally lower fallout and lower bioaccumulation, ^{90}Sr levels in fish were not significant for human doses in comparison to radiocaesium, particularly since ^{90}Sr is accumulated in bone rather than in edible muscle.

In the long term, secondary inputs by run-off of long lived ^{137}Cs and ^{90}Sr from soil continues (at a much lower level) to the present day. At the present time, activity concentrations both in surface waters and in fish are low, see Fig. 6. Therefore, irrigation with surface water is not considered to be a hazard.

While ^{137}Cs and ^{90}Sr levels in water and fish of rivers, open lakes and reservoirs are currently low, in some "closed" lakes with no outflowing streams in Belarus, Russia and

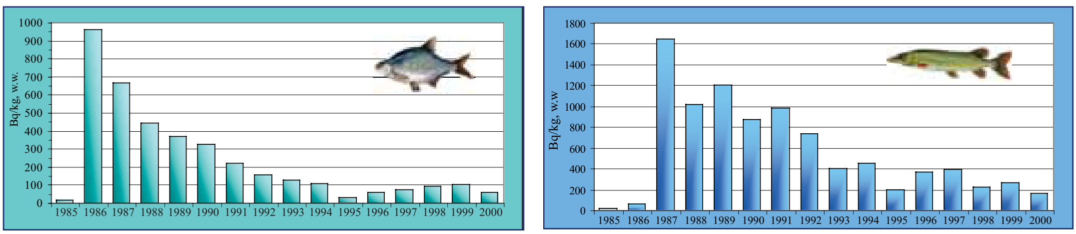


FIG. 6. Averaged ^{137}Cs activity concentrations in non-predatory (Bream, left histogram) and predatory (Pike, right histogram) fish from Kyiv reservoir (UHMI 2004).

Ukraine both water and fish will remain contaminated with ^{137}Cs for decades to come. For example, for some people living next to a "closed" Kozhanovskoe Lake in Russia, consumption of fish has dominated their total ^{137}Cs ingestion.

Owing to the large distance of the Black and Baltic Seas from Chernobyl, and the dilution in these systems, activity concentrations in sea water were much lower than in freshwater. The low water radionuclide levels combined with low bioaccumulation of radiocaesium in marine biota has led to ^{137}Cs levels in marine fish that are not of concern.

What environmental countermeasures and remediation have been implemented?

The Soviet and, later, Commonwealth of Independent States (CIS) authorities introduced a wide range of short and long term environmental countermeasures to mitigate the accident's negative consequences. The countermeasures involved huge human, financial and scientific resources.

Decontamination of settlements in contaminated regions of the USSR during the first years after the Chernobyl accident was successful in reducing the external dose when its implementation was preceded by proper remediation assessment. However, the decontamination has produced a disposal problem due to the considerable amount of low level radioactive waste that was created. Secondary cross-contamination with radionuclides of cleaned up plots from surrounding areas has not been observed.

The most effective agricultural countermeasures in the early phase were exclusion of contaminated pasture grasses from animal diets and rejection of milk based on radiation monitoring data. Feeding animals with "clean" fodder was effectively performed in some affected countries. However, these countermeasures were only partially effective in reducing radioiodine intake via milk because of the lack of timely information about the accident and necessary responses, particularly for private farmers.

The greatest long term problem has been radiocaesium contamination of milk and meat. In the USSR and later in the CIS countries, this has been addressed by the treatment of land used for fodder crops, clean feeding and application of Cs-binders, such as Prussian blue, see Fig. 7, to animals that enabled most farming practices to continue in affected areas and resulted in a large dose reduction.

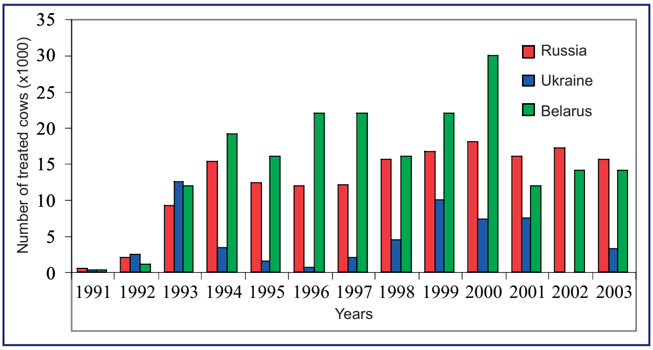


FIG. 7. Changes with time in the use of Prussian blue in the CIS countries (IAEA, 2005).

Application of agricultural countermeasures in the affected CIS countries substantially decreased since the middle of 1990s (to less extent in Belarus) because of economic problems. In a short time, this resulted in an increase of radionuclide content in plant and animal agricultural products.

In Western Europe, because of the high and prolonged uptake of radiocaesium in the affected extensive systems, a range of countermeasures are still being used for animal products from uplands and forests.

The following forest-related restrictions widely applied in the USSR and later in CIS countries and in Scandinavia have reduced human exposure due to residence in radioactively contaminated forests and use of forest products:

— Restrictions on public and forest worker access as a countermeasure against external exposure;

— Restricted harvesting of food products such as game, berries and mushrooms by the public that contributed to reduction of internal doses. In the CIS countries mushrooms are a staple of many diets and, therefore, this restriction has been particularly important;

— Restricted collection of firewood by the public to prevent exposures in the home and garden when the wood is burned and the ash is disposed of or used as a fertilizer; and

— Alteration of hunting practices aiming to avoid consumption of meat with high seasonal levels of radiocaesium.

Numerous countermeasures put in place in the months and years after the accident to protect water systems from transfers of radioactivity from contaminated soils were generally ineffective and expensive. The most effective countermeasure was the early restriction of drinking water and changing to alternative supplies. Restrictions on consumption of freshwater fish have also proved effective in Scandinavia and Germany, though in Belarus, Russia and Ukraine such restrictions may not always have been adhered to.

What were the radiation-induced effects on plants and animals?

Irradiation from radionuclides released from the accident caused numerous acute adverse effects on the plants and animals living in the higher exposure areas, i.e., in localized sites at distances up to 30 kilometres from the release point. Outside the Exclusion Zone, no acute radiation-induced effects in plants and animals have been reported.

The response of the natural environment to the accident was a complex interaction between radiation dose and radiosensitivities of the different plants and animals. Both individual and population effects caused by radiation-induced cell death have been observed in biota inside the Exclusion Zone as follows:

- Increased mortality of coniferous plants, soil invertebrates and mammals; and
- Reproductive losses in plants and animals.

No adverse radiation-induced effect has been reported in plants and animals exposed to a cumulative dose of less than 0.3 Gy during the first month after the accident.

Following the natural reduction of exposure levels due to radionuclide decay and migration, biological populations have been recovering from acute radiation effects. As soon as by the next growing season following the accident, population viability of plants and animals had substantially recovered as a result of the combined effects of reproduction and immigration from less affected areas. A few years were needed for recovery from major radiation-induced adverse effects in plants and animals.

Genetic effects of radiation, in both somatic and germ cells, have been observed in plants and animals of the Exclusion Zone during the first few years after the Chernobyl accident. Both in the Exclusion Zone, and beyond, different cytogenetic anomalies attributable to radiation continue to be reported from experimental studies performed on plants and animals. Whether the observed cytogenetic anomalies in somatic cells have any detrimental biological significance is not known.

The recovery of affected biota in the exclusion zone has been facilitated by the removal of human activities, e.g., termination of agricultural and industrial activities. As a result, populations of many plants and animals have eventually expanded, and the present environmental conditions have had a positive impact on the biota in the Exclusion Zone. Indeed, the Exclusion Zone has paradoxically become a unique sanctuary for biodiversity.

FIG. 8. A white-tailed eagle chick observed recently in the Chernobyl Exclusion Zone. Before 1986, these rare predatory birds have been hardly found in this area (Photo: Courtesy of Sergey Gaschak, 2004).

What are the environmental aspects of dismantlement of the Shelter and of radioactive waste management?

The accidental destruction of Chernobyl's Unit 4 reactor generated extensive spread of radioactive material and a large amount of radioactive waste in the Unit, at the plant site and in the surrounding area. Construction of the Shelter between May and November 1986, aiming at environmental containment of the damaged reactor, reduced radiation levels on-site and prevented further release of radionuclides off-site.

The Shelter was erected in a short period under conditions of severe radiation exposure to personnel. Measures taken to save construction time led to imperfections in the Shelter as well as to lack of comprehensive data on the stability of the damaged Unit 4 structures. In addition, structural elements of the Shelter have degraded due to moisture-induced corrosion during the nearly two decades since it was erected. The main potential hazard of the Shelter is a possible collapse of its top structures and release of radioactive dust into the environment.

To avoid the potential collapse of the Shelter, measures are planned to strengthen unstable structures. In addition, a New Safe Confinement (NSC) that should provide more than 100 years service life is planned as a cover over the existing Shelter, see Fig. 9. The construction of the NSC is expected to allow for the dismantlement of the current Shelter, removal of highly radioactive Fuel Containing Mass (FCM) from Unit 4, and eventual decommissioning of the damaged reactor.

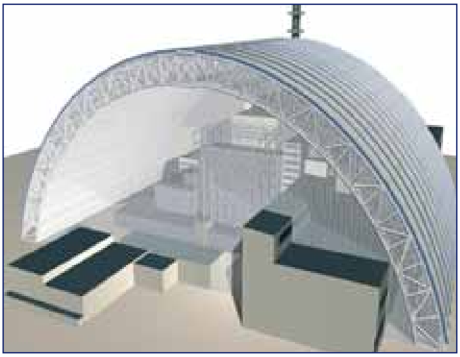


FIG. 9. Planned New Safe Confinement over the destroyed Chernobyl reactor.

In the course of remediation activities both at the Chernobyl nuclear power plant site and in its vicinity, large volumes of radioactive waste were generated and placed in temporary near-surface waste storage and disposal facilities. Trench and landfill facilities were created from 1986 to 1987 in the Exclusion Zone at distances of 0.5 to 15 km from the reactor site with the intention to avoid the spread of dust, reduce the radiation levels, and enable better working conditions at Unit 4 and in its surroundings. These facilities were established without proper design documentation and engineered barriers and do not meet contemporary waste disposal safety requirements.

During the years following the accident large resources were expended to provide a systematic analysis and an acceptable strategy for management of existing radioactive waste. However, to date a broadly accepted strategy for radioactive waste management at the Chernobyl power plant site and the Exclusion Zone, and especially for high level and long lived waste, has not yet been developed.

More radioactive waste is potentially expected to be generated in Ukraine in the years to come during NSC construction, possible Shelter dismantling, FCM removal and decommissioning of Unit 4. This waste should be properly disposed of.

What is the future of the Chernobyl Exclusion Zone?

The overall plan for the long term development of the Exclusion Zone in Ukraine is to recover the affected areas, redefine the Exclusion Zone, and make the less affected areas available for limited use by the public. This will require well defined administrative

controls on the nature of activities that may be performed in the particular areas. In some of them, restriction of food crops planting and cattle grazing, and use of only clean feed for cattle still may be needed for decades to come for radiological reasons. Accordingly, these resettled areas are best suited for an industrial use rather than an agricultural or residential area.

The future of the Exclusion Zone for the next hundred years and more is envisaged to be associated with the following activities:

- Construction and operation of the NSC and relevant engineering infrastructure;
- Defuelling, decommissioning and dismantling of Units 1, 2 and 3 of the nuclear power plant and the Shelter;
- Construction of facilities for processing and management of radioactive waste, in particular a deep geological repository for high-activity and long lived radioactive material;
- Development of natural reserves in the area that remains closed to human habitation; and
- Maintenance of environmental monitoring and research activities.

The Socio-Economic Impact of the Chernobyl Nuclear Accident

What was the economic cost of the Chernobyl nuclear disaster?

The Chernobyl nuclear accident, and government policies adopted to cope with its consequences, imposed huge costs on the Soviet Union and three successor countries, Belarus, the Russian Federation and Ukraine. Although these three countries bore the brunt of the impact, given the spread of radiation outside the borders of the Soviet Union, other countries (in Scandinavia, for instance) sustained economic losses as well.

The costs of the Chernobyl nuclear accident can only be calculated with a high degree of estimation, given the non-market conditions prevailing at the time of the disaster and the high inflation and volatile exchange rates of the transition period that followed the break-up of the Soviet

Union in 1991. However, the magnitude of the impact is clear from a variety of government estimates from the 1990s, which put the cost of the accident, over two decades, at hundreds of billions of dollars.[6]

The scale of the burden is clear from the wide range of costs incurred, both direct and indirect:

- Direct damage caused by the accident;
- Expenditures related to:
    - Actions to seal off the reactor and mitigate the consequences in the exclusion zone;
    - Resettlement of people and construction of new housing and infrastructure to accommodate them;
    - Social protection and health care provided to the affected population;
    - Research on environment, health and production of clean food;
    - Radiation monitoring of the environment; and
    - Radioecological improvement of settlements and disposal of radioactive waste.
- Indirect losses relating to the opportunity cost of removing agricultural land and forests from use and the closure of agricultural and industrial facilities; and
- Opportunity costs, including the additional costs of energy resulting from the loss of power from the Chernobyl nuclear plant and the cancellation of Belarus's nuclear power programme.

Coping with the impact of the disaster has placed a huge burden on national budgets. In Ukraine, 5–7 percent of government spending each year is still devoted to Chernobyl-related benefits and programmes. In Belarus, government spending on Chernobyl amounted to 22.3 percent of the national budget in 1991, declining gradually to 6.1 percent in 2002. Total spending by Belarus on Chernobyl between 1991 and 2003 is estimated at more than US $13 billion.

This massive expenditure has created an unsustainable fiscal burden, particularly for Belarus and Ukraine. Although capital-intensive spending on resettlement programmes has been curtailed or concluded, large sums continue to be paid out in the form of social benefits for as many as 7 million recipients in the three countries. With limited

[6] Belarus, for instance, has estimated the losses over 30 years at US $235 billion.

resources, governments thus face the task of streamlining Chernobyl programmes to provide more focused and targeted assistance, with an eye to helping those groups that are most at risk from health hazards or socio-economic deprivation.

What were the main consequences of Chernobyl for the local economy?

The affected territories are mostly rural. The main source of income before the accident was agriculture, both in the form of large collective farms (in the Soviet period), which provided wages and many social benefits, and small individual plots, which were cultivated for household consumption and local sale. Industry was mainly fairly unsophisticated, concentrated in food processing or wood products. This profile has remained largely the same after the accident, though the three countries have taken different approaches to the legacy of collective farms.

The agricultural sector was the area of the economy worst hit by the effects of the accident. A total of 784 320 hectares of agricultural land was removed from service in the three countries, and timber production was halted for a total of 694 200 hectares of forest. Restrictions on agricultural production crippled the market for foodstuffs and other products from the affected areas. “Clean food” production has remained possible in many areas thanks to remediation efforts, but this has entailed higher costs in the form of fertilizers, additives and special cultivation processes.

Even where remediation measures have made farming safe, the stigma of Chernobyl has caused some consumers to reject products from affected areas. Food processing, which had been the mainstay of industry in much of the region, has been particularly hard-hit by this “branding” issue. Revenues from agricultural activities have fallen, certain types of production have declined, and some facilities have closed altogether. In Belarus, where some of the best arable land was removed from production, the impact on agriculture has affected the whole economy.

Government policies aimed at protecting the population from radiation exposure (both through resettlement and through limitations on agricultural production) could not help but have a negative impact on the economy of the affected regions, particularly the rural economy. However, it is crucial to note that the region also faced great economic turmoil in the 1990s owing to factors completely unrelated to radiation. The disruption of trade accompanying the collapse of the Soviet Union, the introduction of market mechanisms, prolonged recessionary trends, and Russia's rouble crisis of 1998 all combined to undercut living standards, heighten unemployment and deepen poverty. Agricultural regions, whether contaminated by radionuclides or not, were particularly vulnerable to these threats, although Chernobyl-affected regions proved particularly susceptible to the drastic changes of the 1990s.

Wages tend to be lower and unemployment higher in the affected areas than they are elsewhere. This is in part the result of the accident and its aftermath, which forced the closure of many businesses, imposed limitations on agricultural production, added costs to product manufacture (particularly the need for constant dosimetric monitoring), and hurt marketing efforts. But equally important is the fact that farm workers in all three countries are among the lowest-paid categories of employees. Employment options outside of agriculture are also limited in Chernobyl-affected regions, but, again, the causes are as much a consequence of generic factors as of Chernobyl specifics. The proportion of small and medium-sized enterprises (SMEs) is far lower in the affected regions than elsewhere. This is partly because many skilled and educated workers, especially the younger ones, have left the region, and partly because — in all three countries — the general business environment discourages entrepreneurship. Private investment is also low, in part owing to image problems, in part to unfavourable conditions for business nationwide.

The result of these trends is that the affected regions face a higher risk of poverty than elsewhere. In seeking solutions to the region's economic malaise, it is important to address the generic issues (improving the business climate, encouraging the development of SMEs and the creation of jobs outside agriculture, and eliminating the barriers to profitable land use and efficient agricultural production) as well as addressing the issues of radioactive contamination.

What impact did Chernobyl and its aftermath have on local communities?

Since the Chernobyl accident, more than 330 000 people have been relocated away from the more affected areas. 116 000 of them were evacuated immediately after the accident, whereas a larger number were resettled several years later, when the benefits of relocation were less evident.

Although resettlement reduced the population's radiation doses, it was for many a deeply traumatic experience. Even when resettlers were compensated for their losses, offered free houses and given a choice of resettlement location, many retained a deep sense of injustice about the process. Many are unemployed and believe they are without a place in society and have little control over their own lives. Some older resettlers may never adjust.

Opinion polls suggest that many resettlers wished to return to their native villages. Paradoxically, people who remained in their villages (and even more so the "self-settlers," those who were evacuated and then returned to their homes despite restrictions) have coped better psychologically with the accident's aftermath than have those who were resettled to less affected areas.

Communities in the affected areas suffer from a highly distorted demographic structure. As a result of resettlement and voluntary migration, the percentage of elderly individuals in affected areas is abnormally high. In some districts, the population of pensioners equals or already exceeds the working-age population. In fact, the more contaminated a region, the older its population. A large proportion of skilled, educated and entrepreneurial people have also left the region, hampering the chances for economic recovery and raising the risk of poverty.

The departure of young people has also had psychological effects. An aging population naturally means that the number of deaths exceeds the number of births, yet this fact has encouraged the belief that the areas concerned were dangerous places to live. Schools, hospitals, agricultural cooperatives, utility companies and many other organisations are short of qualified specialists, even when pay is relatively high, so the delivery of social services is also threatened.

What has been the main impact on individuals?

As noted in the Chernobyl Forum report on *Health*, "the mental health impact of Chernobyl is the largest public health problem unleashed by the accident to date." Psychological distress arising from the accident and its aftermath has had a profound impact on individual and community behaviour. Populations in the affected areas exhibit strongly negative attitudes in self-assessments of health and well-being and a strong sense of lack of control over their own lives. Associated with these perceptions is an exaggerated sense of the dangers to health of exposure to radiation. The affected populations exhibit a widespread belief that exposed people are in some way condemned to a shorter life expectancy. Such fatalism is also linked to a loss of initiative to solve the problems of sustaining an income and to dependency on assistance from the state.

Anxiety over the effects of radiation on health shows no sign of diminishing. Indeed, it may even be spreading beyond the affected areas into a wide section of the population. Parents may be transferring their anxiety to their children through example and excessively protective care.

Yet while attributing a wide variety of medical complaints to Chernobyl, many residents of the affected areas neglect the role of personal behaviour in maintaining health. This applies not only to radiation risks such as the consumption of mushrooms and berries from contaminated forests, but also to areas where individual behaviour is decisive, such as misuse of alcohol and tobacco.

In this context, it is crucial to note that adult mortality has been rising alarmingly across the former Soviet Union for several decades. Life expectancy has declined precipitously, particularly for men, and in the Russian Federation stood at an average of 65 in 2003 (just 59 years for men). The main causes of death in the Chernobyl-affected region are the same as those nationwide — cardiovascular diseases, injuries and poisonings — rather than any radiation-related illnesses. The most pressing health concerns for the affected areas thus lie in poor diet and lifestyle factors such as alcohol and tobacco use, as well as poverty and limited access to health care. These threats may be even more acute in Chernobyl-affected areas, owing to the impact of low incomes on diet, the high share of socially deprived families, and shortages of trained medical staff.

Added to exaggerated or misplaced health fears, a sense of victimization and dependency created by government social protection policies is widespread in the affected areas. The extensive system of Chernobyl-related benefits (see below) has created expectations of long term direct financial support and entitlement to privileges, and has undermined the capacity of the individuals and communities concerned to tackle their own economic and social problems. The dependency culture that has developed over the past two decades is a major barrier to the region's recovery. These factors underscore the importance of measures aimed at giving the individuals and communities concerned control over their own futures — an approach that is both more efficient in use of scarce resources and crucial to mitigating the accident's psychological and social impact.

How have governments responded to the challenges of Chernobyl?

The Soviet Union undertook far-reaching measures in response to the Chernobyl nuclear accident. The government adopted a very low threshold with regard to the level of radioactive contamination that was considered acceptable for inhabited areas. The same caution applied to the zoning principles that were defined by the Soviet government in the wake of the accident, and that were subsequently reinforced by national legislation after the dissolution of the Soviet Union in 1991. These principles determined where people were permitted to live and imposed limitations on the types of activities that might be pursued (including farming and infrastructure investment). The zones were created based on very cautious standards for radiation risk and using measurements made very soon after the accident occurred.

In the wake of the accident, rehabilitation actions were undertaken on a huge scale (see Table). To accommodate the resettled populations, large investments were made in the construction of housing, schools, and hospitals, and also in physical infrastructure such as roads, water and electricity supply and sewerage. Because of the risk that was believed to be involved in burning locally produced wood and peat, many villages were provided with access to gas supplies for heating and cooking. This involved laying down a total of 8,980 kilometres of gas pipeline in the three countries in the fifteen years following the accident. Large sums were also spent to develop methods to cultivate "clean food" in the less contaminated areas where farming was allowed.

Chernobyl-related construction, 1986–2000

	Belarus	Russia	Ukraine	Total
Houses and flats	64 836	36 779	28 692	130 307
Schools (number of places)	44 072	18 373	48 847	111 292
Kindergartens (number of places)	18 470	3 850	11 155	33 475
Outpatient health centres (visits/day)	20 922	8 295	9 564	38 781
Hospitals (beds)	4 160	2 669	4 391	11 220

An extensive benefits system was established for the populations that were seen to have suffered as a result of the Chernobyl accident, either through exposure to radiation or resettlement. Benefits were offered to very broad categories of Chernobyl victims, defined as people who:

— Fell ill with radiation sickness or became invalids due to the consequences of the accident;

— Took part in clean-up activities at the Chernobyl site and in the evacuation zones in 1986–1987 (known colloquially as "liquidators");

— Participated in clean-up activities in 1988–1989;

— Continued to live in areas designated as contaminated; or,

— Were evacuated, or resettled, or left the affected areas at their own initiative.

Some 7 million people are now receiving (or are at least entitled to receive) special allowances, pensions, and health care privileges as a result of being categorized as in some way affected by Chernobyl. Significantly, benefits include measures that have no identifiable relation to the impact of radiation. Moreover, the benefits confer certain advantages and privileges even to those citizens who had been exposed to low levels of radiation or who continue to live in only mildly affected locations, where the level of radiation is close to natural background levels in some other European countries. In effect, these benefits compensate risk rather than actual injury.

By the late 1990s, Belarusian and Russian legislation provided more than seventy, and Ukrainian legislation more than fifty, different privileges and benefits for Chernobyl victims, depending on factors such as the degree of invalidity and the level of contamination. The system also guaranteed allowances, some of which were paid in cash, while others took the form of, for example, free meals for schoolchildren. In addition, the authorities undertook to finance health holidays in sanatoria and summer camps for invalids, liquidators, people who continued to live in highly affected areas, children and adolescents. In Belarus, almost 500 000 people, including 400 000 children, had the right to free holidays in the early 2000s. In Ukraine, the government funded 400 000–500 000 health holiday months per year between 1994 and 2000.

These government efforts were successful in protecting the overwhelming majority of the population from unacceptably high doses of radiation. They also stimulated the development of agricultural and food-processing techniques that reduced the radionuclide level in food. In the absence of alternative sources of income, government-provided Chernobyl benefits became the key to survival for many whose livelihoods were wiped out by the accident. And the health care system detected and treated thousands of cases of thyroid cancer that developed among children who were exposed to radioactive iodine in the weeks following the accident.

Alongside these successes, however, government efforts undertaken in response to the accident contained the seeds of later problems. First, the zones delineated to restrict the areas where people could live and work soon proved unwieldy. As the level of radiation declined over time, and knowledge on the nature of the risks posed by radiation became more sophisticated, the continuation of limitations on commercial activities and infrastructure development in the less affected areas became more of a burden than a safeguard. Zoning adjustments have been made in some places, but more needs to be done in light of new research.

Second, the massive investment programmes initiated to serve resettlement communities proved unsustainable, particularly under market economic conditions. Funding for Chernobyl programmes has declined steadily over time, leaving many projects half completed and thousands of half-built houses and public facilities standing abandoned in resettlement villages.

Third, the Soviet government delayed the public announcement that the accident had occurred. Information provision was selective and restrictive, particularly in the immediate aftermath of the accident. This approach left a legacy of mistrust surrounding official statements on radiation, and this has hindered efforts to provide reliable information to the public in the following decades.

Fourth, wide applicability meant that Chernobyl benefits mushroomed into an unsustainable fiscal burden. Somewhat counter-intuitively, the number of people claiming Chernobyl-related benefits soared over time, rather than declining. As the economic crisis of the 1990s deepened, registration as a victim of Chernobyl became for many the only means to an income and to vital aspects of health provision, including medicines. According to Ukrainian figures, the number of people designated as permanently disabled by the Chernobyl accident (and their children) increased from 200 in 1991 to 64 500 in 1997 and 91 219 in 2001.

In conditions of high inflation and increasing budget constraints, moreover, the value of the payments fell steadily in the early 1990s. In many cases, Chernobyl payments became meaningless in terms of their contribution to family incomes, but, given the large number of eligible people, remained a major burden on the state budget. Especially for Belarus and Ukraine, Chernobyl benefits drained resources away from other areas of public spending. By the late 1990s, however, any attempt to scale back benefits or explore alternative strategies to target high-risk groups was politically difficult, given the likelihood of protests from current recipients.

Despite this constraint, some changes to Chernobyl legislation have already been made to improve policy efficiency. In Belarus, for example, individual benefits are no longer paid to the least-affected categories of the population, and the meagre sums paid out as compensation to individual families living in the contaminated areas are now accumulated at the regional level and used by local authorities to improve medical and communal services for the affected population.

The enormous scale of the effort currently being made by the three governments means that even small improvements in efficiency can significantly increase the resources available for those in need. Governments realize that the costs and benefits of particular interventions need to be assessed more rigorously, and resources targeted more carefully to those facing true need. Resources now committed to Chernobyl health care benefits should be targeted to high-risk groups (e.g., liquidators) and those with demonstrated health conditions, or be shifted into a mainstream health care system that promotes preventive medicine and improved primary care. Similarly, Chernobyl benefits that in practice meet socio-economic needs should be folded into a nationwide means-tested social protection programme that targets the truly needy. Such changes take political courage, as reallocating resources faces strong resistance from vested interests.

Do people living in the affected regions have an accurate sense of the risks they face?

Nearly two decades after the Chernobyl accident, residents of affected areas still lack the information they need to lead healthy, productive lives, according to a range of opinion polls and sociological studies conducted in recent years. Although accurate information is accessible and governments have made many attempts at dissemination, misconceptions and myths about the threat of radiation persist, promoting a paralysing fatalism among residents. This fatalism yields both excessively cautious behaviour (constant anxiety about health) and reckless conduct (consumption of mushrooms, berries and game from areas of high contamination).

These findings were most recently confirmed by three country-specific reports prepared as part of the International Chernobyl Research and Information Network (ICRIN), a UN initiative to provide accurate and credible information to populations affected by the Chernobyl disaster. Surveys and focus group meetings involving thousands of people in each of the three countries in 2003–2004 showed that, despite concerted efforts by governments, scientists, international organizations, and the mass media, people living in the areas affected by the Chernobyl accident express deep confusion and uncertainty about the impact of radiation on their health and surroundings. Awareness is low of what practical steps to take to lead a healthy life in the region.

Overcoming mistrust of information provided on Chernobyl remains a major challenge, owing to the early secrecy with which Soviet authorities treated the accident, the use of conflicting data by different institutions, the unresolved controversies surrounding the impact of low-dose radiation on health, and the often complex scientific language in which information is presented.

Surveys showed that Chernobyl-area residents in all three countries are preoccupied with their own health and that of their children, but concern about low living standards is also extremely pronounced. Indeed, socio-economic concerns were viewed as more important than the level of radiation. Specifically, low household incomes and high unemployment cause uncertainty (see Fig. 10).

What worries you most today?

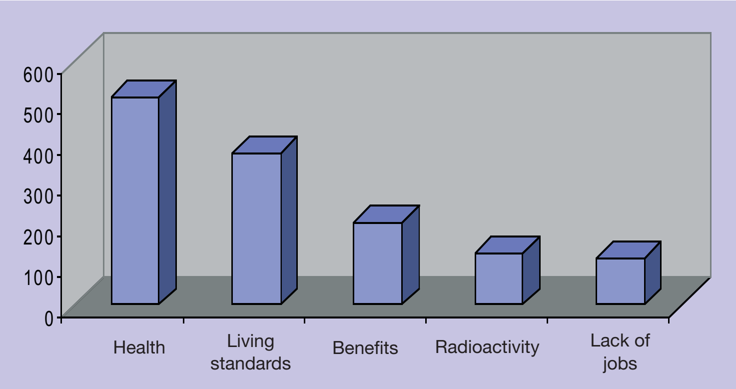


FIG. 10. Data from 2003 Russian survey, 748 respondents, multiple responses allowed

The ICRIN country studies confirm that Chernobyl-affected populations need unambiguous and comprehensible answers to a range of questions, as well as fresh policies that would focus on promoting the region's economic development. To get the message across, new ways of information delivery and education need to be found. The Chernobyl Forum findings should provide authoritative source material for creative dissemination to the affected populations, helping them both to lead healthier lives and overcome a paralyzing legacy of worry and fear.

How many people need direct assistance in coping with the consequences of Chernobyl, and how many are now in a position to help themselves?

In order best to address the human needs resulting from the accident, and to optimize the use of limited resources, it is important to understand the true nature of the threat, and the number of people actually at risk. Current scientific knowledge suggests that a small but important minority, numbering between 100 000–200 000, is caught in a downward spiral of isolation, poor health and poverty; these people need substantial material assistance to rebuild their lives. This group includes those who continue to live in severely affected areas and are unable to support themselves, unemployed resettlers, and those whose health is most at risk, including patients with thyroid cancer and other malignant cancers, and those with psychosomatic disorders. These people are right at the core of the cluster of problems created by Chernobyl. Resources should be focused on resolving their needs and on helping them to take control of their destinies in the circumstances that have resulted from the accident.

A second group, numbering several hundreds of thousands of individuals, consists of those whose lives have been directly and significantly affected by the consequences of the accident but who are already in a position to support themselves. This group includes resettlers who have found employment and many of the former clean-up workers. The priority here should be to help these people to normalize their lives as quickly and as far as is possible. They need to be reintegrated into society as a whole, so that their needs are increasingly addressed through mainstream provision and according to the same criteria as those that apply to other sections of society.

A third group consists of a much larger number of people, totalling several million in the three countries, whose lives have been influenced by the accident primarily in that they have been labelled as, or perceive themselves as, actual or potential victims of Chernobyl. Here the main need is for full, truthful and accurate information on the effects of the accident based on dependable and internationally recognized research, coupled with access to good quality mainstream provision in health care and social services; and to employment.

The approach of defining the most serious problems and addressing them with special measures, while pursuing an overall policy of promoting a return to normality, should apply to the affected territories as well as to the affected individuals and communities. Where in the light of the best scientific knowledge it is reasonably possible, measures should be adopted to integrate less severely affected areas back into productive use. This combination of measures — *focusing resources on those most in need, while actively promoting integration with mainstream provision wherever possible* — is not a second best. Within the available budgets it is really the only alternative to sweeping cutbacks in the recovery effort, wasteful dispersion of limited resources and continuing distress for the people at the centre of the problem. By fostering a process of healing, these measures will help to address the widespread psychosocial effects of the accident. They will protect the most vulnerable as Chernobyl budgets inevitably decline and will enable the authorities to promote an orderly process of recovery over the coming years.

Recommendations to the Governments of Belarus, the Russian Federation and Ukraine

Introduction

At the Chernobyl Forum meeting in April 2005 where the two reports of the expert groups —"Health", coordinated by the WHO, and "Environment", coordinated by the IAEA — were considered and approved, the Forum participants from Belarus, the Russian Federation and Ukraine requested the Forum to develop recommendations for the Governments of these three countries on special health care programmes and environmental remediation, including needs for further research, as well as for economic and social policies.

The document was prepared by the Forum Secretariat initially based on the recommendations presented in the Forum's technical reports. In addition, UNDP has contributed recommendations for economic and social policies based largely on the 2002 UN study, *Human Consequences of the Chernobyl Nuclear Accident — A Strategy for Recovery as well as on the World Bank's Belarus: Chernobyl Review* (2002). The recommendations were circulated among the Forum's participants and eventually accepted by consensus.

This document contains mostly generic advice for the Governments of the three affected countries; more detailed recommendations can be found in the respective technical reports. With regard to radiation protection of the public and the environment, the recommendations are based on current concepts of the International Commission on Radiological Protection (ICRP) and international safety standards developed by the IAEA.

Recommendations on Health Care and Research

Health care programmes and medical monitoring

Medical care and annual examinations of the workers who recovered from Acute Radiation Syndrome (ARS) and other highly exposed emergency workers should continue. This should include periodic examination for cardiovascular disease.

Current follow-up programmes for those persons with whole-body exposures of less than 1 Gy should be reconsidered relative to necessity and cost-effectiveness. From previous knowledge, these follow-up programmes are unlikely to be cost-effective or beneficial to individuals. Resources used for extensive examinations by teams of experts and blood and urine examination on an annual basis might more profitably be directed towards programmes to reduce infant mortality, reduce alcohol and tobacco use, to detect cardiovascular disease and to improve the mental health status of the affected population.

The following specific health related actions are recommended:

- Subgroups of populations known to be particularly sensitive (e.g. children exposed to significant amounts of radioiodine) that are at much higher risk than the general population should be considered for screening;

- Screening for thyroid cancer of those who were children and adolescents and resided in 1986 in the areas with radioactive fallout, should continue. However, as the population ages, many additional benign lesions will be found and there is a risk from unnecessary invasive procedures. Therefore, thyroid screening should be evaluated periodically for cost/benefit.
- For health planning purposes, continuous estimation of the predicted number of cases of thyroid cancer expected to occur in exposed populations, should be based on updated estimates of risk in those populations;
- High quality cancer registries should continue to be supported. They will be useful not only for epidemiological studies but also for public health purposes, e.g., providing reliable information to help guide the allocation of public health resources;
- Incidence rates for leukaemia in populations exposed as children to Chernobyl radiation and liquidators should continue to be monitored to detect increases that may still occur;
- Continued eye follow-up studies of the Chernobyl populations, will allow greater predictive capability of risk of radiation cataract onset and more importantly provide the data necessary to assess the likelihood of a resulting visual dysfunction. Annual monitoring for radiation cataract development may be recommended in case of occupational exposure to radiation;

— The local registers on reproductive health outcomes should be based on standard protocols for such conditions as congenital malformations and genetic disorders. It should be understood that such registers are unlikely to provide useful scientific information on radiation effects, however, may provide reassurance to the local population;

— Programs targeting minimization of the psychosocial impact on children and those who were children at the time of the accident should be encouraged and supported

— Renewed efforts at risk communication should be undertaken, providing the public and key professionals with accurate information about the physical and mental health consequences of the disaster.

Future research and follow-up studies

— In the years to come, careful studies of selected populations are needed in order to study the real effect of the accident and compare it to predictions.

— Registries of exposed persons should continue as well as studies of morbidity and mortality. These are typically for documentation or research purposes and usually will not be of direct medical benefit to the individual.

— Incidence of non-thyroid solid cancers in both the general population and cohorts of liquidators should continue to be monitored through the existing cancer registries and other specialized registries. Efforts to evaluate the quality of those registries and to reduce any deficiencies should be given high priority.

— Elevated radiation-induced morbidity and mortality from solid cancers of both emergency workers and populations of areas contaminated with radionuclides still might be expected during decades to come and requires more research. The feasibility and informativeness of studies should, however, be carefully evaluated before they are started.

— Well-designed epidemiological studies, with careful individual organ-specific dose reconstruction, should be conducted to confirm or inform recent findings about increases in leukaemia risk among accident recovery workers and in breast cancer among young women in the most affected districts.

— Presently, it is not possible to exclude an excess risk of thyroid cancer in persons exposed to Chernobyl radiation as adults. Carefully designed and appropriately analysed studies should be conducted to provide more information on ^{131}I related risks following adult exposure.

— Further work on the evaluation of uncertainties in thyroid dose estimates is strongly encouraged. This should lead to the determination of the parameters that give rise to the highest uncertainties and to research aimed at reducing those uncertainties. Cooperation and exchange of information among the dosimetrists from Belarus, Russia and Ukraine working in that area is strongly encouraged.

— A study is needed in the three affected countries on the role of radiation in the induction of cardiovascular diseases in emergency workers, using an appropriate control group, adequate dosimetry and common standardized clinical and epidemiological strategies and protocols.

— There should be continued study of immune system effects after high radiation doses (particularly on the survivors of the acute radiation syndrome). Studies of immune function in populations with less than several tens of mGy are unlikely to yield significant information.

Further information

More details and specific recommendations on Chernobyl-related health research can be found in the WHO report entitled “Health Effects of the Chernobyl Accident and Special Health Care Programmes”.

Recommendations on Environmental Monitoring, Remediation and Research

Environmental monitoring and research

— Long term monitoring of radionuclides (especially, ^{137}Cs and ^{90}Sr) in various environmental compartments is required to meet the following general practical and scientific needs:

Practical:

- To assess current and predict future levels of human exposure and radionuclides in foods to assess the need for remedial actions and long term countermeasures;

- To inform the general public in affected areas about the persistence of radioactive contamination in natural food products (such as mushrooms, game, freshwater fish from closed lakes, berries, etc);

- To inform the general public in affected areas about changing radiological conditions to relieve public concerns.

Scientific:

- To determine parameters of long term transfer of radionuclides in various ecosystems and different natural conditions to improve predictive models both for the Chernobyl-affected areas and for potential future radioactive releases;

- To determine mechanisms of radionuclide behaviour in less studied ecosystems (e.g., role of fungi in the forest) and explore remediation possibilities with special attention to processes important in contributing to human and biota doses.

— Various ecosystems considered in the present report have been intensively monitored and studied during the years after Chernobyl and environmental transfer and bioaccumulation of the most important long term contaminants, ^{137}Cs and ^{90}Sr are now generally well understood. There is therefore little need for major new research programmes on radioactivity; but there is a requirement for continued but more limited targeted monitoring of the environments, and for further research in some specific areas.

— As activity concentrations in environmental compartments are now in quasi-equilibrium and change slowly, the number and frequency of sampling and measurements performed for monitoring and research programmes can be substantially reduced compared with the early years after the Chernobyl accident.

— As current human exposure levels caused by the Chernobyl fallout are generally well known and they change slowly, large-scale monitoring of foodstuffs, whole-body counting of individuals, and provision of dosimeters to members of the general population are no longer necessary. However, individual measurements should be still used for critical groups in areas of high contamination and/or high transfer of radiocaesium.

— To further develop the system of environmental protection against radiation, the long term impact of radiation on plant and animal populations should be further investigated in the highly affected Chernobyl Exclusion Zone; this is a globally unique area for radioecological and radiobiological research in an otherwise natural setting. Such studies are, except for very small-scale experiments, not possible or difficult to perform elsewhere.

Remediation and countermeasures

- A wide range of different effective long term remediation measures are available for application in the areas contaminated with radionuclides, but their use should be radiologically justified and optimized. In optimizing countermeasures, social and economic factors should be taken into account, along with formal cost-benefit analysis, so that the use of the countermeasures is acceptable to the public.

- The general public, along with the authorities, should be particularly informed about existing radiation risk factors and methods to reduce them in the long term via remediation and regular use of countermeasures, and involved in discussion and decision-making.

- Particular attention must be given to the production on private farms in several hundred settlements and about 50 intensive farms in Belarus, Russia and Ukraine where radionuclide concentrations in milk still exceed national action levels.

- In the long term after the Chernobyl accident, remediation measures and regular countermeasures remain efficient and justified mainly in agricultural areas with poor (sandy and peaty) soils where there is a high radiocaesium transfer from soil to plants.

- Among long term remediation measures, radical improvement of pastures and grasslands as well as draining of wet peaty areas is very effective. The most efficient regular agricultural countermeasures are pre-slaughter clean feeding of animals accompanied with in-vivo monitoring, application of Prussian Blue to cattle and enhanced application of mineral fertilisers in plant breeding.

- There are still agricultural areas in the three countries that are taken out of use. However this land can be safely used after appropriate remediation, for which technologies are available, but at the moment legal, economic and social constraints may make this difficult. It is desirable to identify sustainable ways to make use of the most affected areas that reflect the radiation hazard, but also revive the economic potential for the benefit of the community. To this end, the three governments should urgently revisit the classification of Chernobyl-affected zones, as current legislation is too restrictive, given the low radiation levels that now prevail in most territories.

- Technologically based forest countermeasures, such as the use of machinery and/or chemical treatments to alter the distribution or transfer of radiocaesium in the forest, will not be practicable on a large scale.

- Restricting harvesting of wild food products such as game, berries, mushrooms and fish from 'closed lakes' by the public still may be needed in areas where their activity concentrations exceed national action levels.

- Advice on diet aiming to reduce consumption of highly contaminated wild food products and on simple cooking procedures that remove radiocaesium are still important countermeasures aimed at reducing internal exposure.

- It is unlikely that any future countermeasures to protect surface waters will be justifiable in terms of economic cost per unit of dose reduction. It is expected that restrictions on consumption of fish will remain, in a few cases (such as closed lakes), for several more decades. Future efforts in this area should be focused on public information, since there are still significant public misconceptions concerning health risks due to contaminated waters and fish.

- There is nothing that can be done to remedy the radiological conditions for plants and animals residing in the Exclusion Zone of the Chernobyl NPP that would not have an adverse impact on plants and animals.

- An important issue that requires more sociological research is the perception by the public of the introduction, performance and withdrawal of countermeasures after an emergency as well as development of social measures aimed at involvement of the public in these processes at all stages beginning with the decision making.

- There is still substantial diversity in international and national radiological criteria and safety standards applicable to remediation of areas contaminated with radionuclides. Experience with protection of the public after the Chernobyl accident has clearly shown the need for further international harmonization of appropriate radiological criteria and safety standards.

Environmental aspects of the Shelter dismantlement and radioactive waste management

- Safety and environmental assessments for individual facilities at and around the Chernobyl NPP should take into account the safety and environment impact assessment for all activities inside the entire Exclusion Zone.

- During the preparation and construction of the New Safe Containment (NSC) and soil removal, it is important to maintain and improve environmental monitoring strategies, methods, equipment and staff qualification needed for adequate monitoring of the conditions at the Chernobyl NPP site and the Exclusion Zone.

- Development of an integrated radioactive waste management programme based on existing programmes for the Shelter, the Chernobyl NPP site and the Exclusion Zone is needed to ensure application of consistent management approaches, and sufficient facility capacity for all waste types. Specific emphasis needs to be paid to the characterisation and classification of waste (in particular waste containing transuranic elements) from all the remediation and decommissioning activities, as well as the establishment of sufficient infrastructure for safe long term management of long lived and high level waste at the Chernobyl NPP site and in the Exclusion Zone.

- A coherent and comprehensive strategy for rehabilitation of the Exclusion Zone in Ukraine based on existing programmes is needed with particular focus on improving safety of the existing waste storage and disposal facilities. This will require development of a prioritization method for remediation of the sites, based on safety assessment results, aimed at determining at which sites waste will be retrieved and disposed, and at which sites waste will be allowed to decay in situ.

- Return of the Exclusion Zone to limited economic use will require well-defined administrative controls as to the nature of activities that may be performed in particular areas. In some of them, prohibition of agriculture may be needed for decades to come for radiological reasons. Accordingly, these re-used areas are best suited for an industrial site rather than an agricultural or residential area.

Further information

More specific recommendations on Chernobyl-related environmental remediation, monitoring and research issues can be found in the technical report of the Chernobyl Forum entitled "Environmental Consequences of the Chernobyl Accident and Their Remediation: Twenty Years of Experience", IAEA (2006).

Recommendations for Economic and Social Policy

What is to be done?

Current scientific knowledge about the impact of the disaster suggests that five general principles should underlie any approach to tackling the consequences of the accident:

— Chernobyl-related needs should be addressed in the framework of a holistic view of the needs of the individuals and communities concerned and, increasingly, of the needs of society as a whole;

— Moving away from a dependency culture in the affected areas, the aim must be to help individuals to take control of their own lives and communities to take control of their own futures;

— Efficient use of resources means focusing on the most affected people and communities. The response must take into account the limited budgetary resources at government disposal;

— The new approach should seek changes that are sustainable and long term, and based on a developmental approach;

— The international effort can only be effective if it supports, amplifies and acts as a lever for change in the far larger efforts made by local and national government agencies and the voluntary sector in the three countries.

Specific recommendations

Find new ways to inform the public

Innovative ways need to be developed to increase knowledge about how to live safely in environments that have suffered radioactive contamination, as well as to reassure people who live in areas where radiation exposure is too low to pose any real threat to health and well-being. These need to address the problems of credibility and comprehensibility that have hampered past efforts. Information provision targeted to specific audiences is needed, as well as trusted community sources.

Any new information strategy should embrace a comprehensive approach to promoting healthy lifestyles, and not simply focus on radiation hazards. Health education aiming at reducing internal and external radiation should be just one part of health promotion policies and interventions that aim at reducing the main causes of disease and rising mortality that affect Belarus, Russia and Ukraine.

Focus attention on highly affected areas. Government programmes need to be differentiated depending on radiation level, as problems are different among zones. Given that natural recovery processes along with protection measures have resulted in a significant reduction of radiation levels, governments need to make a renewed effort to revisit the classification of zones. Current delineations are far more restrictive than demonstrated radiation levels can justify.

Governments also need to clarify to the public, with the assistance of credible international agencies, that many areas previously considered to be at risk are in fact safe for habitation and cultivation. Zones with mild radiation levels can be made fit for adequate and even prosperous living with limited, cost-effective measures to reduce radiation exposure. The far smaller areas with higher levels of contamination require a different strategy focused on greater monitoring, provision of health and social services, and other assistance.

Streamline and refocus government programmes on Chernobyl. In order to meet the objectives of reducing the population's exposure to radiation and providing support to those who have been directly affected by the accident, current Chernobyl programmes need to be refocused in order to meet these objectives in a cost-effective manner. Programs should shift from those that create a victim and dependency mentality to those that support opportunity, promote local initiatives, involve the people and spur their confidence in shaping their destinies.

Adjustments to Chernobyl programmes should be guided by the following criteria:

a) Aligning programmes with new objectives;

b) Preventing the creation of perverse incentives; and

c) Matching the mandates with available resources.

These criteria suggest that certain programmes should be strengthened and expanded (e.g., supporting the production of clean food, monitoring and certification), whereas others should be revamped to target those genuinely in need (e.g., cash benefits linked to place of residence, mandatory mass screening).

— **Improve benefits targeting.** Many entitlements are not related to the health impact of radiation, but are mainly socio-economic in nature and correlated with residence rather than with any demonstrated need. These should be replaced with targeted programs for the needy. Chernobyl-related benefits and privileges should be folded into a mainstream social assistance programme that is targeted and means-tested. The definition of those who qualify as "Chernobyl victims" should be made more stringent and its application more effective, so that only those who indeed suffered from the accident benefit from this assistance. To make such a change palatable, consideration should be given to a "buy-out" plan for Chernobyl benefits that would exchange benefit entitlements for a lump-sum payout designed to encourage new small businesses.

— **Where not already done, eliminate benefits for individuals living in areas with mild contamination.** Enormous sums are currently spent on benefits that make little significant difference to individual households yet pose a huge burden on national budgets — or are not paid at all owing to revenue shortfalls. Moreover, correlating benefits with area of residence alone is unsound public policy, particularly where radiation levels are as low as natural background levels in other parts of Europe. Special health care benefits should be applicable only if individual ill health or a need for high-risk monitoring can be demonstrated. Those who need state assistance on poverty grounds should be covered by a nationwide targeted and means-tested system of social assistance.

— **Improve primary health care, including psychological support.** Strengthening of primary health care services in affected areas should receive priority. This should include promotion of healthy lifestyles; improvement in access and quality of reproductive health care, especially obstetric health care in the most contaminated areas; and provision of psychological support and diagnosis and treatment of mental diseases, especially depression.

— **Rethink health recuperation programmes.** Government-funded recuperation programmes, such as stays in sanatoria and summer camps, need to be reassessed. Such benefits are not generally effective in reducing radiation exposure, but they can offer important psychological and health benefits to residents of Chernobyl-affected areas. What is needed is to review such entitlements with the aim of linking benefit provision more tightly with diagnosed medical conditions or documented health risks. Better targeting of such benefits will yield savings that could be devoted to improving general health care provision and promoting healthy lifestyles.

Many international charities offer similar “health holidays” abroad to children of the affected regions. Such programs are popular and generally beneficial to participants. However, governments should encourage charities providing travel abroad to engage as well in the effort to promote better health outcomes in the affected communities themselves. Both government and charitable recuperation programs should ensure that travel outside the region is provided in a way that does not exaggerate the danger of living in Chernobyl-affected areas.

— **Encourage safe food production.** Continued efforts are needed to develop and promote agricultural products that can be produced safely where radionuclides are present in the soil. Know-how is available, but some countermeasures are currently not being applied due to the lack of funds. Little is being done to ensure the production of clean food on private plots, and thus to address the issue of food being produced for personal consumption or for sale on village markets. But cost-benefit analysis is essential in propagating mitigation measures, as the costs of producing “clean food” may exceed any reasonable market value.

Adopt a new approach to economic development of the affected regions

— **Put economic development aiming to make the affected communities economically and socially viable** in the medium and long term at the centre of strategies to address the effects of Chernobyl. This should be done in such a way as to give the individuals and communities concerned **control over their own futures**, which is both efficient in terms of resources and crucial in addressing the psychological and social effects of the accident. Understand that very large resources are needed to promote economic recovery in these communities, but also that achieving **economic self-sufficiency and community self-reliance** will free up large national resources, which are at present tied up in subsidies and special Chernobyl-related assistance.

— **Improve the business climate, encourage investment and support private sector development.** At the national level, sound finances and the creation of an open competitive market economy and an investment friendly business environment are preconditions for sustained recovery in the affected areas. Appropriate national policies need to be supplemented by a proactive approach to stimulating economic development at the regional and local levels. Economic incentives, such as special zones, should be used only in tandem with improvement in the business environment, as the use of tax and other incentives to attract entrepreneurial and skilled people to the region may not work in an unfriendly business environment or because badly designed instruments may lead to perverse incentives.

— **Support initiatives to promote inward investment, both domestic and international,** at the regional level, to promote employment and create a positive image for the areas concerned. The international community can play an important part in this effort by assisting in **transferring experience** from successful initiatives in other parts of the world that have been blighted by economic restructuring, high levels of unemployment and environmental contamination. Build on experience of the **local economic development agencies** already functioning in the region to build a network of intermediary organisations that are sensitive to local conditions and can act as an interface with national and international development bodies and donors.

— **Encourage the creation and growth of small and medium-size enterprises** in the affected areas and in the adjacent towns and cities using the whole range of business support techniques that have been tried and tested in other parts of the world. Because of the nature of the local economies concerned, particular efforts are needed to promote **indigenous agricultural and food processing businesses** by supporting the growth of existing enterprises (whatever their ownership status), and through new ventures.

— **Adapt examples of good practice** in the three countries and abroad, including community based solutions such as **credit unions and producer and consumer cooperatives**, to the special circumstances that apply in the affected areas. An appropriate legal and organisational framework should be developed to ensure that such businesses get the support that they need.

— **Give high priority to supporting very small-scale business development** as the local level, including village level enterprise clusters to boost the incomes of the poorest households. Such initiatives must draw on the growing body of international experience in this area and be sensitive to the very special problems affecting communities that largely depend on food production in areas suffering from radioactive contamination.

— **Promote the rebuilding of community structures** to replace those that were lost in the process of evacuation and as a result of the break up of the Soviet Union. Initiatives specifically designed to strengthen social interactions and promote community and economic leadership in towns and villages are needed to underpin sustainable recovery.

— **Explore the possibilities for promoting specialized ecological tourism** and for maximising the contribution that these areas can make to the **preservation of international biodiversity**. Little attempt has been made to exploit the reduction of human disturbance to the ecosystems and cultural landscape in a positive way and the current national plans for biodiversity protection and cultural preservation hardly refer to this potential. The territories could be used to fulfil the three countries' **international obligations on the protection of biodiversity**.

Further information

More detailed policy recommendations on improving socio-economic conditions and reviving community life in Chernobyl-affected areas can be found in the UN publication, *Human Consequences of the Chernobyl Nuclear Accident: A Strategy for Recovery* (2002), and the World Bank's *Belarus: Chernobyl Review* (2002).

Acknowledgement

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Atoms For Peace

The Chernobyl Forum: Major Findings and Recommendations

Mikhail BALONOV
Scientific Secretary

IAEA
International Atomic Energy Agency

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- **Expert Group "Environment"**
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- **Expert Group "Health"**
  - Dr Geoff Howe, USA, EGH Co-chair (Thyroid Studies)
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  - Louisa Vinton, UNDP

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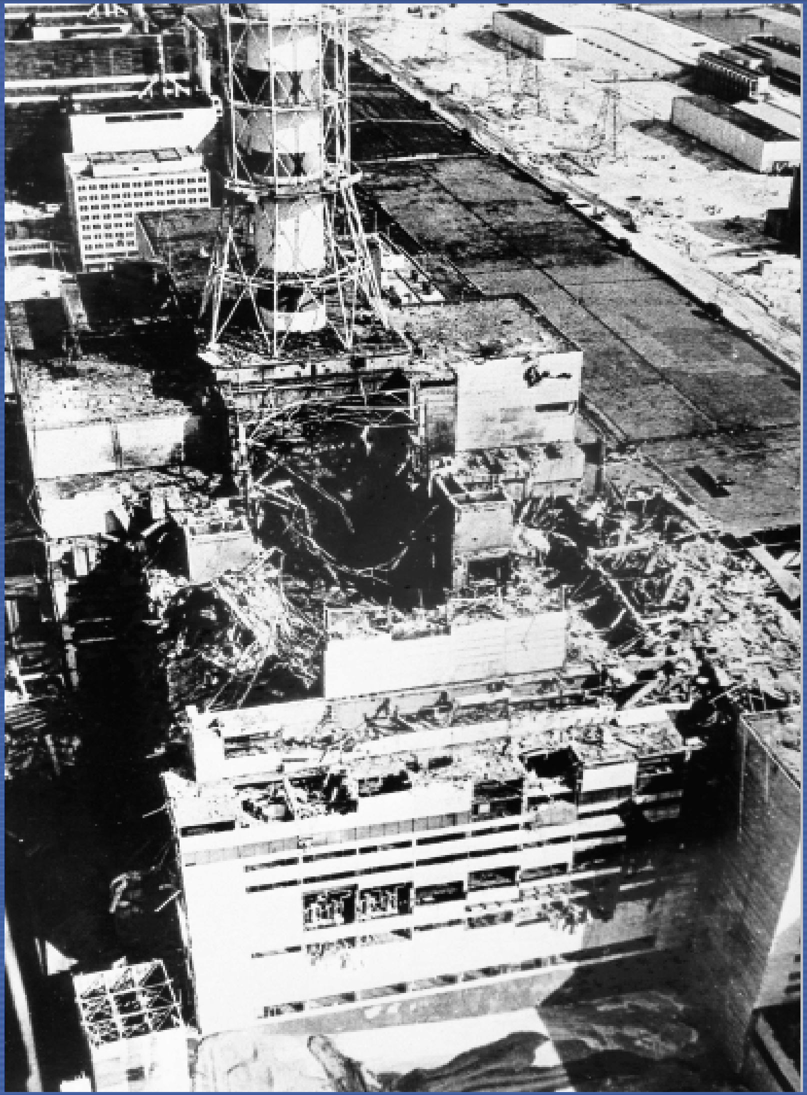
  - Major scientific findings and recommendations for future actions
- Dissemination of Forum materials:
  - Chernobyl Conference in Vienna, September 2005
  - 60th Session of UN GA, November 2005
  - Presentation at more than 20 meetings
  - Distribution of Forum reports

The accident

- On 26 April, 1986, at 01:23 a.m. two explosions destroyed Unit 4 of the Chernobyl NPP located 100 km N from Kiev (~2.5 mln) and just 3 km from Pripyat (~50 ths.)
- The destroyed reactor got fire that continued for 10 days.



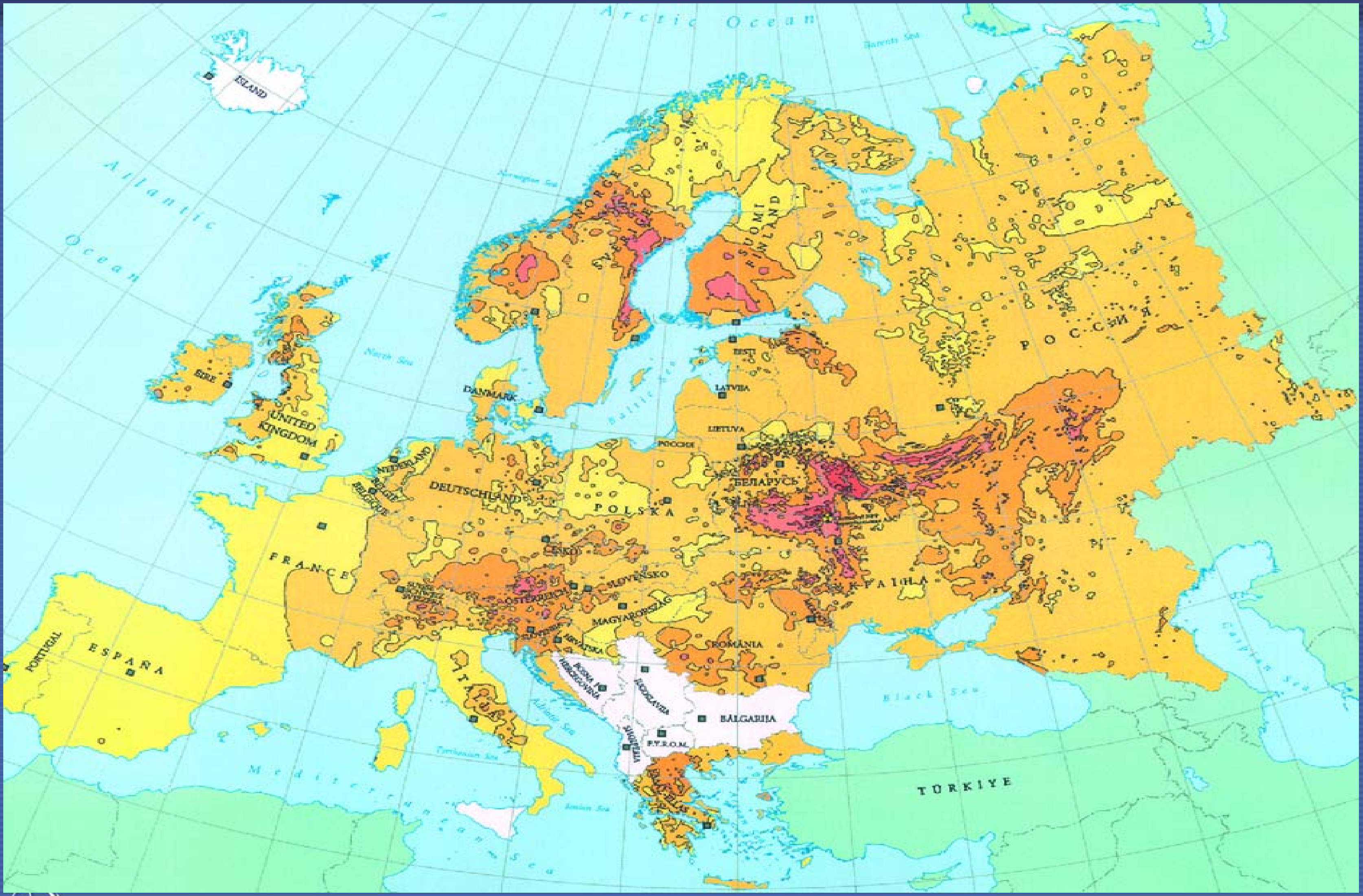
Mitigation of the accident consequences

- Evacuation of 116 ths. residents of the most affected areas
- Construction of the Shelter by November 1986
- Decontamination of settlements
- Countermeasures in agriculture, water supply and forestry

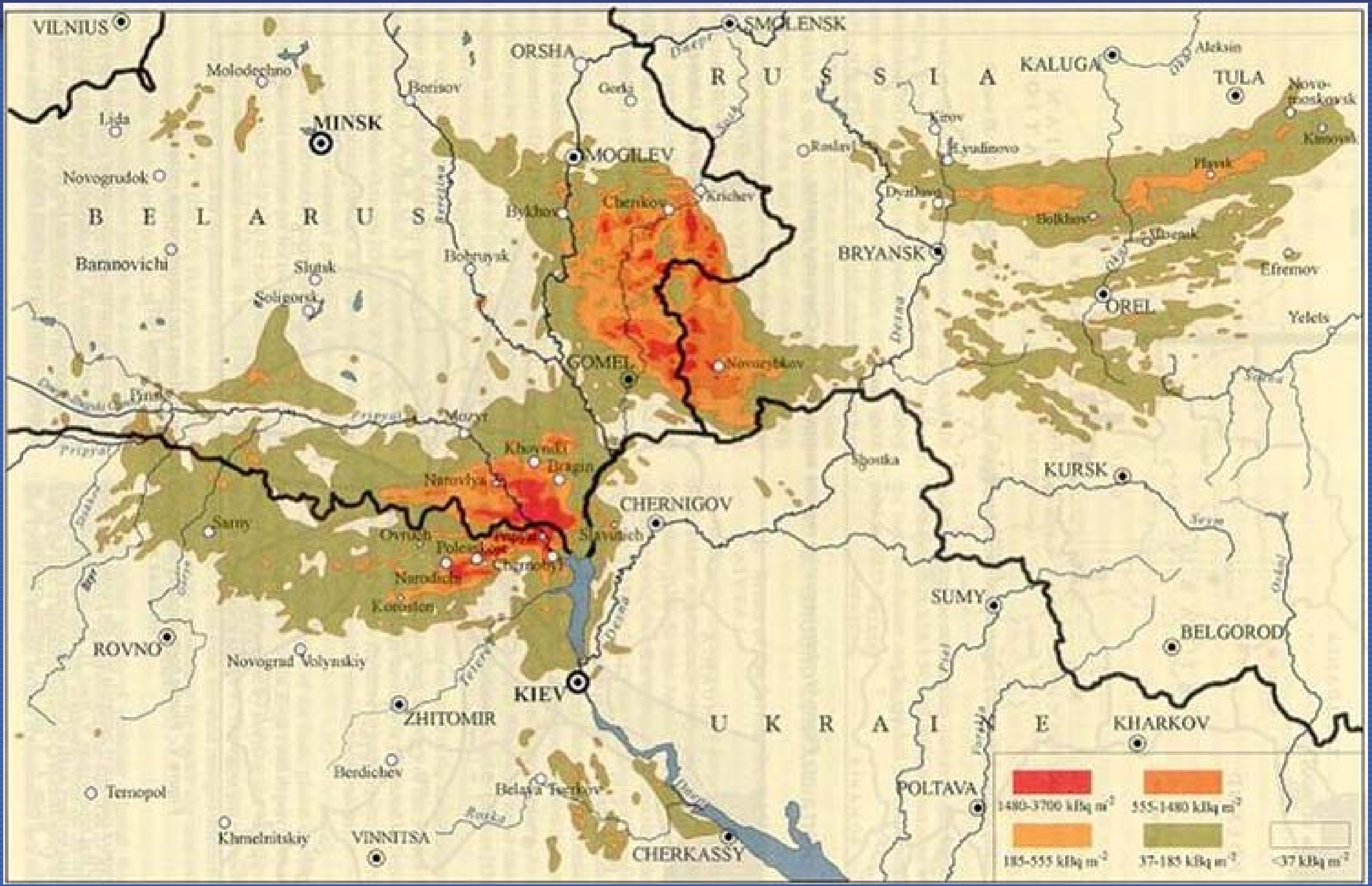
Enormous scale of the accident consequences

- Early health effects:
  - Two persons killed by explosion and thermal burns;
  - ARS in 134 emergency workers;
  - 28 of them died in 1986, 19 more died in 1987-2004
- More than 600 ths recovery operation workers exposed
- About 14×10^{18} Bq radioactivity released; the most radiologically important radionuclides were ^{131}I and ^{137}Cs
- More than 200,000 sq. km of Europe 'contaminated' with ^{137}Cs, mostly in FSU countries
- 340 ths people evacuated or resettled
- More than 5 mln. people live in 'contaminated' areas
- Economic costs of hundreds billions USD

Deposition of ^{137}Cs in Europe



^{137}Cs spots in Belarus, Russia and Ukraine



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Assessment of Chernobyl consequences

- **National assessments:**
  - **Environmental – Acad. Yu. Izrael,**
  - **Agricultural – Acad-s R. Alexakhin and B. Prister,**
  - **Health – Acad-s L. Ilyin, A. Tsyb**
  - **Social and Economic - Acad. S. Belyaev**
- **Lack of credibility at the national level, because of early secrecy and for political reasons**
- **Substantial concern and controversy worldwide**
- **International assessments needed**

International assessments

- Post-accident review meeting – IAEA, August 1986
- International Chernobyl Project – IAEA, 1990
- UNSCEAR reports – 1988, 1993 and 2000
- IPHECA – WHO, 1991-1995
- EC + FSU joint research projects – 1992-1999
- International Conference "One Decade after Chernobyl: Summing up the Consequences" - IAEA, WHO and EC, 1996
- The Human Consequences of the Chernobyl Nuclear Accident – A Strategy for Recovery – UNDP, 2002
- **The Chernobyl Forum – 2003-2005**

The Chernobyl Forum: political context

- Initiated by the IAEA DG Mr ElBaradei
- Contribution to the implementation of the UN “Strategy for Recovery”
- 8 UN organisations + 3 Governments (Belarus, Russia and Ukraine) involved
- An attempt to agree on fact interpretation and recommendations for future actions by 20th anniversary.
- The results considered by 60th UN General Assembly, Nov 2005.

Major tasks of the Chernobyl Forum

- To generate authoritative consensual statements on the health effects attributable to radiation exposure and the environmental consequences induced by the radioactive materials released due to the accident;
- To provide advice on remediation and special health care programmes; and
- To consider the necessity for continued research, aimed at resolving the disputed issues.

Forum operation

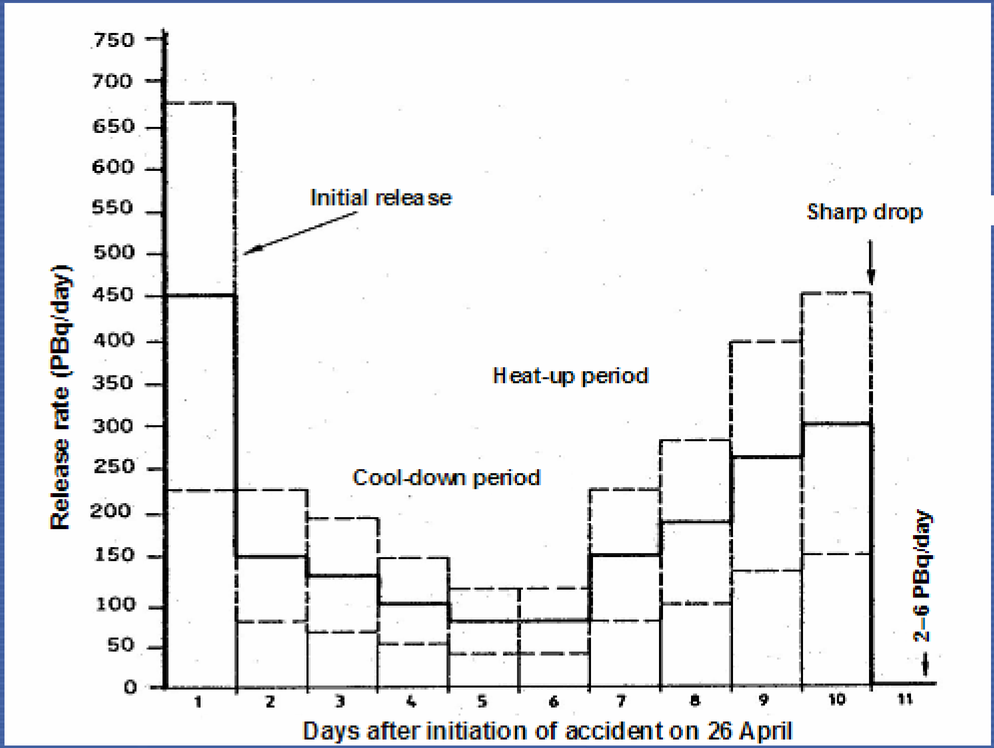
- Annual managerial meetings of senior officials from 8 UN organizations and the 3 affected States + observers
- Regular expert meetings on the environmental consequences organised by the IAEA (EGE) and those on human health (EGH) organised by the WHO – in total 11 meetings
- More than 80 experts from 12 countries and 6 international organisations, such as UNSCEAR, IUR, IARC, etc.
- Forum reports on environment and health and the Digest report approved by consensus in April 2005
- UNDP complemented the Digest report with the social and economic issues based on UN, 2002

Chernobyl Forum's products

http://www.iaea.org/NewsCenter/Focus/Chernobyl/index.shtml

Main conclusions of the Chernobyl Forum -1

- The accident at the Chernobyl NPP in 1986 was the most severe in the history of the world nuclear industry.
- Due to the vast release of radionuclides it also became the first magnitude radiological accident.

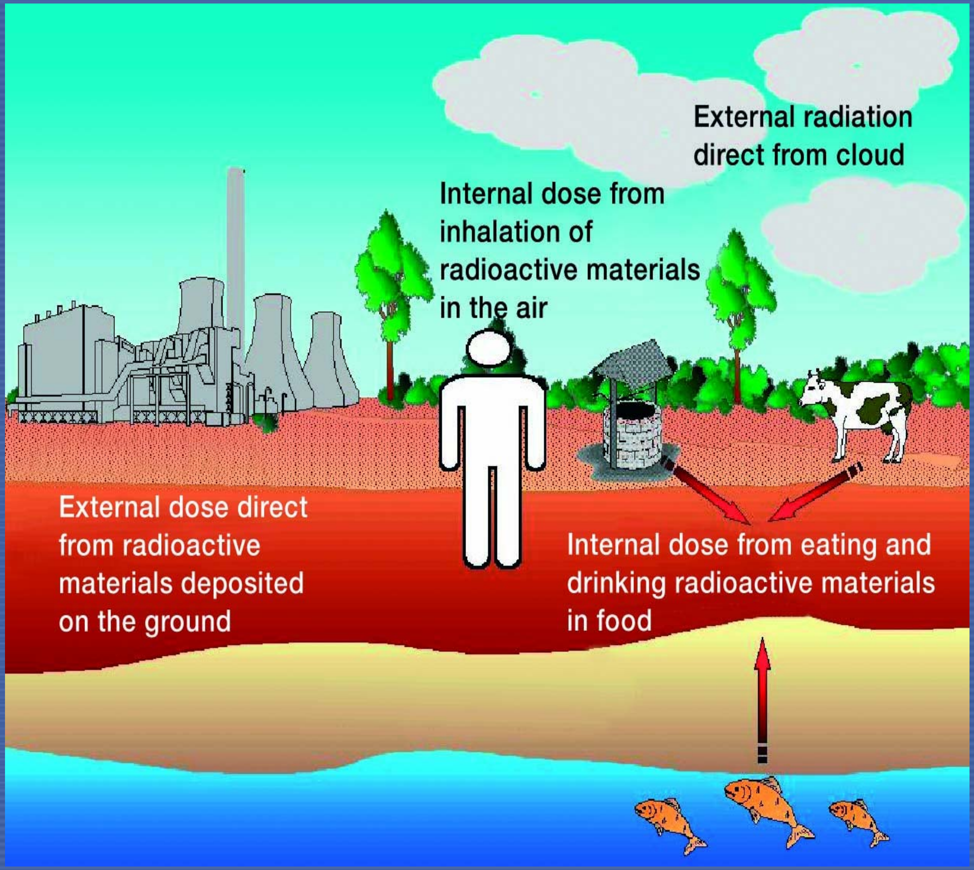


Main conclusions of the Chernobyl Forum - 2

However, in the course of years, the most significant problems have become the severe social and economic depression of the affected Belarusian, Russian and Ukrainian regions and the associated serious psychological problems of the general public and emergency workers.

Main conclusions of the Chernobyl Forum - 3

- The majority of the more than 600 ths. recovery operation workers and 5 mln. residents of the contaminated areas in Belarus, Russia and Ukraine received relatively minor radiation doses which are comparable with the natural background levels.
- This level of exposure did not result in any observable radiation-induced health effects.



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Summary of average accumulated doses to affected populations from Chernobyl fallout

Population category	Number	Average dose, mSv
Liquidators (1986-1989)	**600,000**	**~100**
Evacuees (1986)	**116,000**	**33**
Residents of SCZ (1986-2005)	**270,000**	**>50**
Residents of other 'contaminated' areas (1986-2005)	**5,000.000**	**10-20**

Natural background dose during 20 y: 50 mSv (20-200 mSv)

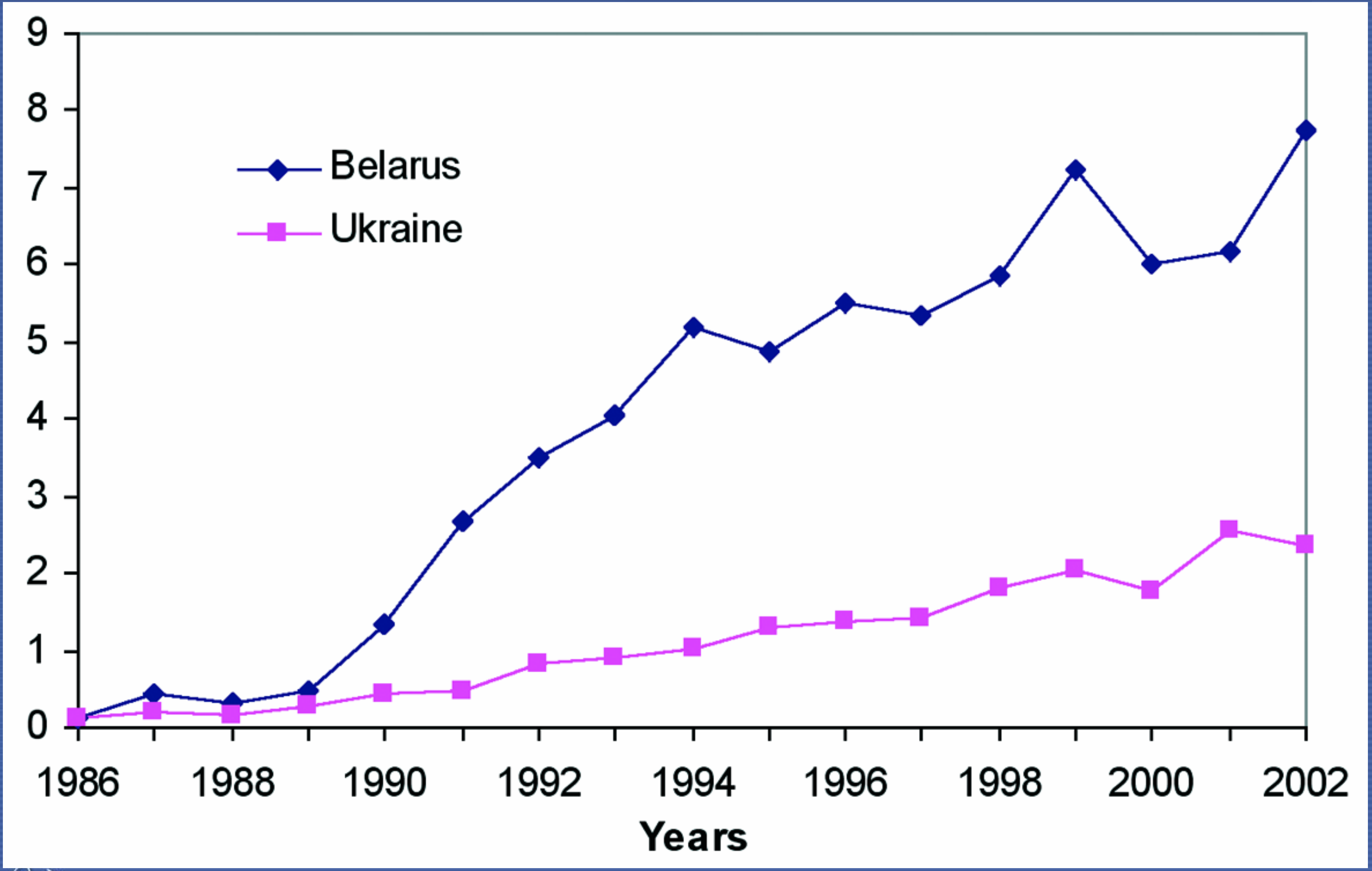
Main conclusions of the Chernobyl Forum – 4

- An exception is a cohort of several hundred emergency workers who received high radiation doses; of whom near 50 died due to radiation sickness and subsequent diseases.
- According to bio-statistical forecast, radiation has caused, or will cause, the premature deaths of around 4000 people from the 600 000 affected by the higher radiation doses due to the Chernobyl accident.

Main conclusions of the Chernobyl Forum - 5

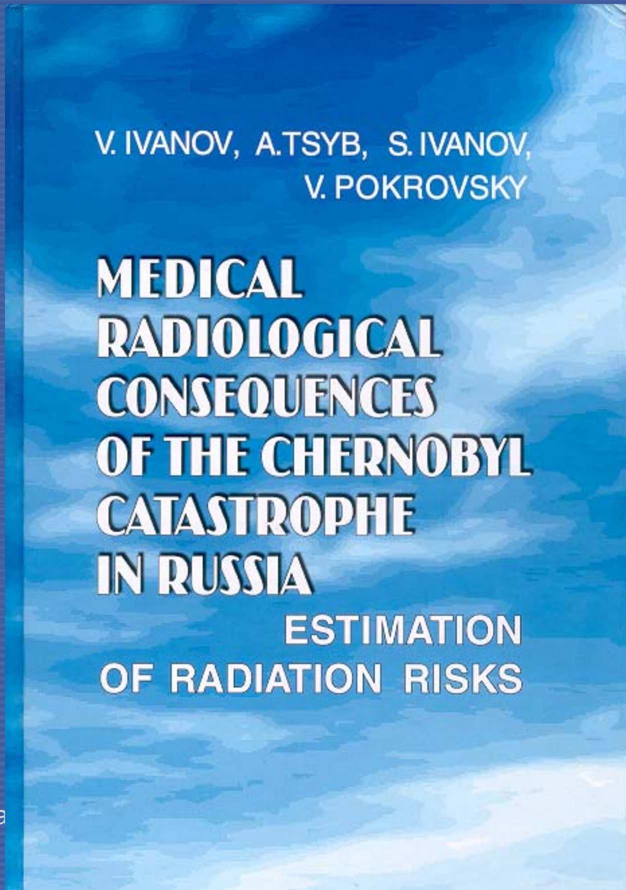
- Another cohort affected by radiation are children and adolescents who in 1986 received substantial radiation doses in the thyroid due to the consumption of milk contaminated with radioiodine.
- In total, about 4000 thyroid cancer cases have been detected in this cohort during 1992–2002; more than 99% of them were successfully treated, but fifteen persons died (as of 2004).

Incidence rate of thyroid cancer per 100,000 children and adolescents as of 1986 (after Jacob et al., 2005)

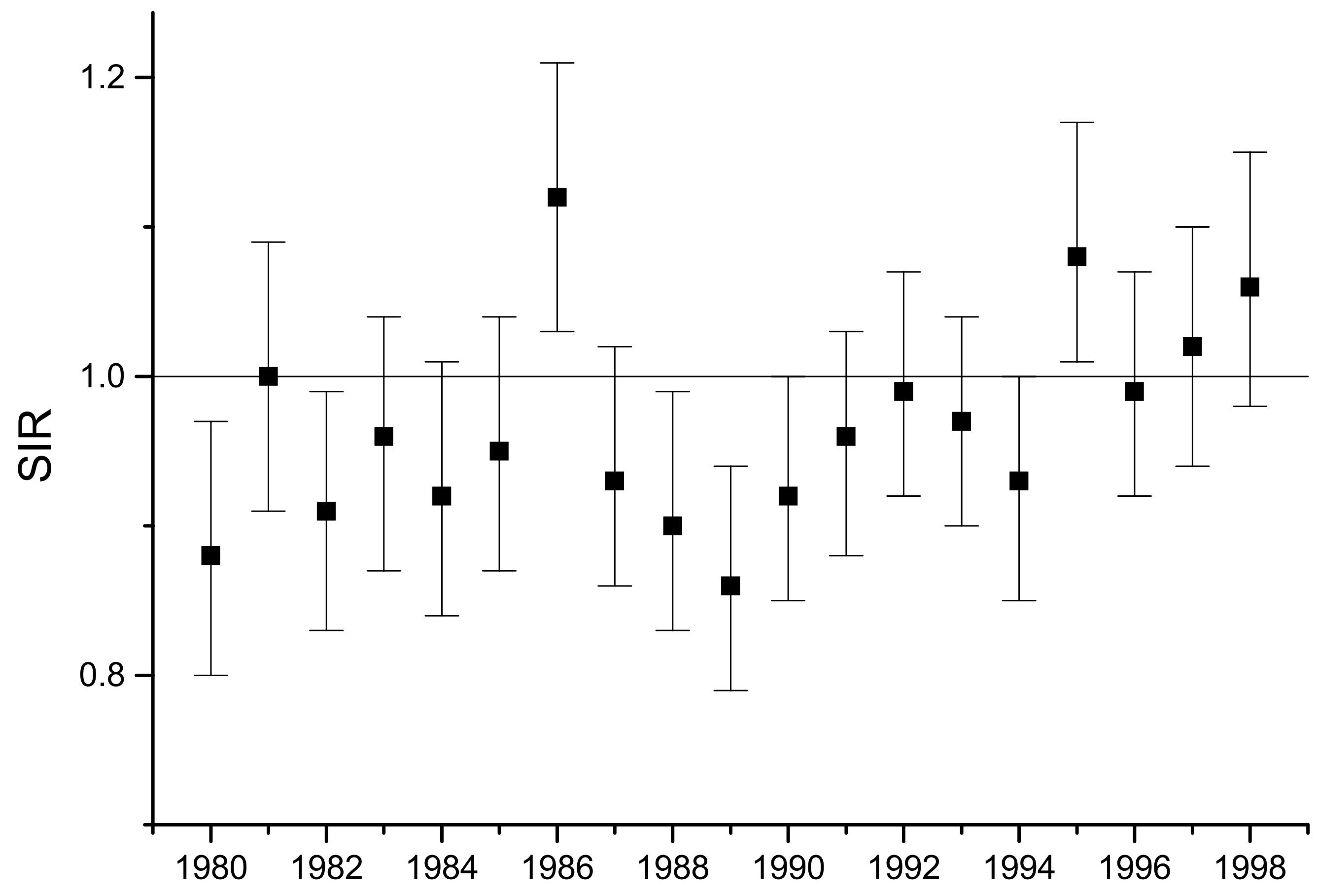


Other diseases resulted from the Chernobyl radiation exposure

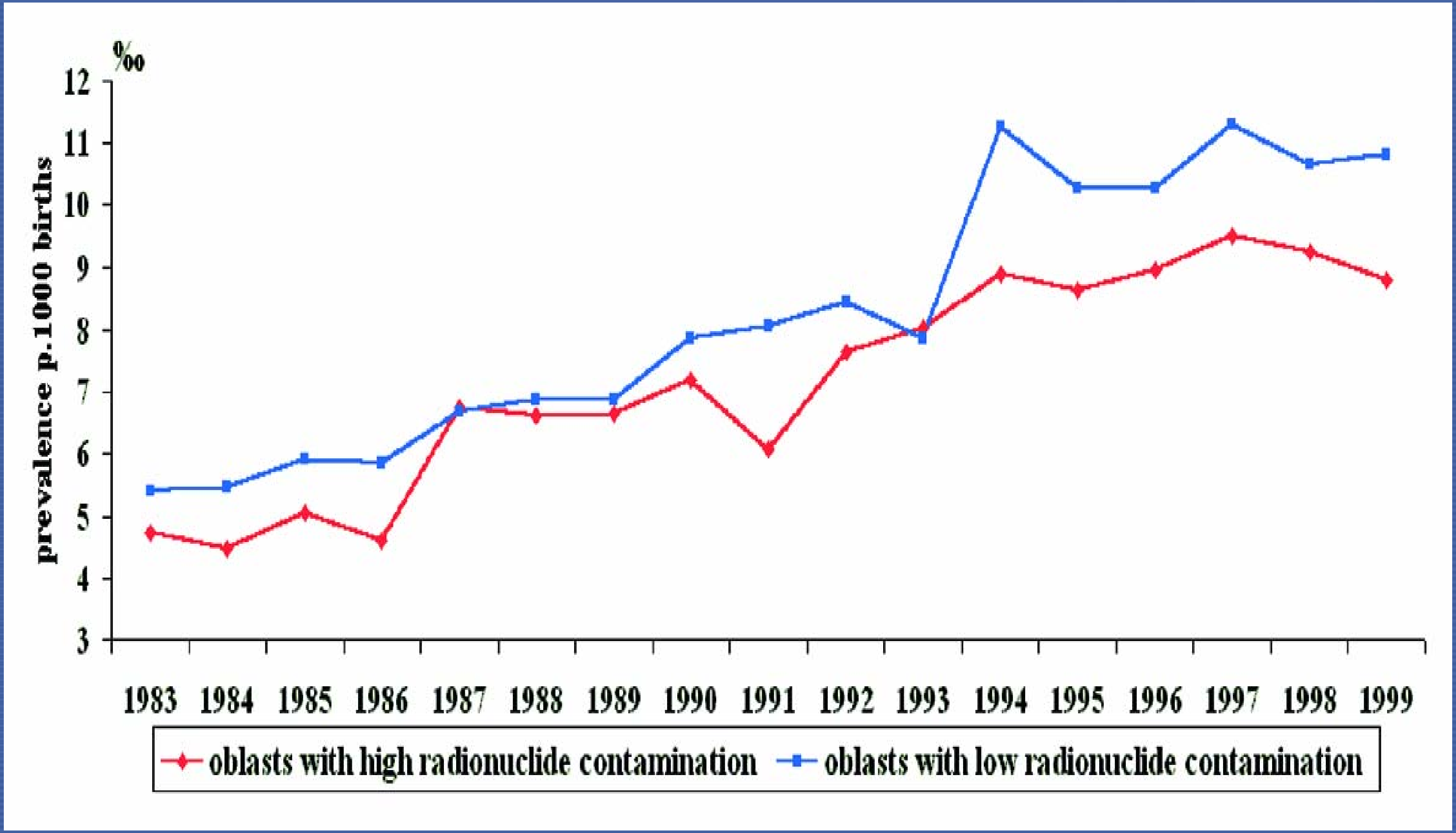
- **Russian emergency and recovery operation workers, according to RNMDR (Ivanov et al. 2004):**
  - **Doubling of leukemia morbidity in workers with D>150 mGy,**
  - **Some increase of mortality (~5%) caused by solid cancer and cardiovascular diseases,**
  - **Increased cataract frequency.**
- **Residents of contaminated areas:**
  - **No reliable data on increased incidence of any somatic disease except of thyroid cancer in children and adolescents (considered above),**
  - **According to bio-statistical forecast, substantial increase of radiation-induced somatic morbidity in the future is unlikely.**



Dynamics of solid cancer incidence among residents of 5 contaminated rayons of the Bryansk oblast standardized to incidence in other rayons (SIR) (Ivanov&Tsyb, 2004)



Prevalence of malformations at birth in 4 oblasts of Belarus with high and low levels of radionuclide contamination (Lazjuk GI et al., 1999)



Main conclusions of the Chernobyl Forum – 6

Psychological consequences:

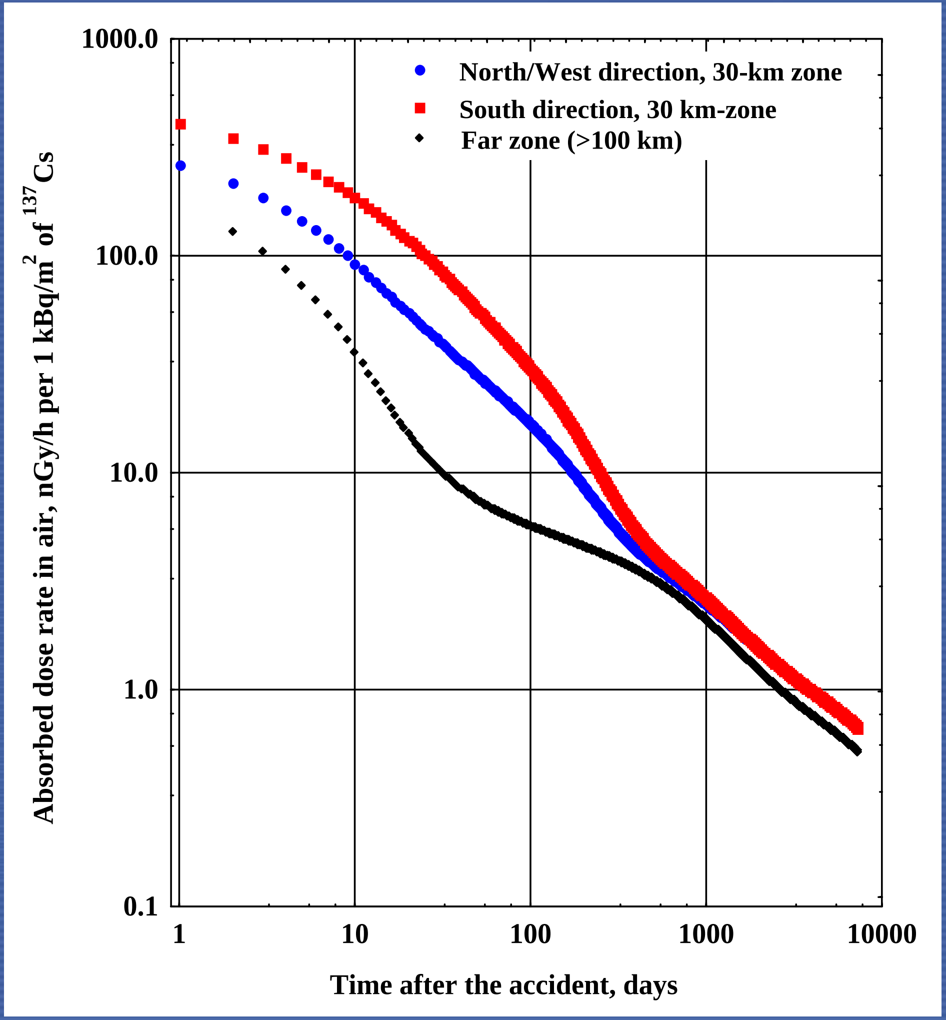
- Many people have been traumatised by the relocation, the breakdown in social contacts, fear and anxiety about what health effects might result.
- Elevated anxiety and unexplained physical symptoms among affected people reported.
- Self-perception as“Chernobyl Victims or Invalids” and not the “Chernobyl Survivors”.
- Renewed efforts at risk communication, based on accurate information about the health and mental health consequences of the disaster, should be undertaken.

Recommendations on health care and research

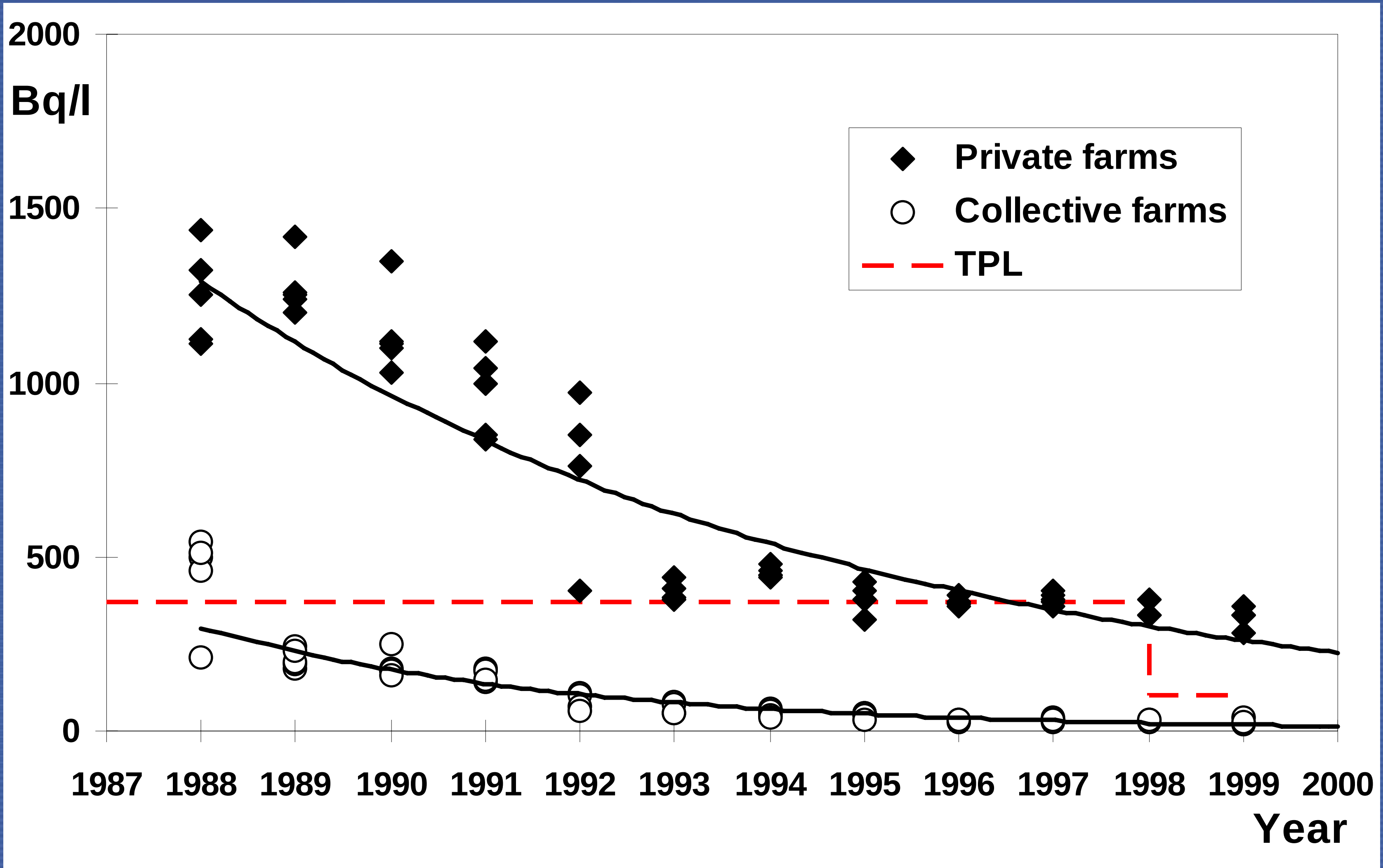
- Medical care and annual examinations of the highly exposed emergency workers, including those recovered from ARS should continue.
- Current follow-up programmes for persons with whole-body doses of less than 1 Gy should be reconsidered relative to necessity and cost-effectiveness.
- Resources might more profitably be directed towards reduction of infant mortality, alcohol and tobacco use, detection cardiovascular disease and improvement of mental health status of the affected population.
- Screening for thyroid cancer of children and adolescents, who resided in 1986 in the areas with radioactive fallout, should continue.
- A number of other targeted recommendations.

Main conclusions of the Chernobyl Forum – 7

- Radiation levels in the environment have reduced by a factor of several hundred since 1986 due to natural processes and countermeasures.
- Therefore, the majority of the land that was previously contaminated with radionuclides is now safe for life and economic activities.

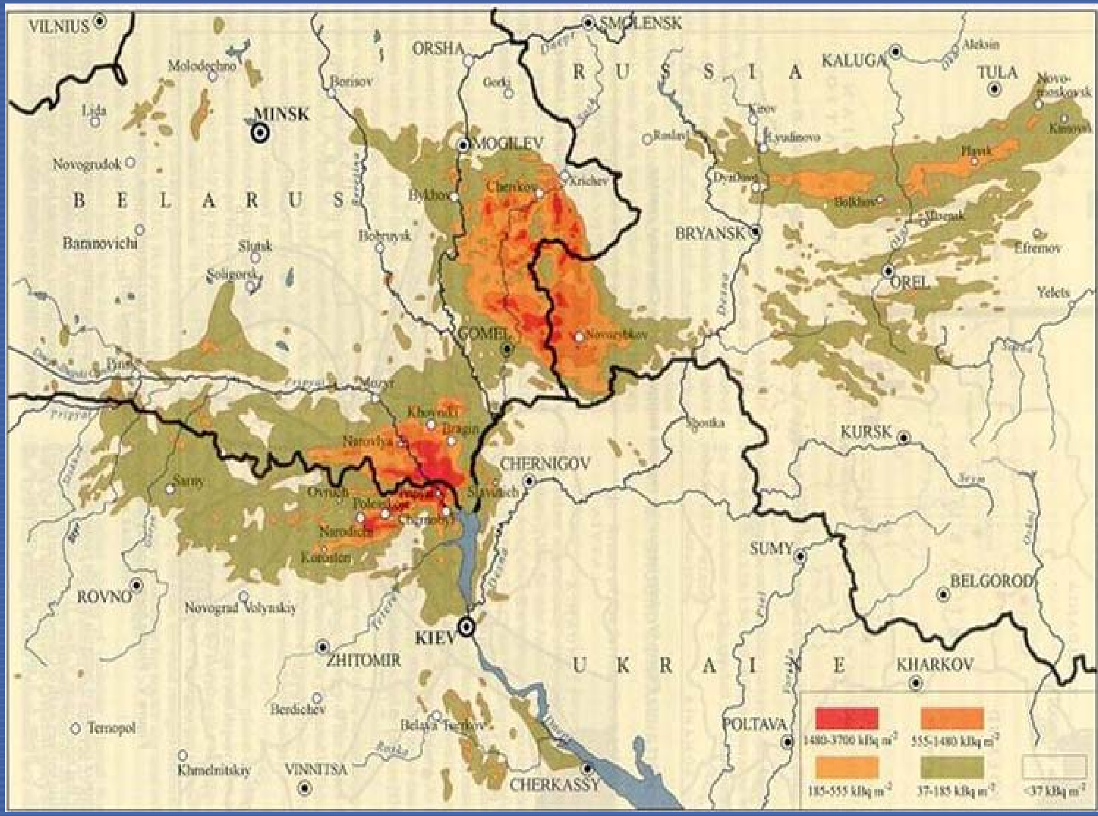


Typical dynamics of Cs-137 activity concentration in milk with a comparison to TPL, Rovno region, Ukraine



Main conclusions of the Chernobyl Forum – 8

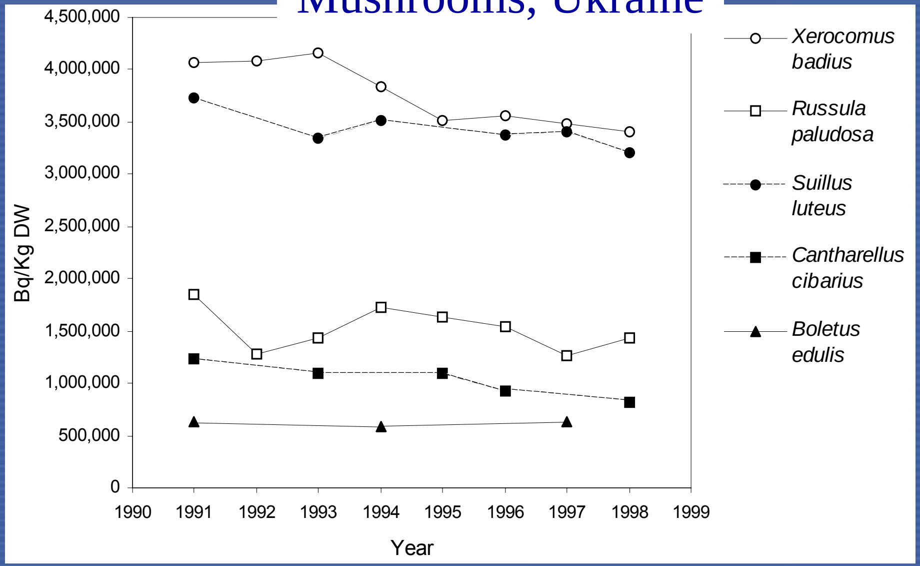
However, in the Chernobyl Exclusion Zone and in some limited areas of Belarus, Russia and Ukraine some restrictions on land-use should be retained for decades to come.

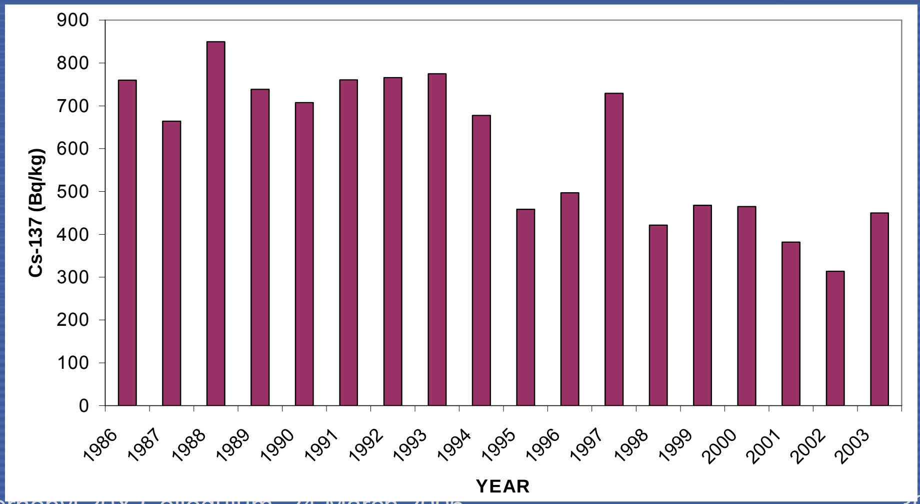


Main conclusions of the Chernobyl Forum – 9

- Particularly high ^{137}Cs activity concentrations have been found in mushrooms, berries, and game;
- These high levels have persisted for two decades, and this can be expected to continue for several decades.

Mushrooms, Ukraine





Moose, Sweden

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Main conclusions of the Chernobyl Forum – 10

Radiation-induced effects on plants and animals

- Irradiation caused numerous acute adverse effects on the plants and animals living up to 10-30 kilometres from the release point.
- The following effects caused by radiation-induced cell death have been observed in biota:
  - Increased mortality of coniferous plants, soil invertebrates and mammals; and
  - Reproductive losses in plants and animals.
- A few years were needed for recovery from major radiation-induced adverse effects in populations of plants and animals.
- Due to removal of human activities, the Exclusion Zone has paradoxically become a unique sanctuary for biodiversity.
- There is nothing that can be done to remedy the radiological conditions for plants and animals residing in the Exclusion Zone that would not have an adverse impact on plants and animals.

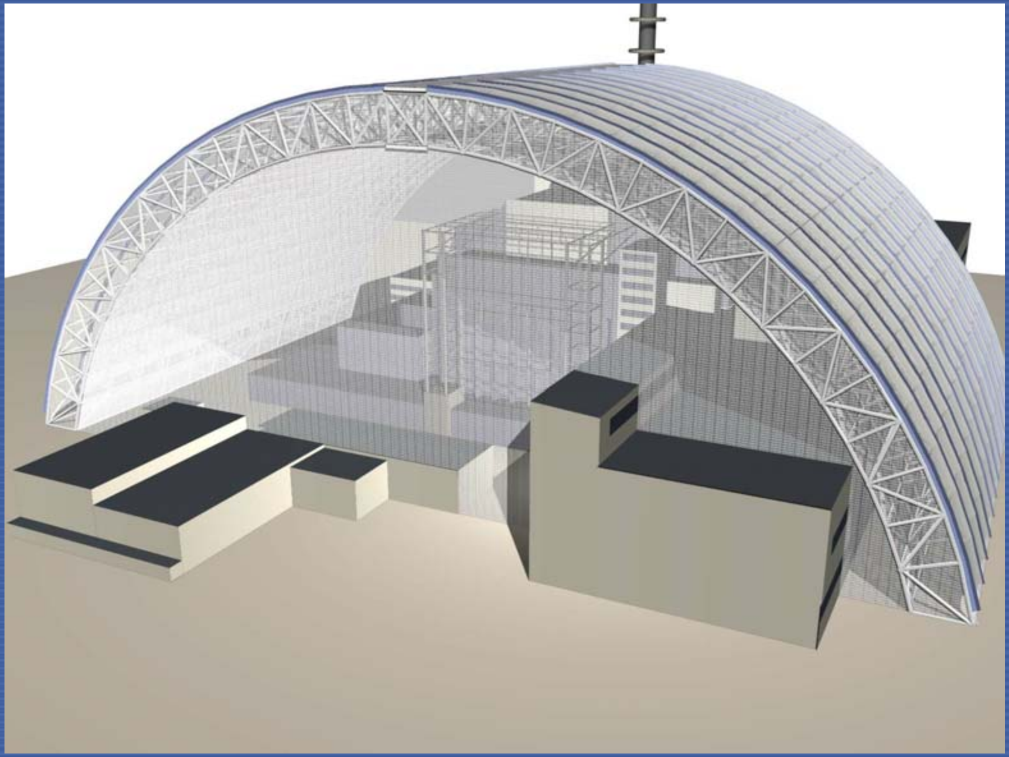
A white-tailed eagle chick in the CEZ. Before 1986, these rare birds have been hardly found in this area (S. Gaschak, 2004)

Recommendations on environmental monitoring, remediation and research

- There is no need for major new research programmes on radioactivity; but it is of use to continue limited targeted monitoring of some specific areas.
- To inform the public on persistent high contamination of wild food products (fungi, game, berries, etc.) and on simple cooking procedures aimed at reducing internal exposure.
- The number and frequency of sampling and measurements can be substantially reduced.
- Remediation measures remain efficient mainly in areas with poor (sandy and peaty) soils where there is a high radiocaesium transfer from soil to plants.
- Technologically based remediation measures applied to forests and surface waters will not be practicable on a large scale.

Main conclusions of the Chernobyl Forum – 11

Priority for Ukraine should be the decommissioning of the destroyed Chernobyl Unit 4 and the safe management of radioactive waste in the Chernobyl Exclusion Zone, as well as its gradual remediation.



Socio-Economic Impact of the Chernobyl Accident - 12

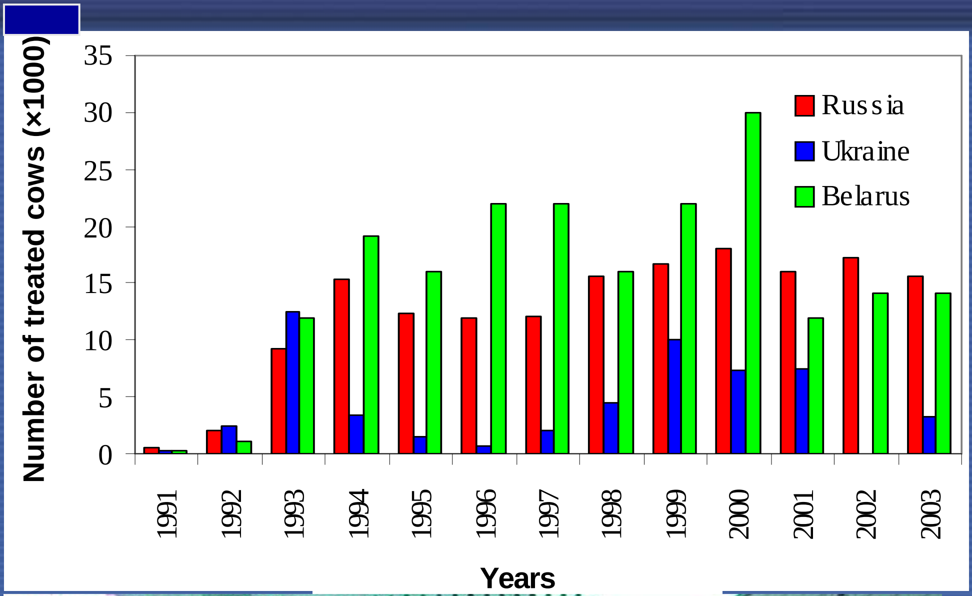
- Enormous damage to economy of the USSR and its successors, Belarus, Russia and Ukraine, due to direct and indirect costs,
- Depression of local economy in the affected regions,
- Destruction of local communities due to resettlement of 340 ths. people,
- Psychological distress of people, development of the “Chernobyl victim” complex,
- Compensating exposure to risk rather than actual injury to health or economy has been ineffective,
- Difficulties in implementation of expensive investment programmes, particularly in market conditions.

Chernobyl-related construction, 1986-2000 (thousands)

	Belarus	Russia	Ukraine	Total
Houses and flats	65	37	29	130
Schools (places)	44	18	49	112
Kindergartens (places)	19	4	11	34
Outpatient health centres (visits/day)	21	8	10	39
Hospitals (beds)	4.2	2.7	4.4	11.2

Main conclusions of the Chernobyl Forum – 13

- Countermeasures implemented by the Governments in coping with the consequences of the Chernobyl accident were on the whole timely and adequate.
- However, recent research shows that the direction of these efforts must be changed. Social and economic restoration of the affected Belarusian, Russian and Ukrainian regions must be a priority.



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Main conclusions of the Chernobyl Forum – 14

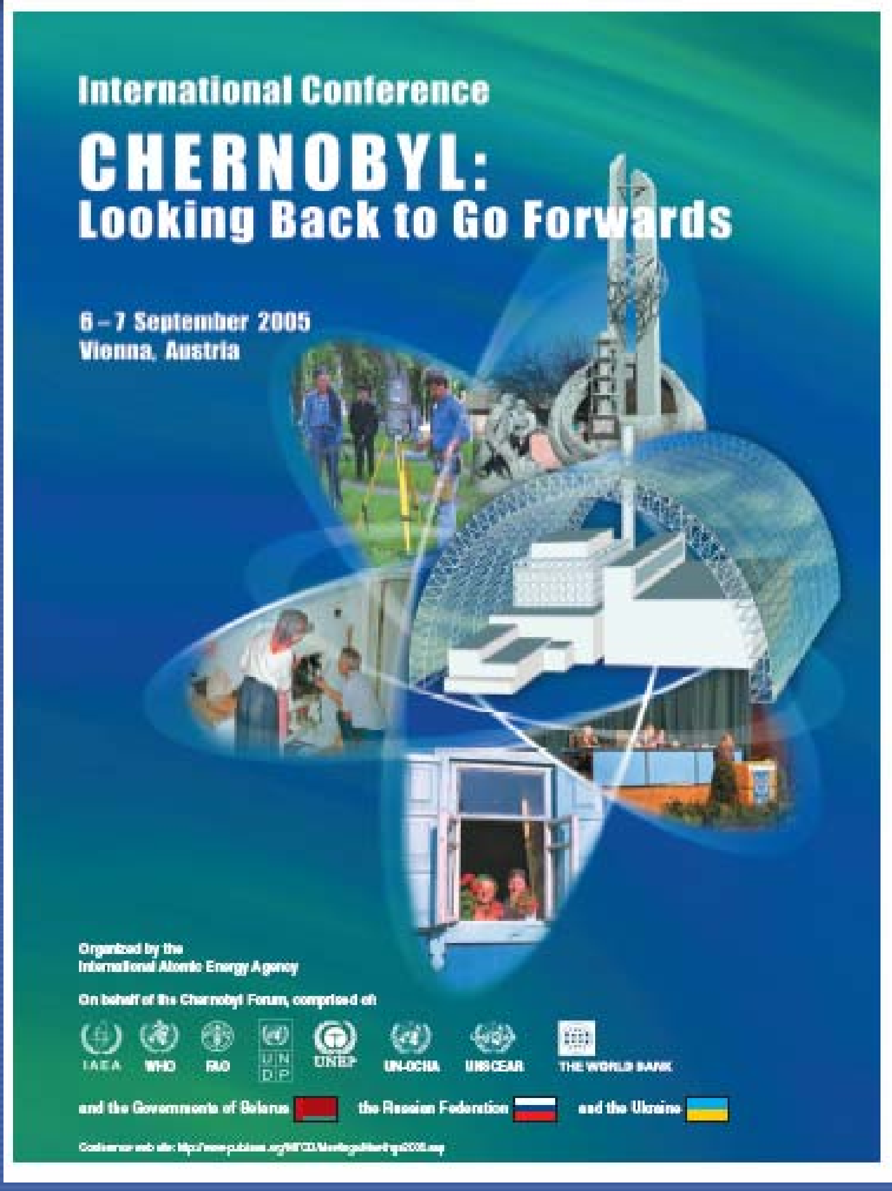
- Targeted research of some long-term environmental, health and social consequences of the Chernobyl accident should be continued for decades to come.
- Preservation of the tacit knowledge developed in the mitigation of the accident consequences is essential.

Main conclusions of the Chernobyl Forum – 15

- The Forum report is the most complete on the Chernobyl accident because it covers environmental radiation issues, human health and socio-economic consequences. About 100 recognised experts in the field of Chernobyl-related research from many countries, including experts from Belarus, Russia and Ukraine, have contributed to it.
- This report is a consensus view of the eight organisations of the UN family and of three affected countries.

International Conference “Chernobyl: Looking Back to Go Forwards”

- **Held 6-7 September 2005 in Vienna**
- **About 250 participants from 41 country and 20 organisations:**
  - **summarized the Forum’s work,**
  - **informed decision-makers, mass media and the general public, and**
  - **promoted the proposed actions**
- **Accompanied by extensive press campaign**



60th Session of the UN General Assembly

- Considered on 14 November 2005 the report A/60/443 of the Secretary-General on Chernobyl that includes, *inter alia*, the results of the Chernobyl Forum.
- Accepted Resolution A/60/L.19, in which:
  - Noted consensus reached among members of the Chernobyl Forum regarding assessment of the accident consequences and future actions;
  - Noted the necessity to widely disseminate Forum's findings and recommendations;
  - Requested to organise further studies consistent with the recommendations of the Chernobyl Forum.
- <u>Thus, for the first time the Chernobyl Forum reached highest international consensus in the assessment of the accident consequences and recommendations for future actions.</u>

Thyroid cancer after the Chernobyl accident

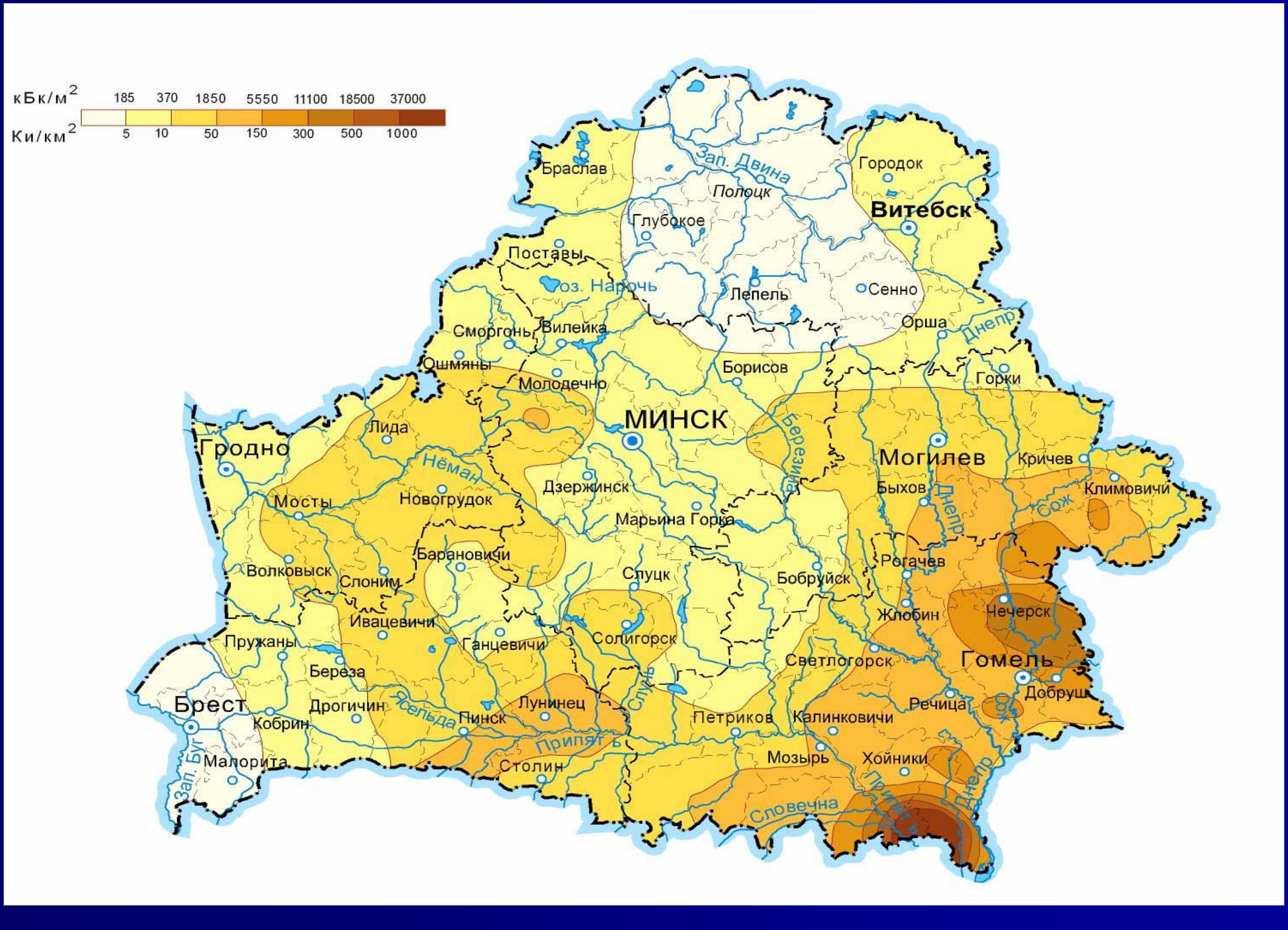
Jacov Kenigsberg
National Commission of Radiation Protection
Republic of Belarus

Damaged reactor of Chernobyl NPP

Release of iodine-131

Year	Activity of I-131 in, PBq
Windscail, UK, 1957	0,74
SL-1, Idaho Falls, USA, 1961	0,00037 at 1st 16 h Total 0,003 for 30 days
Hanford,USA, 1963	0,0022
Savanna River, USA, 1964	0,0035 in 1st several days, Total 0,0057 for 26 days
TMI, USA, 1979	0,0006 – 0,0007
Chernobyl,USSR, 1986	1760
Nuclear tests, 1945-1962	740 000

Contamination by I-131 of Belarus (10 May, 1986)



Estimated collective thyroid doses

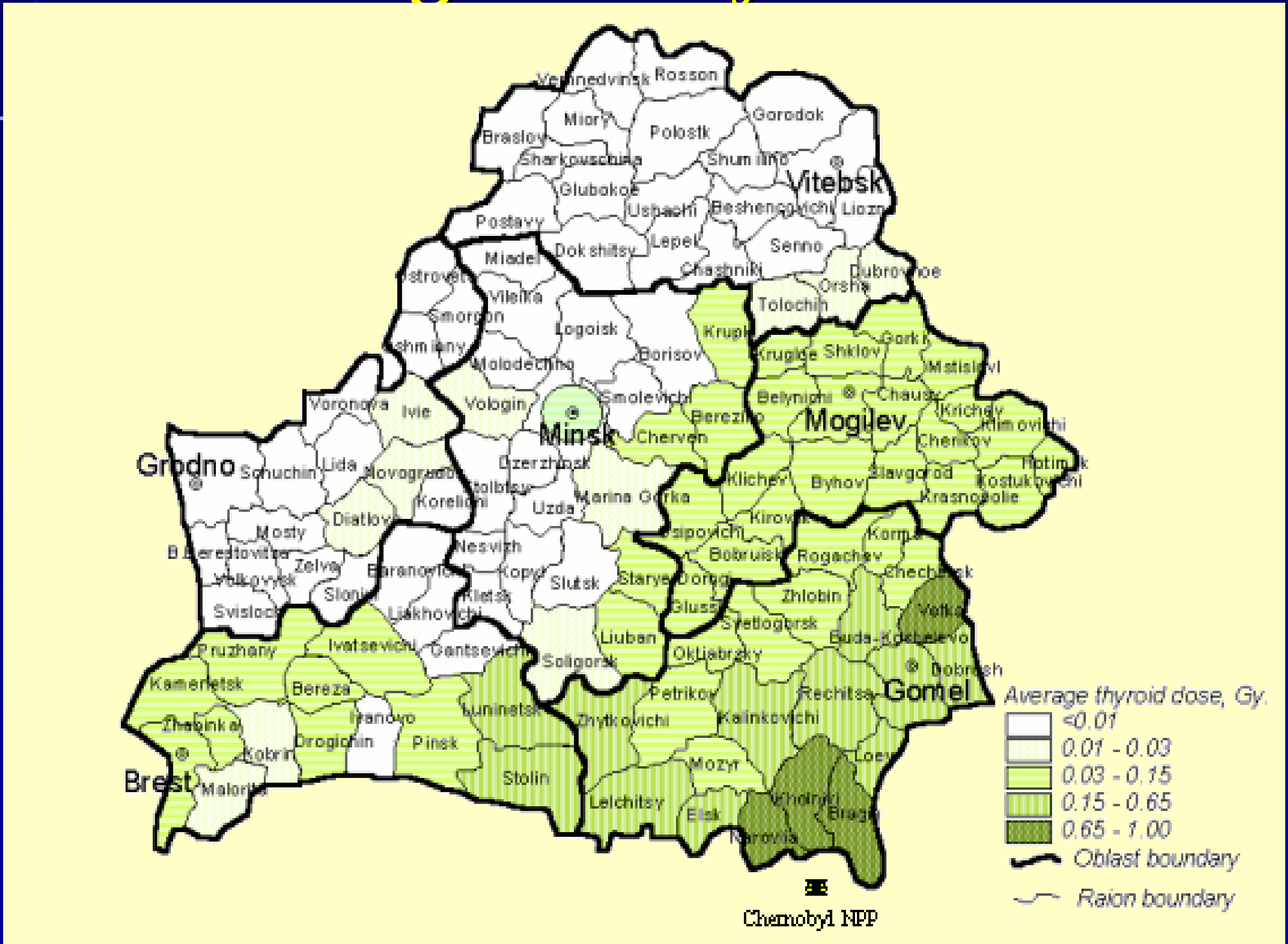
Country	Collective thyroid dose, man-Gy
Belarus	550 000
Russia	300 000
Ukraine	740 000
Total	1 600 000

Distribution of thyroid doses among Belarusian population

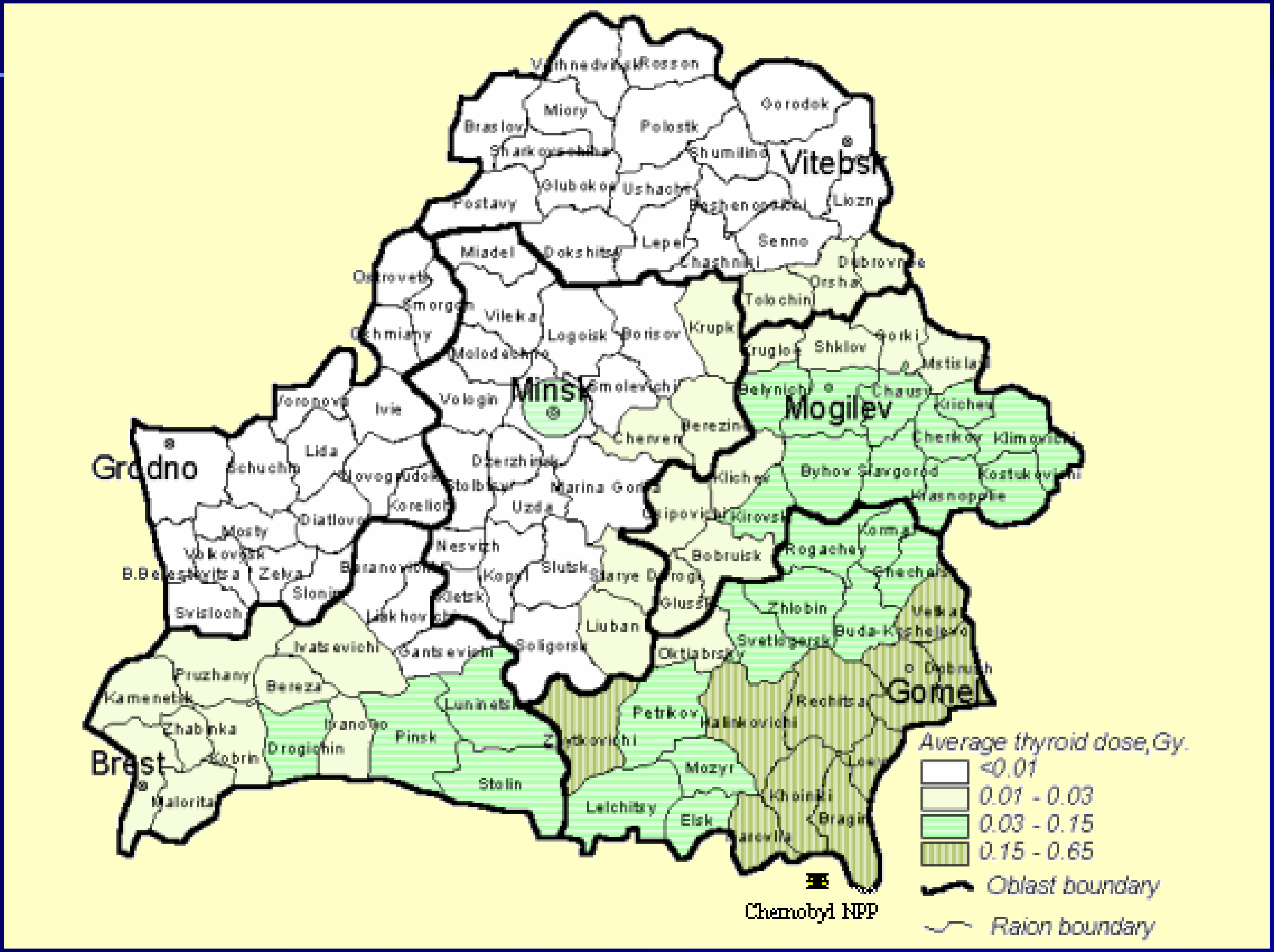
Age group*	Dose interval, Gy					Number of persons
	0-0.05	0.05-0.1	0.1-0.5	0.5-1.0	>1.0	
0 - 18	1 605 129	514 086	434 058	85 164	28 082	2 666 519
19 - +	5 597 593	502 866	727 086	46 966	596	6 875 107
Total	7 202 722	1 016 952	1 161 144	132 130	28 678	9 541 626

* - Age in April, 1986

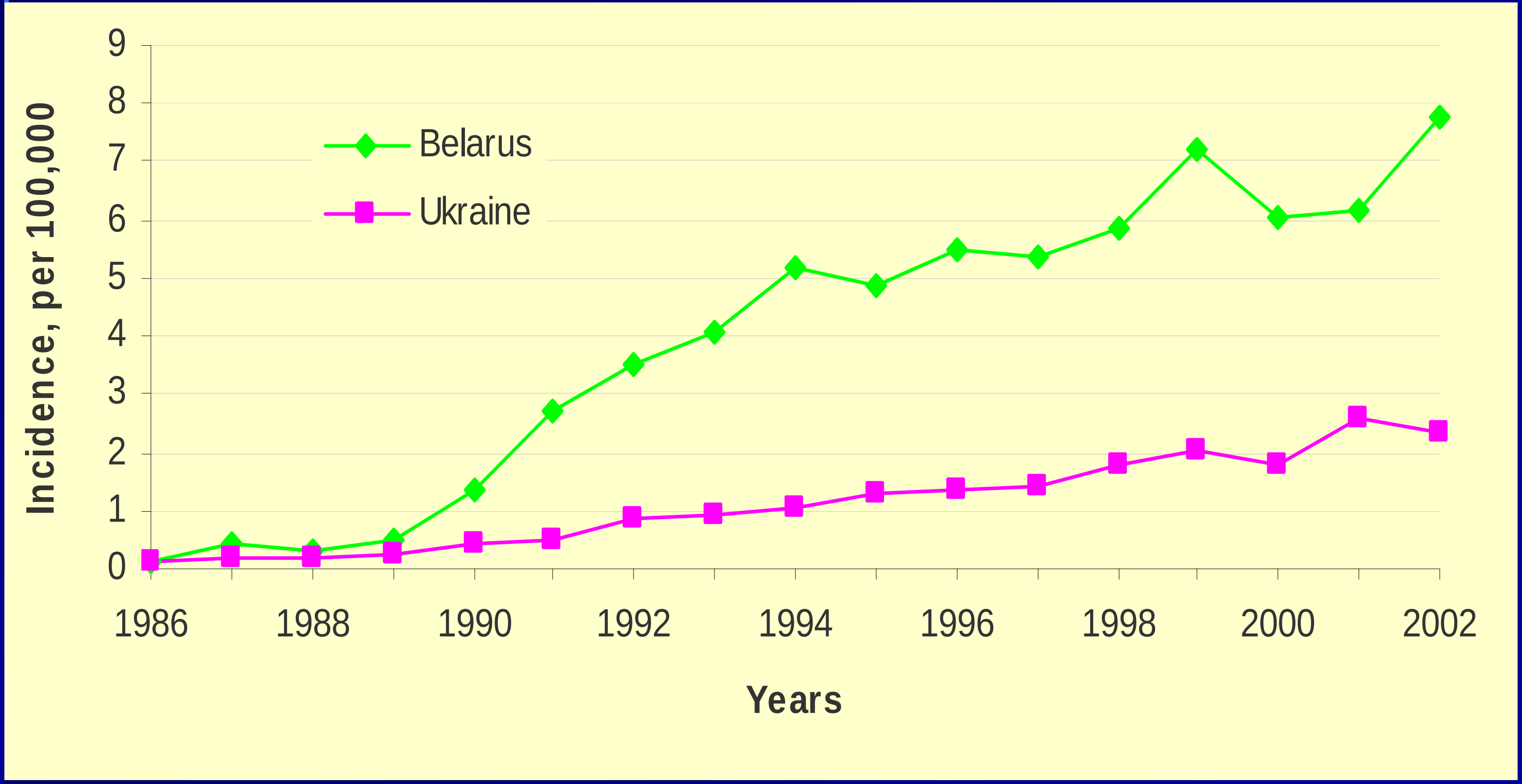
Thyroid dose pattern for children aged 0-18 years



Thyroid dose pattern for adults

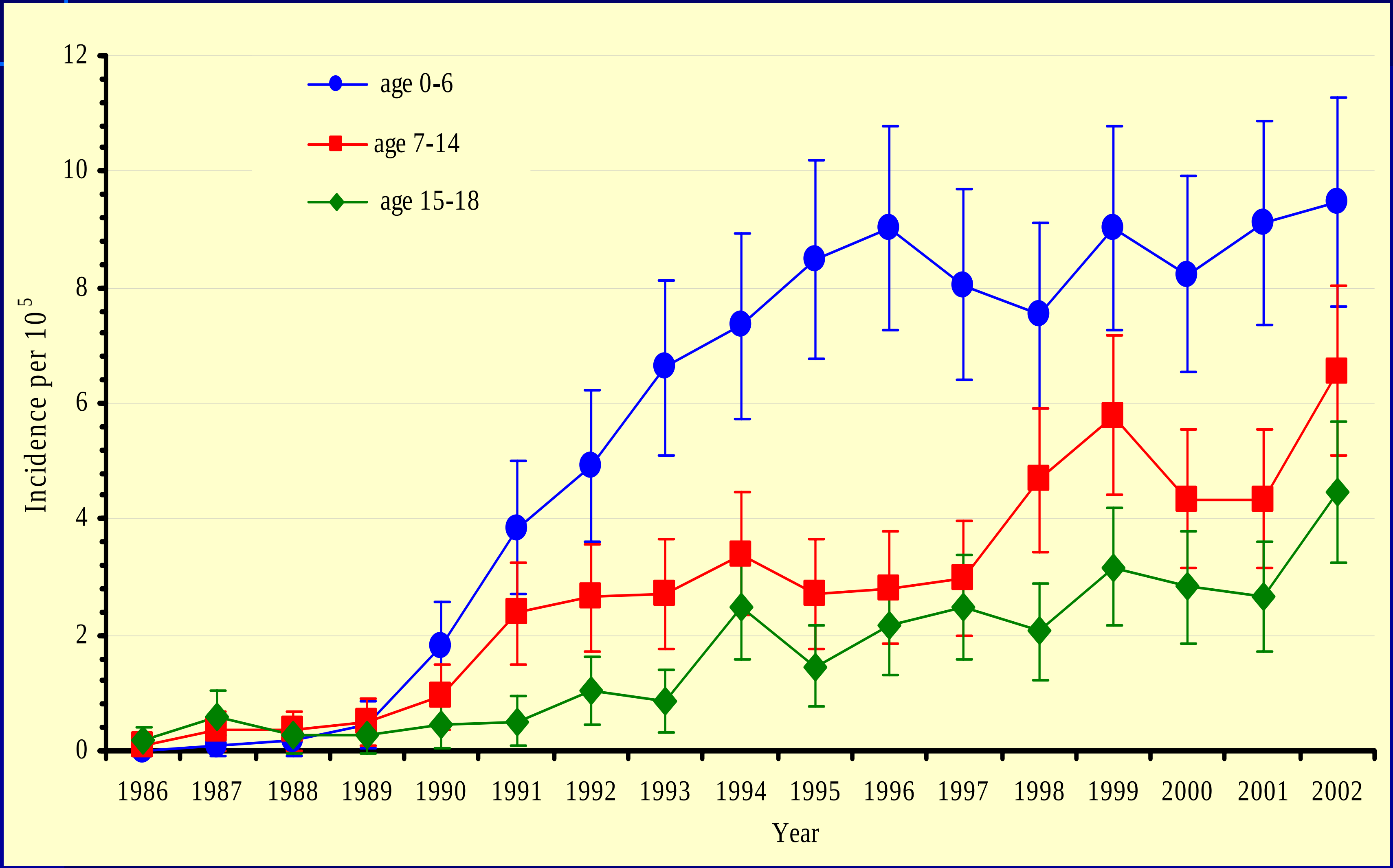


Incidence rate of thyroid cancer in children and adolescents* (Jacob et al., 2005)

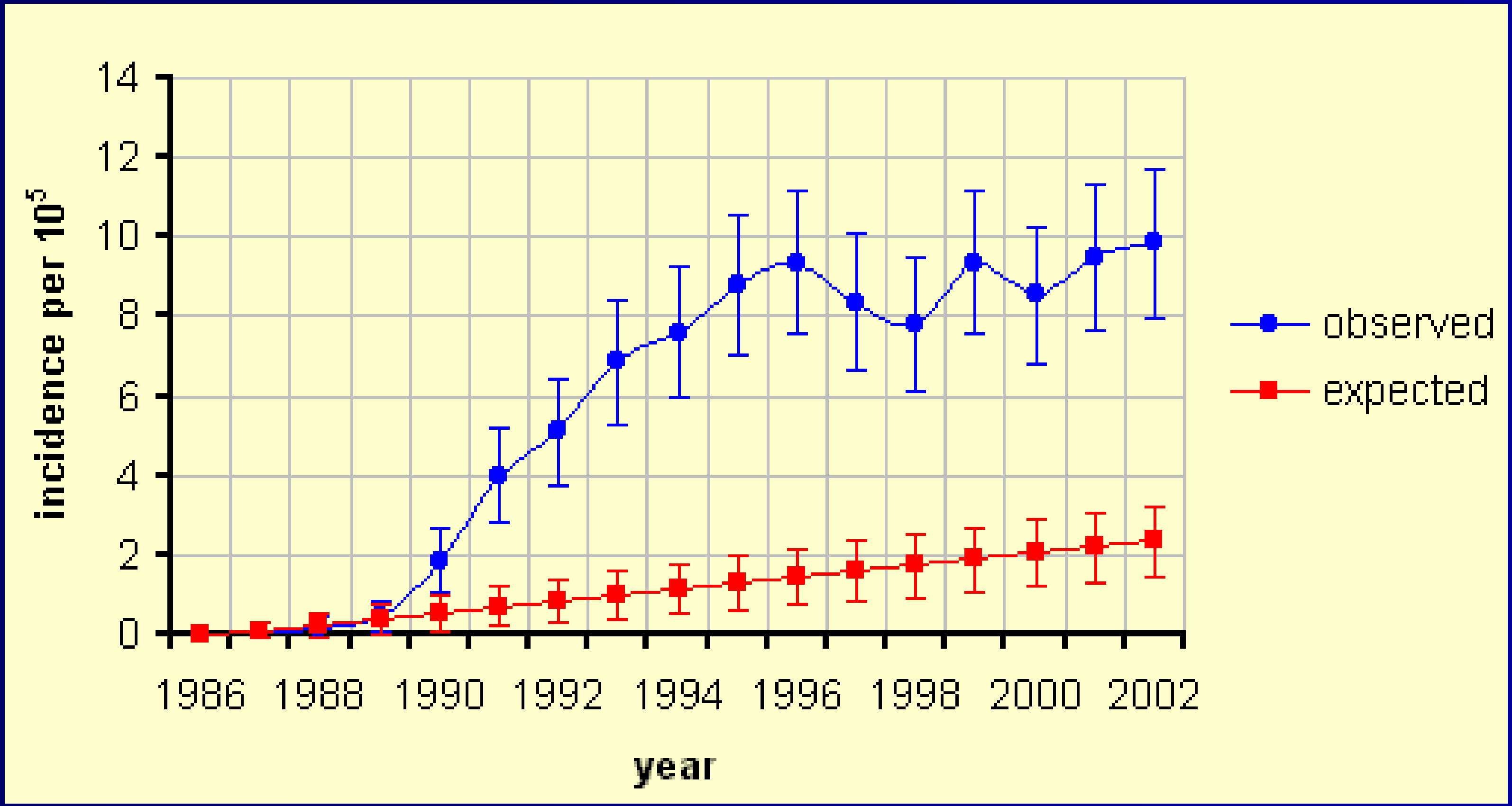


* - Age in April, 1986

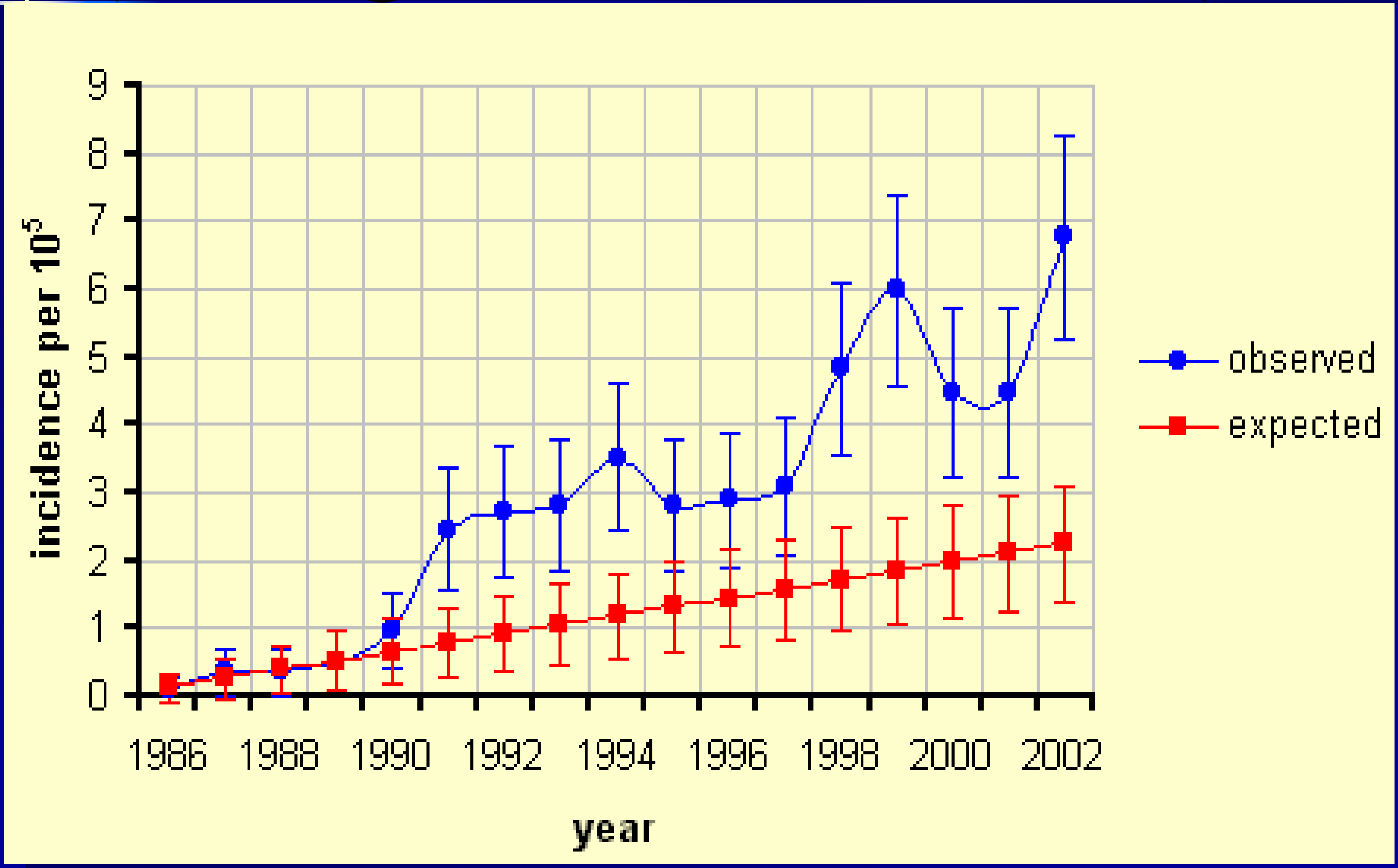
Thyroid cancer incidence (different age at time of accident)



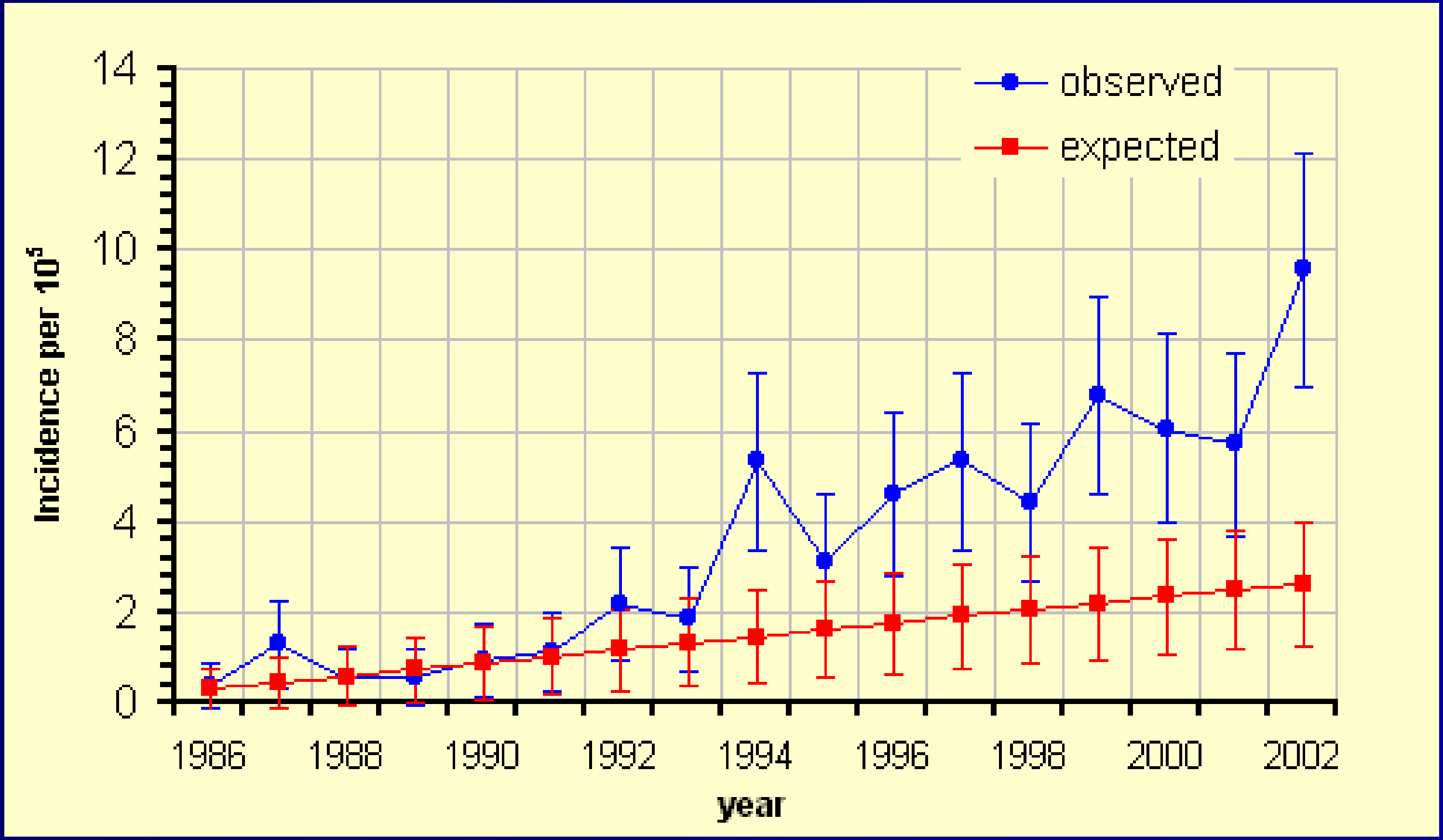
Comparison observed and expected thyroid cancer incidence (0-6 age at time of accident)



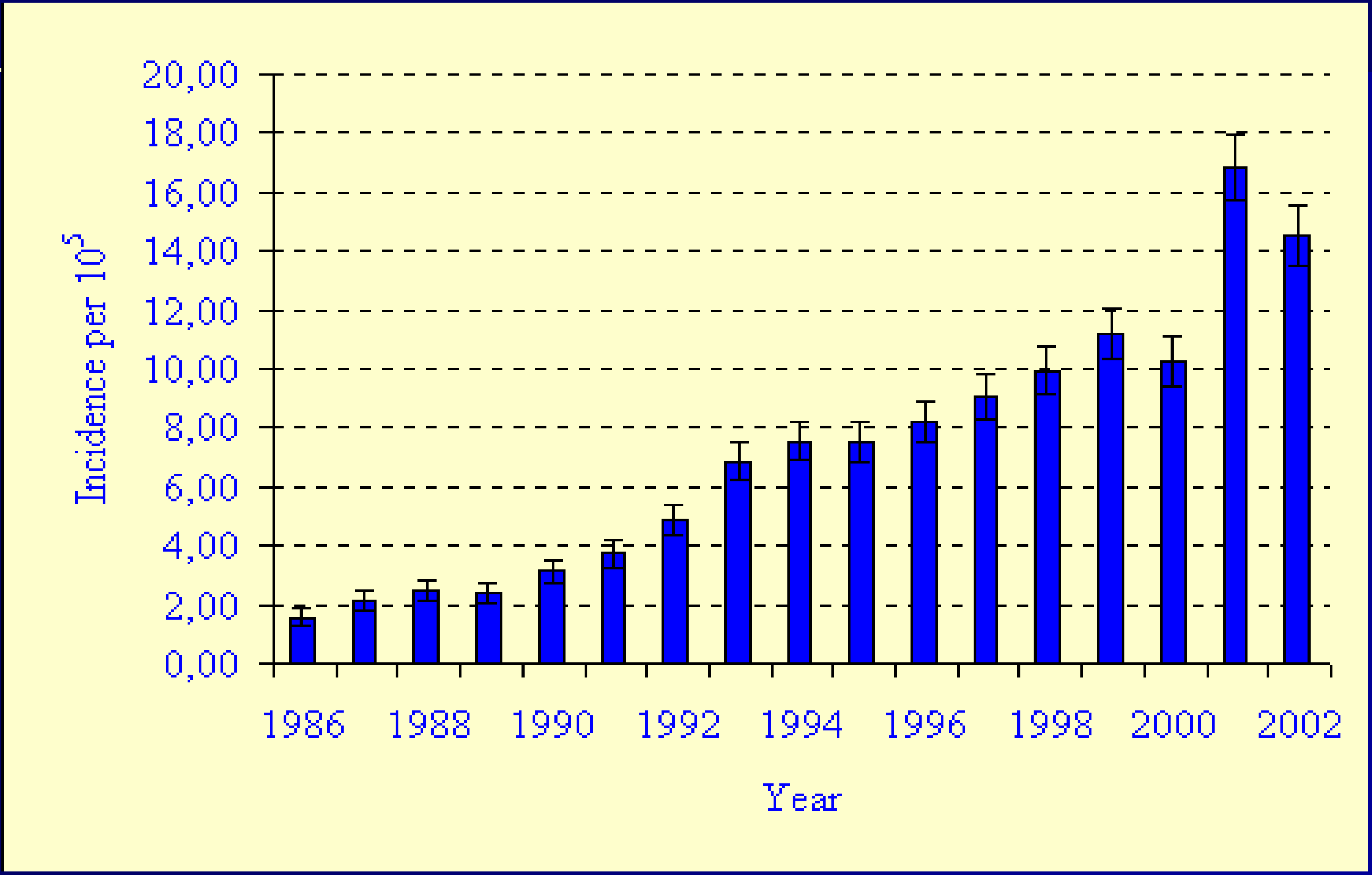
Comparison observed and expected thyroid cancer incidence (7-14 age at time of accident)



Comparison observed and expected thyroid cancer incidence (15-18 age at time of accident)

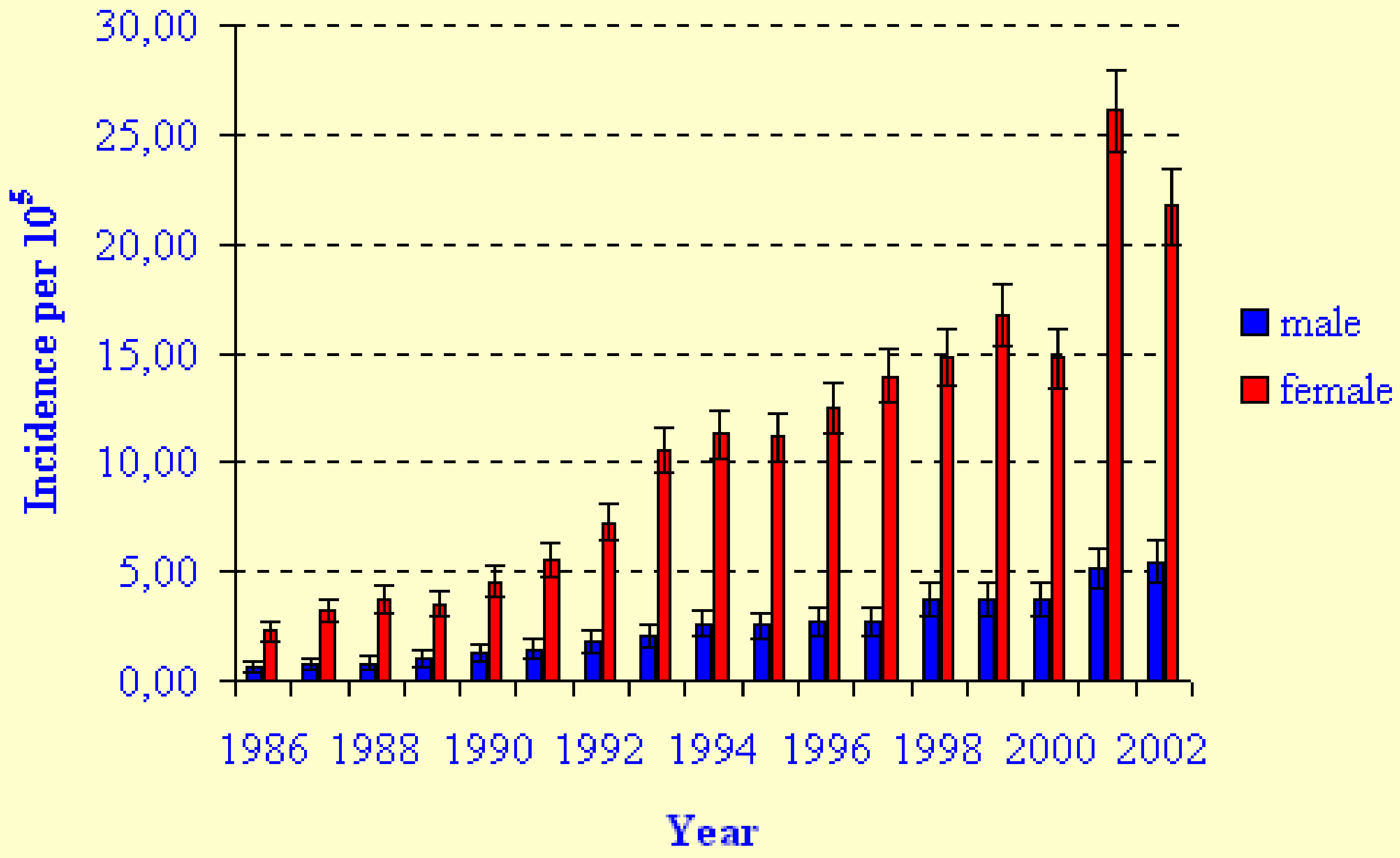


Thyroid cancer incidence for adults (19+ ATA)



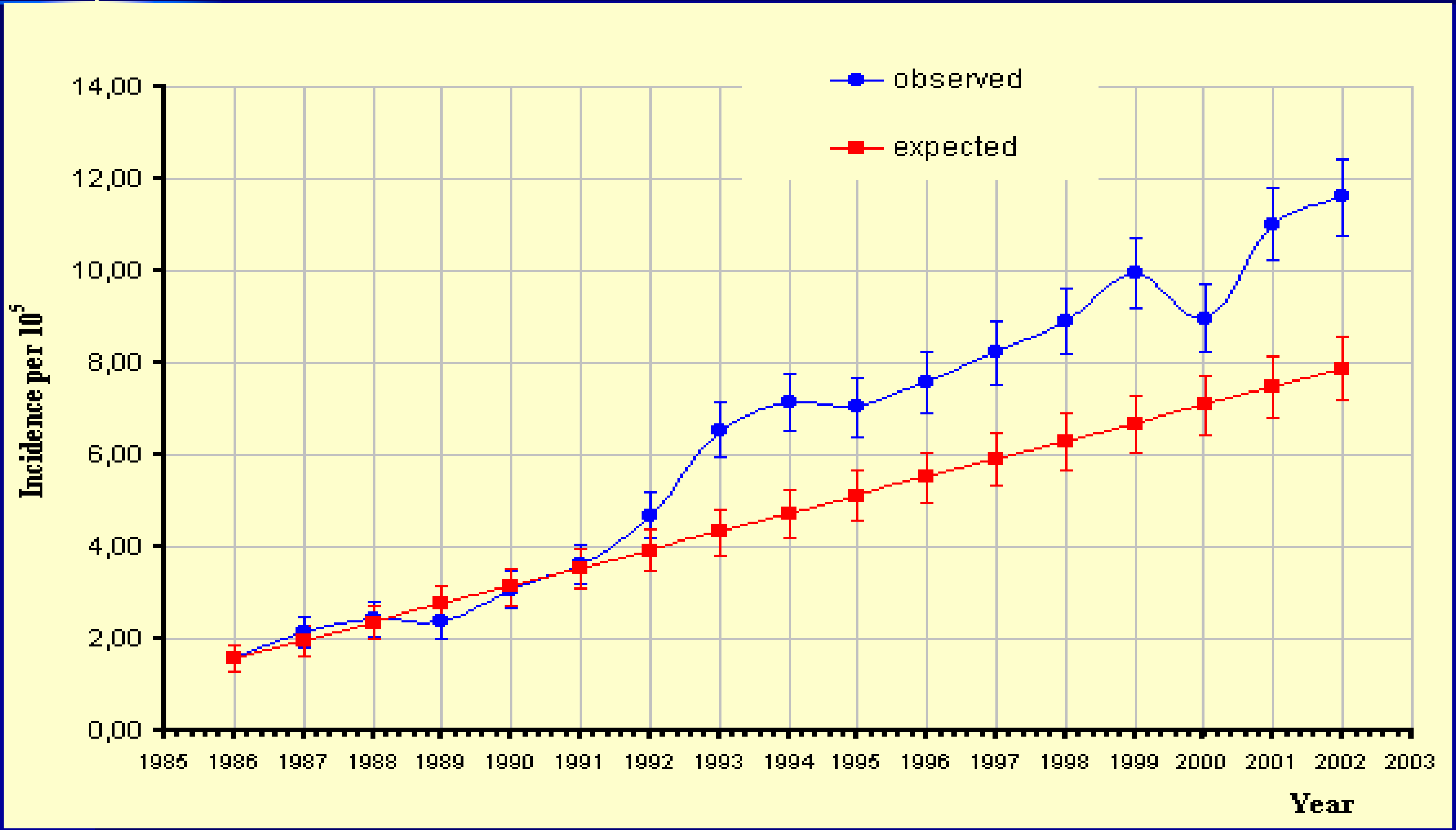
J. Kenigsberg, NCRP, Belarus

Thyroid cancer incidence for adults (19+ ATA) Separate genders

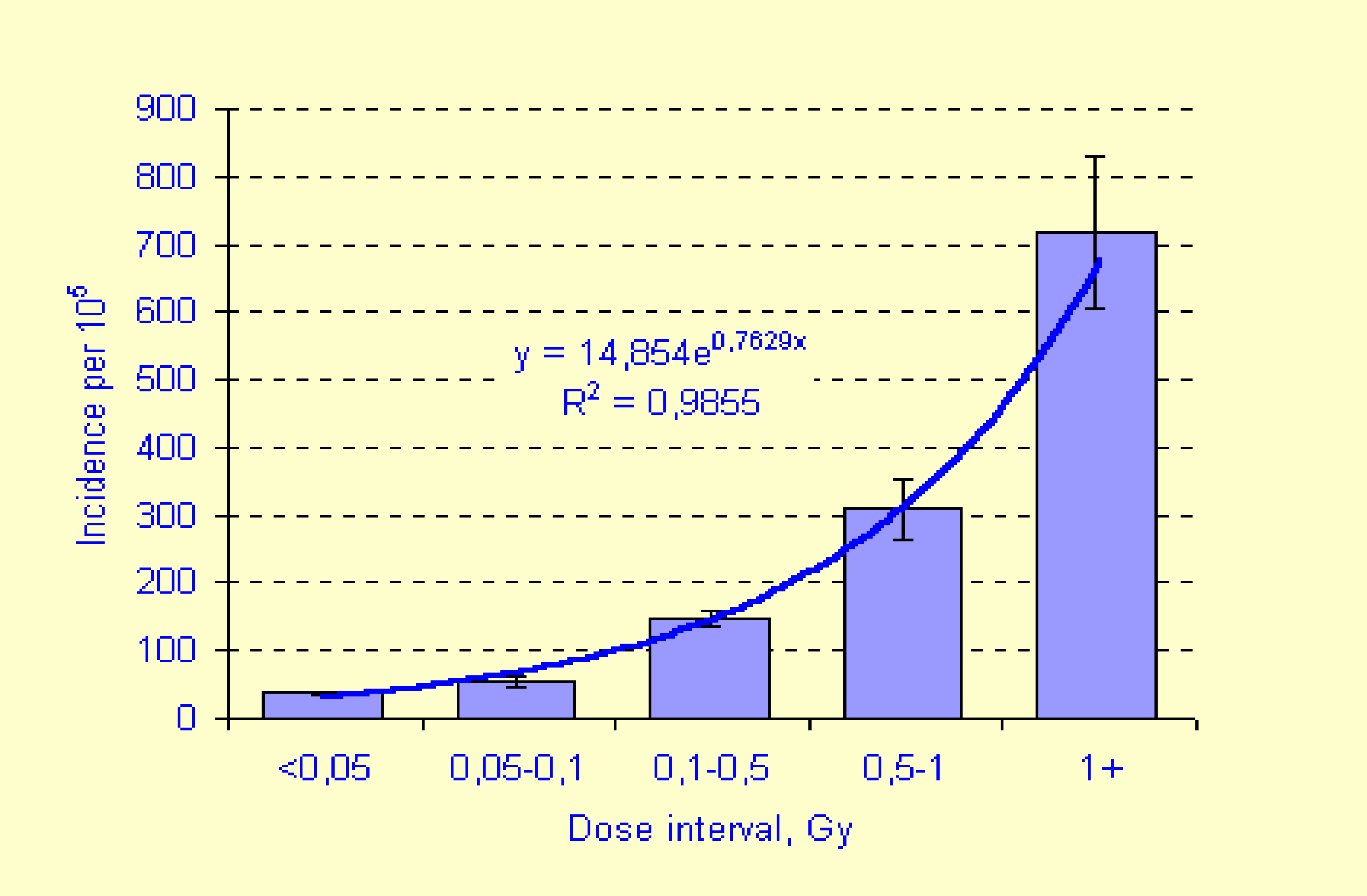


J. Kenigsberg, NCRP, Belarus

Comparison observed and expected thyroid cancer incidence (19+ age at time of accident)



Cumulative thyroid cancer incidence rate vs dose intervals (1990 – 2002)



J. Kenigsberg, NCRP, Belarus

Results of risk analysis of radiation-induced thyroid cancer for children and adolescents exposed to ^{131}I in different age

EAR/ 10^4 person-year-Gy, (95% CI)			ERR / Gy, (95% CI)		
Male	Female	Both	Male	Female	Both
0-6 years of age					
1,5 (1,2; 1,9)	2,6 (1,8; 3,4)	2,1 (1,6; 2,6)	86,4 (67,7; 124,0)	46,2 (33,8; 63,5)	55,9 (43,9;76,2)
7-14 years of age					
1,0 (0,1; 4,4)	2,3 (0,2; 3,4)	1,7 (1,2; 2,9)	32,9 (0,9; 78,9)	21,5 (1,8; 33,5)	24,2 (16,9; 47,2)
15-18 years of age					
0,8 (-0,1; 1,8)	3,9 (-0,4; 4,9)	2,4 (-0,2; 2,9)	18,3 (-0,4; 26,9)	22,5 (-0,9; 28,4)	21,7 (-0,8; 26,7)

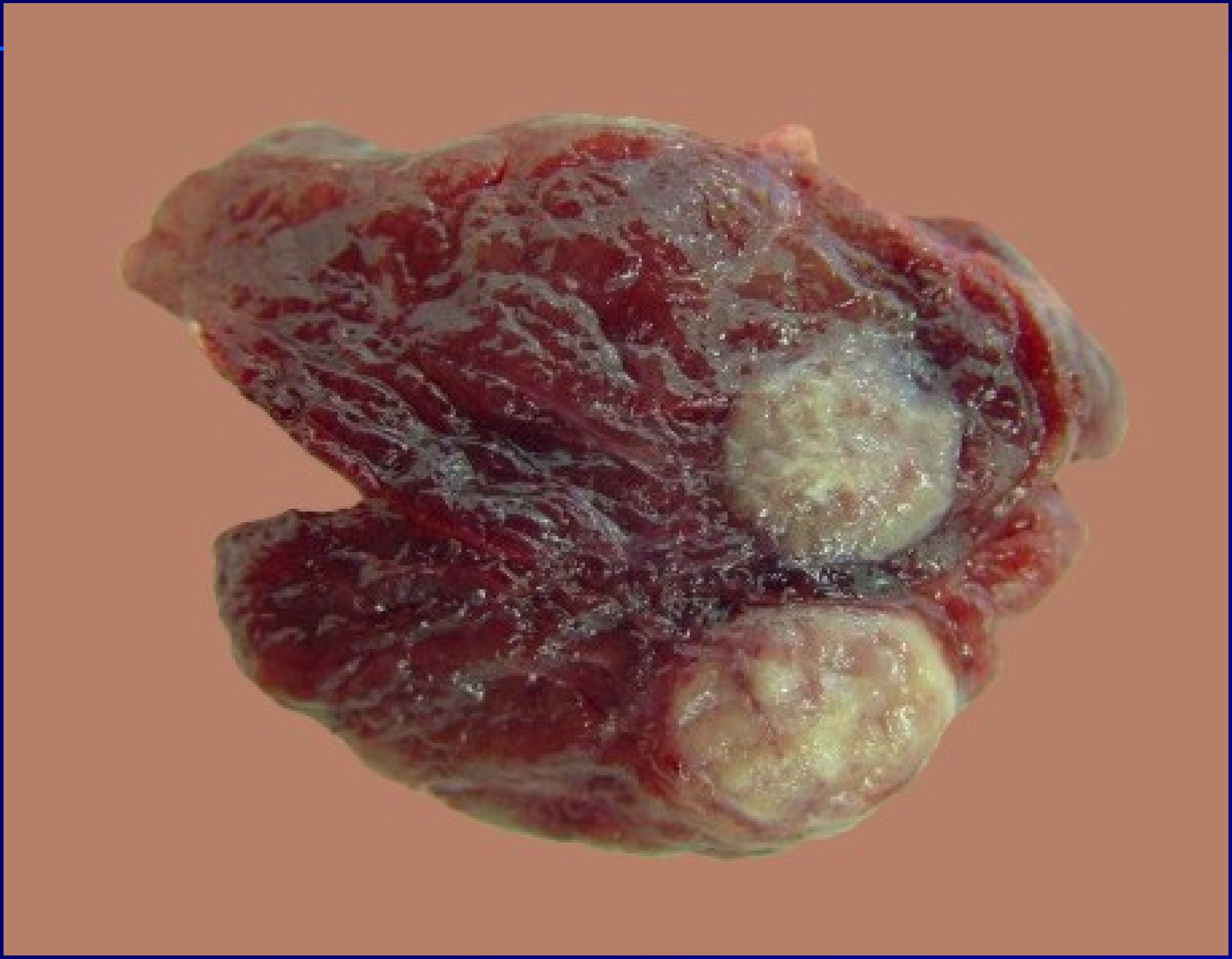
Results of risk analysis of radiation-induced thyroid cancer for Belarus population exposed to ^{131}I in the age of 19 and older

Parameters	Male	Female	Both
EAR/ 10^4 person-year-Gy (95% CI)	0,4 (-0,6; 1,5)	2,5 (1,9; 4,7)	1,7 (0,3; 3,2)
ERR / Gy (95% CI)	3,9 (-0,9; 5,9)	2,4 (0,8; 5,6)	3,8 (0,1; 9,8)

Female patient with advanced papillary thyroid carcinoma (positive neck lymph nodes)

Male patient with advanced papillary thyroid carcinoma (positive neck lymph nodes)

Papillary carcinoma sample



Thyroid cancer
Survival after treatment

Observed 5 years	Observed 10 years
99,3 %	98,5 %

Prognosis of thyroid cancer cases

Sex	Age in 1986				
	0-14	15-18	0-18	19+	Total
Male	3807	295	4102	230	4332
Female	7862	589	8451	1930	10381
Both	11699	884	12553	2160	14713

Attributive risk

0-18 age – 76.5%

19+ age – 15.6%

Radiation induced thyroid cancer

- Could it be prevented and how?
  - Prevention of consumption of contaminated food
  - Stable iodine prophylaxis
- Could easily be prevented by:
  - Timely warning
  - Effective thyroid blocking
  - Timely restriction of consumption for contaminated food

Implications for protection of thyroid gland

- Children are at highest risk
- Lower risk for adults, but this is still a risk!
- Criteria for stable iodine prophylaxis for all ages
  - 50 mGy proposed by IAEA
- Food restriction may be needed

Prevent cases of thyroid cancer – it's real!!!

From lessons learned to practical application

Health Effects of Chernobyl in the European Union

Dr. Elif Hindié

Maître de Conférences des Universités- Praticien Hospitalier

Hôpital Saint-Louis

Paris, France

- Although the radioactive fallout was mainly concentrated in the three countries close to the nuclear power plant (Ukraine, Belarus and the Russian Federation), lower concentrations came down over much of the entire Europe.

Land contamination in western Europe

- Initially the wind was blowing in a northwesterly direction and this phase was responsible for much of the deposition in the north of Europe.

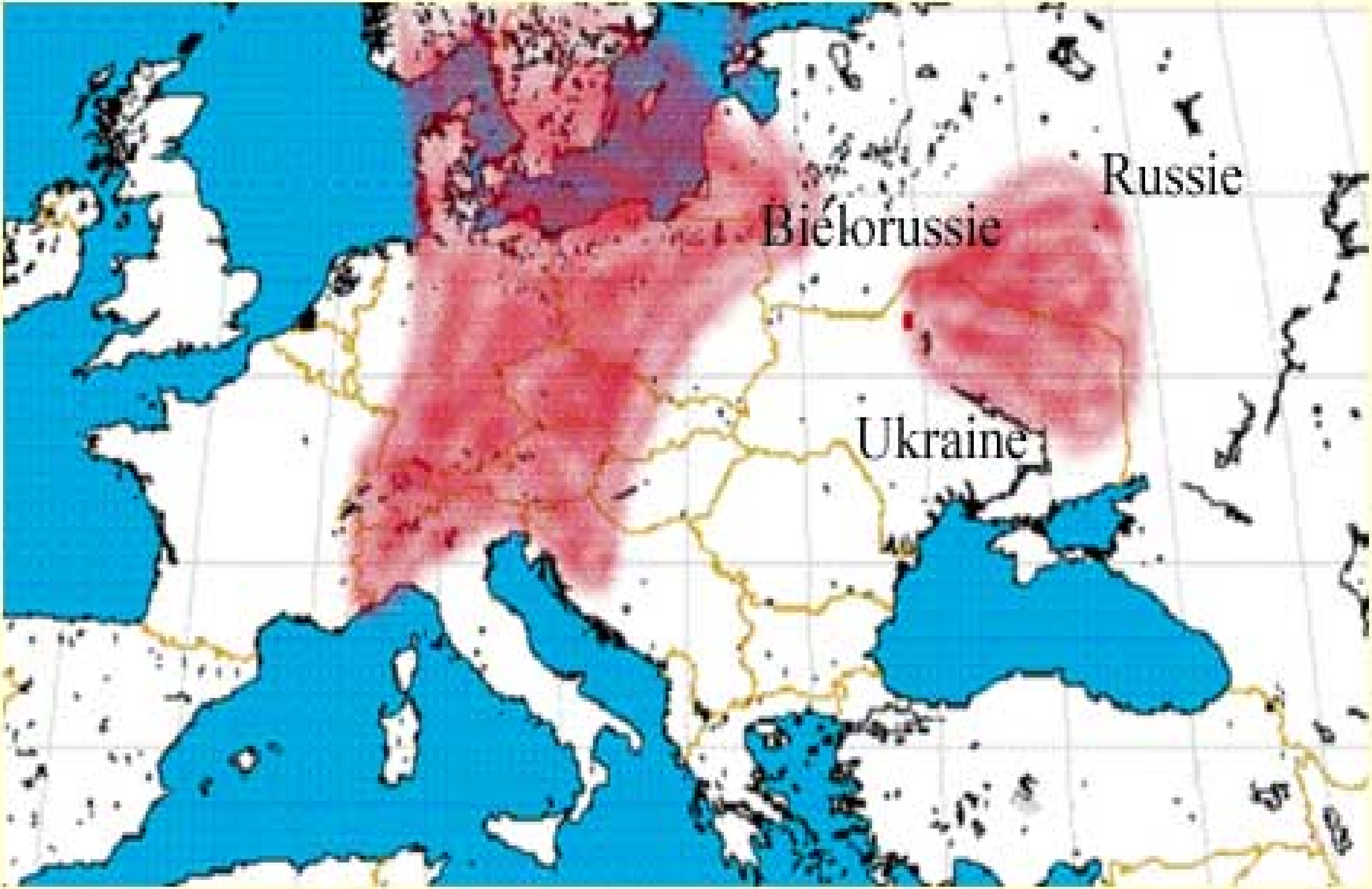
- The Swedish nuclear power agency detected an increase in radioactivity and alerted other European countries in 28 April, about 60 hours after the accident had occurred.

- Later the plume shifted to the south-west and much of central Europe, as well as the northern Mediterranean and Balkans, received some deposition.

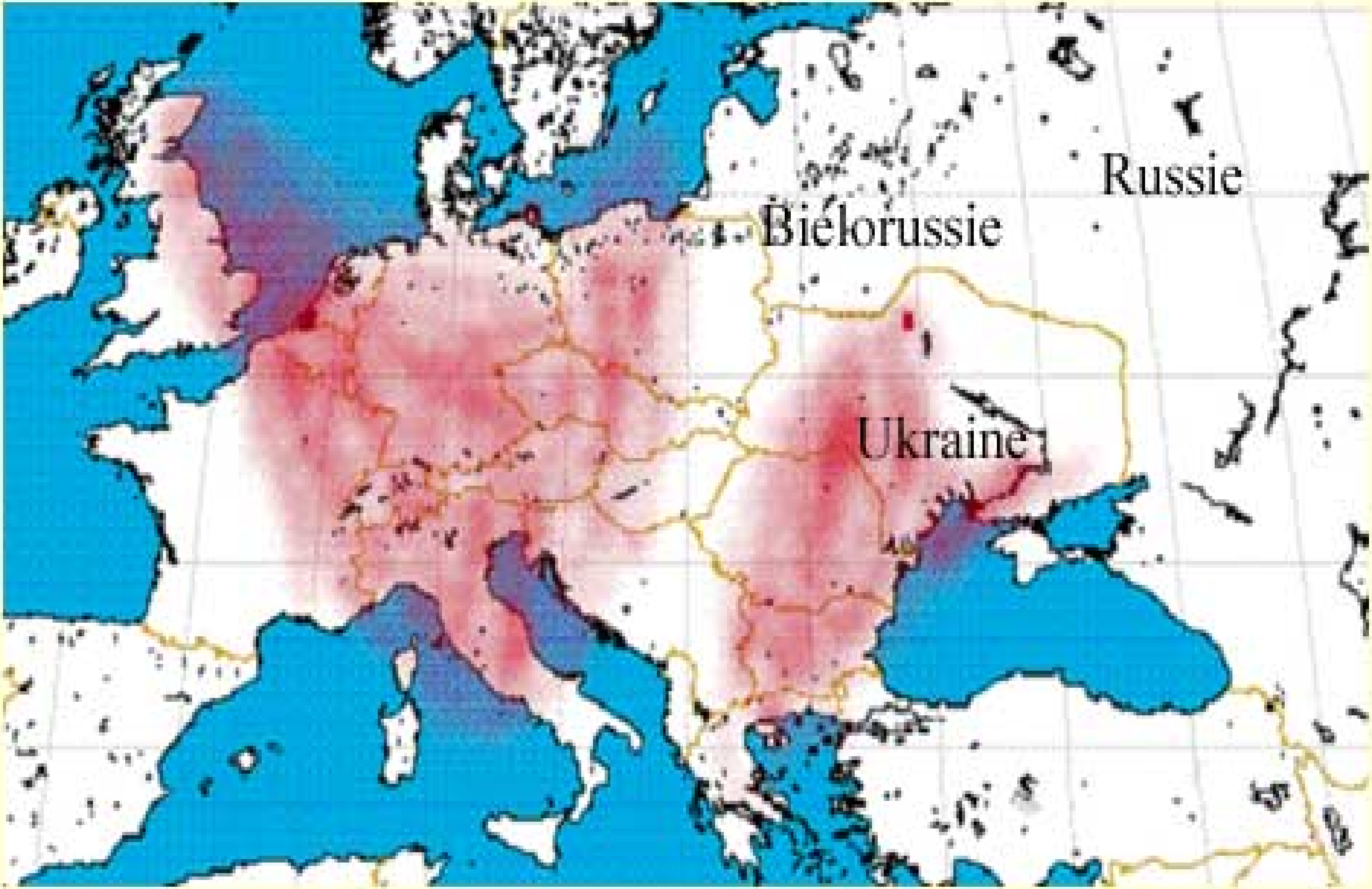
26 avril 1986

28 avril 1986

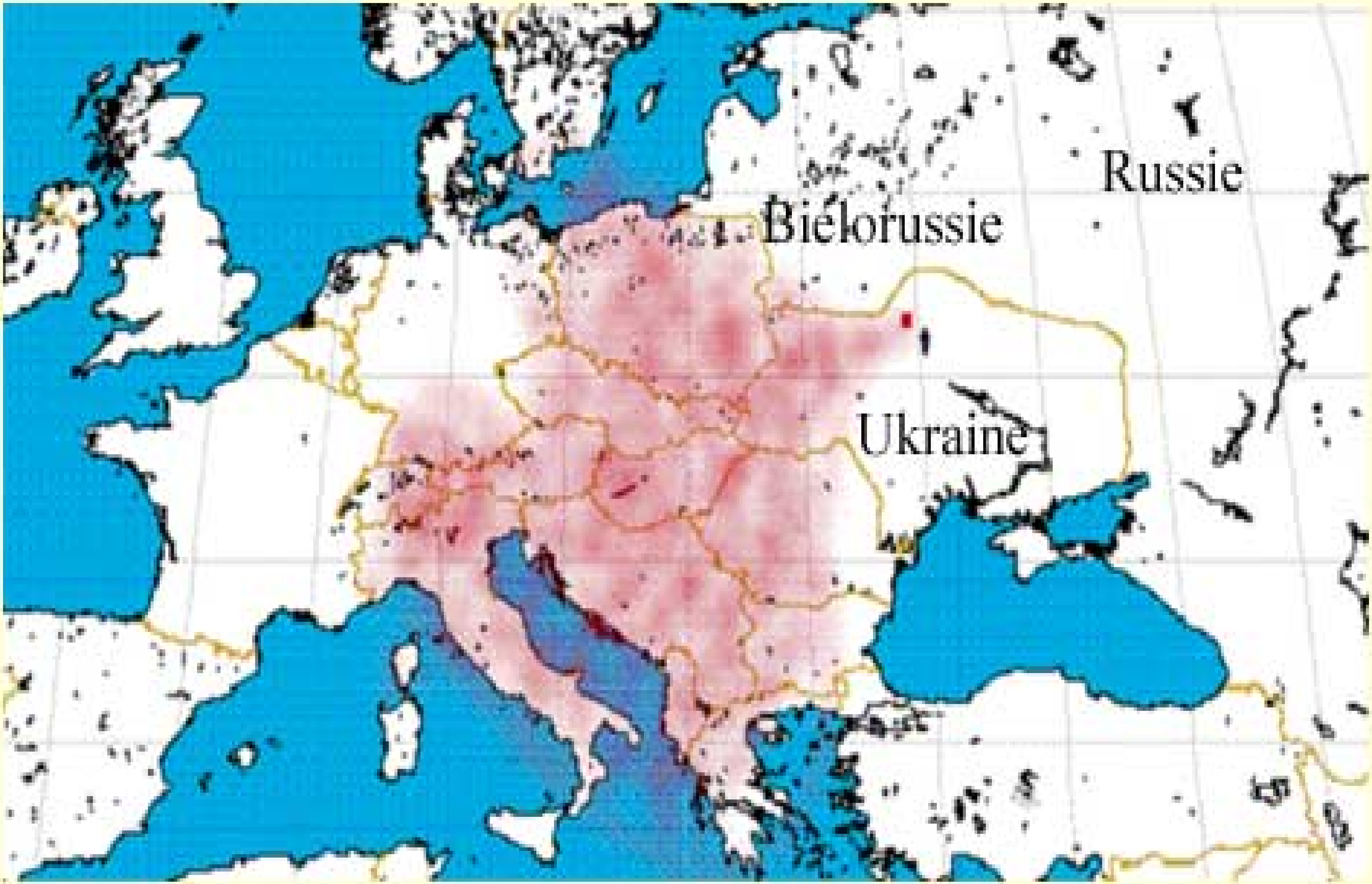
30 avril 1986



2 mai 1986



5 mai 1986

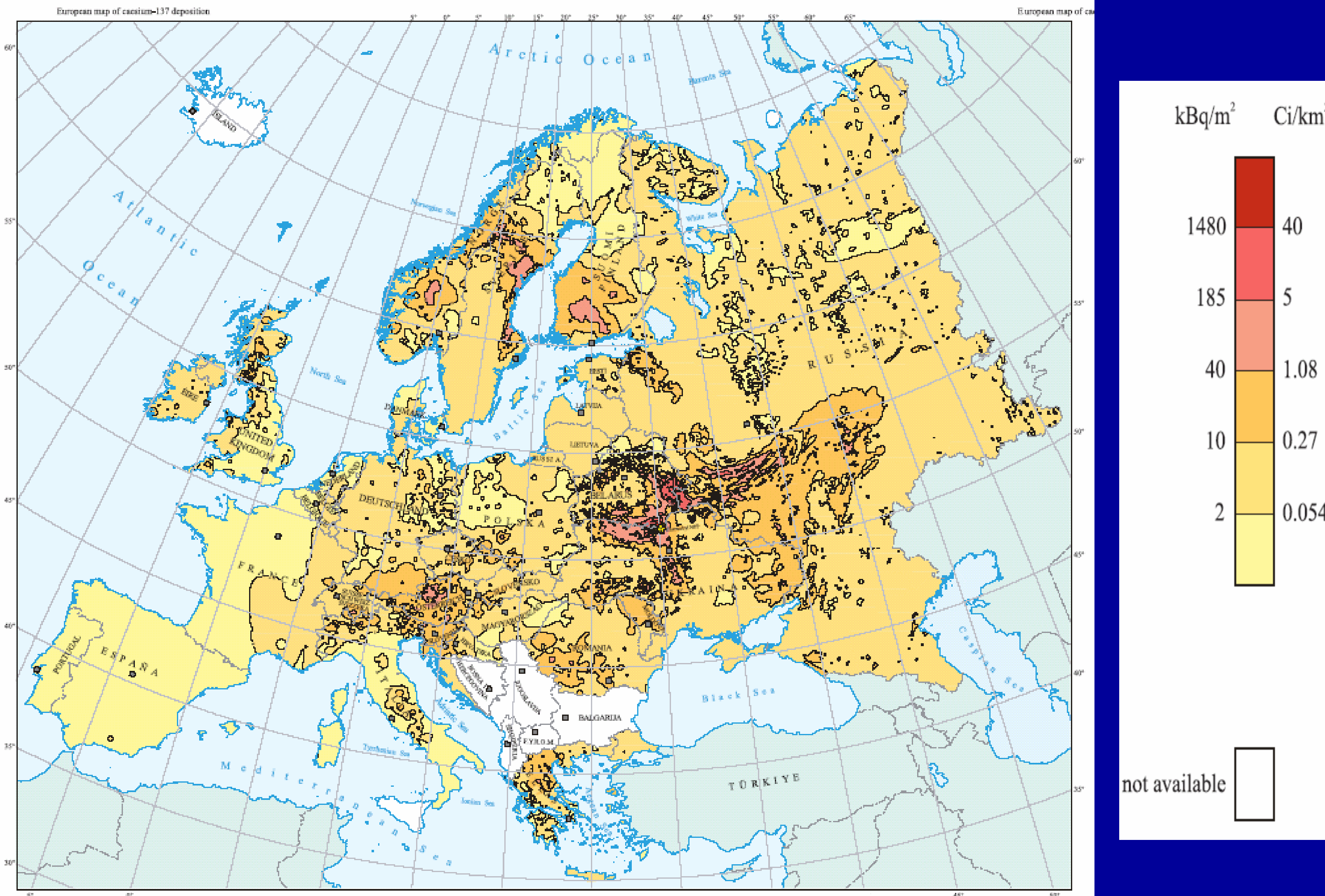


Land contamination in western Europe

- Local deposition varied largely depending on wind direction, time of arrival of the radioactive plume, terrain features, and the presence and intensity of rainfall during this period.

- The most radiologically important radionuclides detected were 131-I, 132-Te/132-I, 137-Cs and 134-Cs.

Figure XI. Surface ground deposition of caesium-137 released in Europe after the Chernobyl accident [D13].



Total caesium-137 (nuclear weapons test, Chernobyl, ...) deposition

D13 De Cort, M., G. Dubois, Sh.D. Fridman et al. Atlas of caesium deposition on Europe after the Chernobyl accident. EUR 16733 (1998).

Land contamination in western Europe

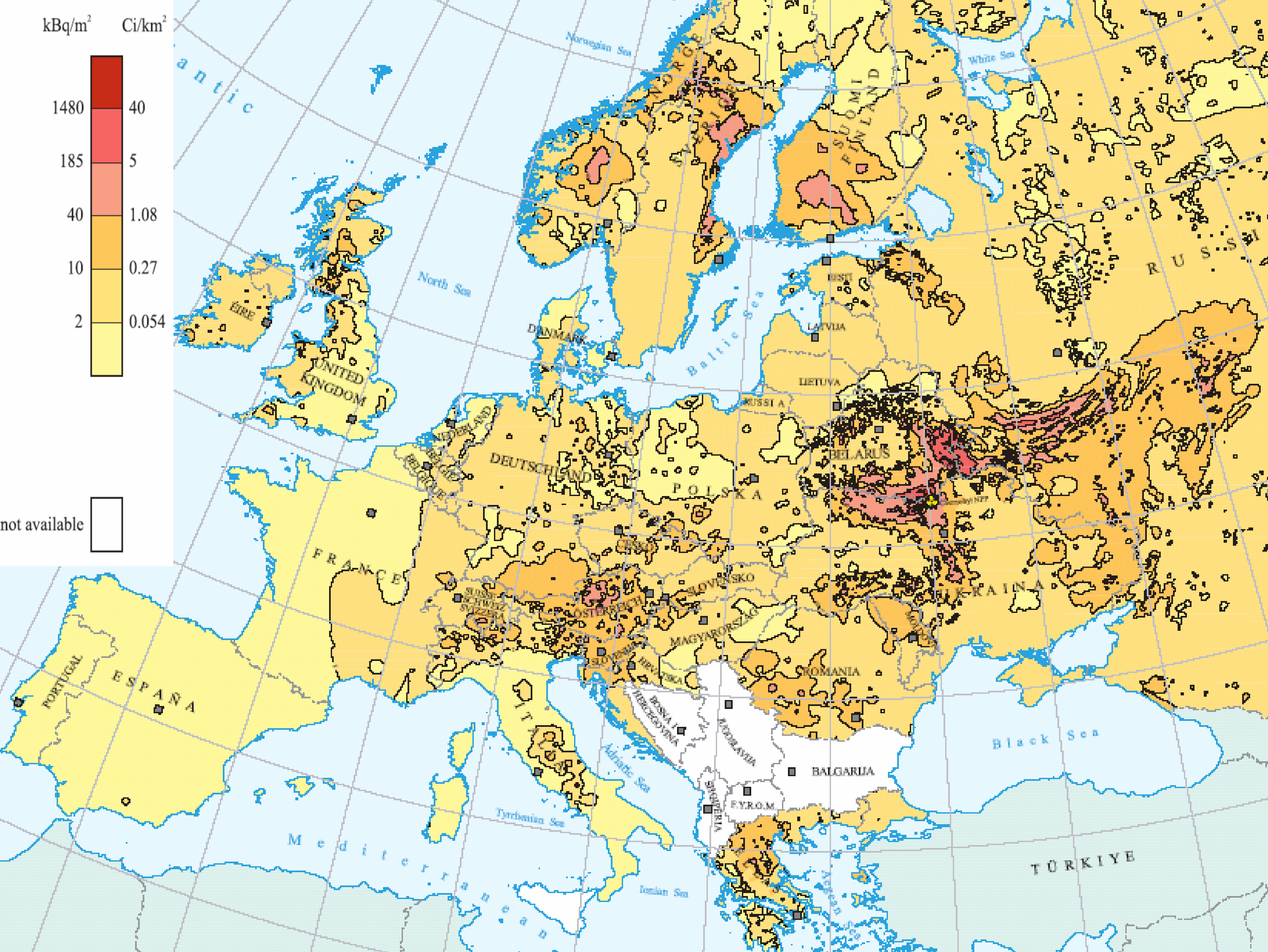
- In Austria, Eastern and Southern Switzerland, parts of Southern Germany and Scandinavia, where the passage of the plume coincided with heavy rainfall, the total deposition from the Chernobyl release was high locally (up to and even exceeding 37 Bq/m^2). On average, however, it remained 5 – 10 times weaker.

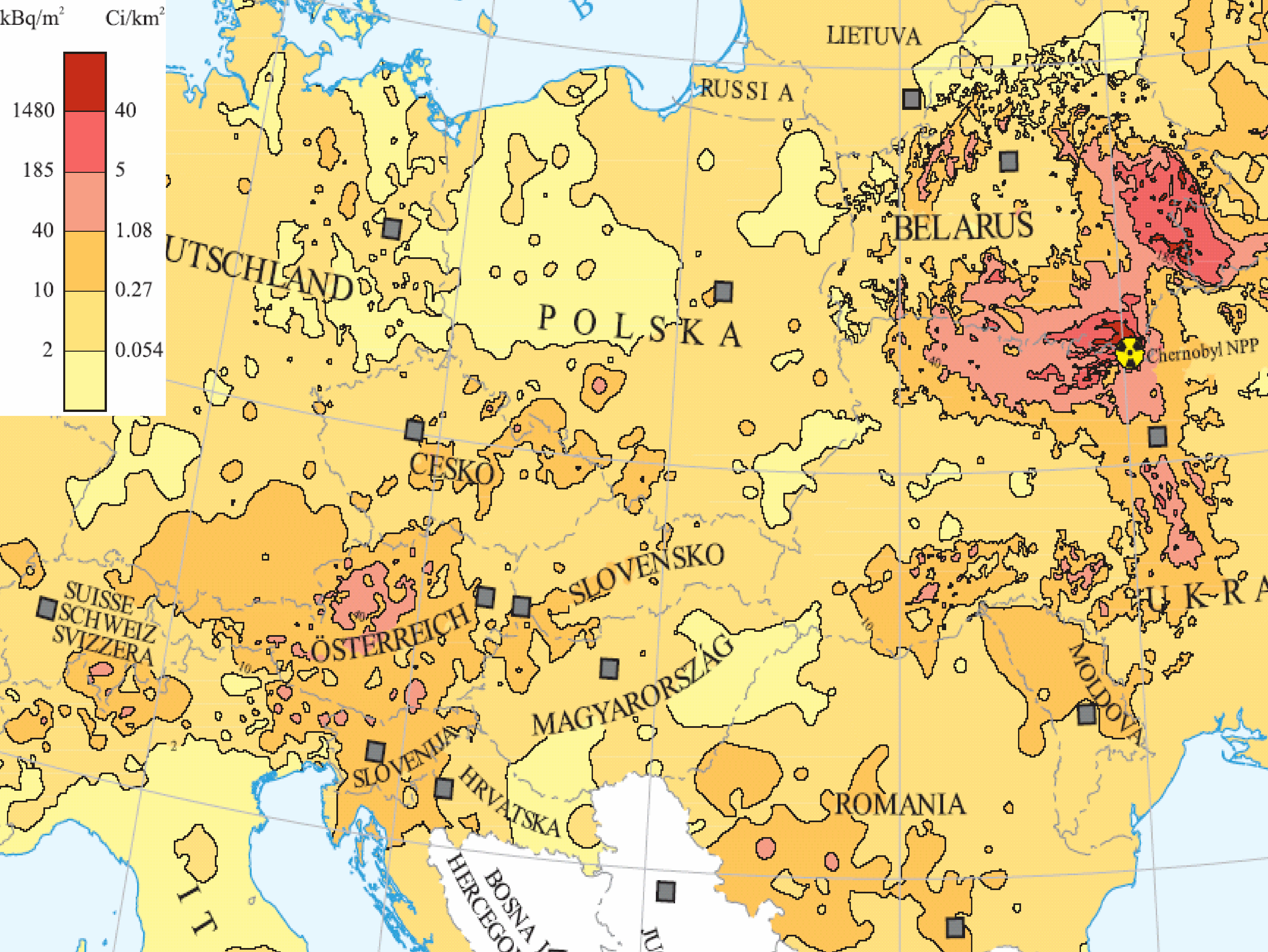
- Further to the west, in Spain and Portugal, the depositions amounted to practically zero (0.02 Bq/m^2).

- In France, the depositions showed a gradient from east to west, in decreasing level.

- In Germany, the gradient ran from the south (“hot spots” in Southern Bavaria) to the North.

- In Greece, one of the most contaminated countries, average 137Cs deposition was 6 kBq/m2, but with variations from 0.5 to 60 kBq/m2.


kBq/m²
Ci/km²
1480
40
185
5
40
1.08
10
0.27
2
0.054
not available
Norwegian Sea
White Sea
North Sea
Baltic Sea
Black Sea
Mediterranean
Tyrrhenian Sea
Adriatic Sea
Ionian Sea
ÉIRE
UNITED KINGDOM
DANMARK
DEUTSCHLAND
POLSKA
FRANCE
ESPAÑA
PORTUGAL
SLOVENSKO
MAGYARORSZÁG
ROMANIA
BELARUS
LIETUVA
LATVIJA
BALGARIJA
F.Y.R.O.M.
TÜRKIYE



kBq/m²
Ci/km²
1480
40
185
5
40
1.08
10
0.27
2
0.054
LIETUVA
RUSSIA
BELARUS
UTSCHLAND
POLSKA
Chernobyl NPP
CESKO
SLOVENSKO
UKRA
SUISSE
SCHWEIZ
SVIZZERA
ÖSTERREICH
MAGYARORSZÁG
MOLDOVA
SLOVENIJA
HRVATSKA
ROMANIA
BOSNA I
HERCEGO

Table 5
Contaminated areas in European countries following the accident
[I24]

Country	*Area in deposition density ranges (km^2)* [a]			
	37–185 kBq m^{-2}	185–555 kBq m^{-2}	555–1 480 kBq m^{-2}	>1 480 kBq m^{-2}
Russian Federation	49 800	5 700	2 100	300
Belarus	29 900	10 200	4 200	2 200
Ukraine	37 200	3 200	900	600
Sweden	12 000	–	–	–
Finland	11 500	–	–	–
Austria	8 600	–	–	–
Norway	5 200	–	–	–
Bulgaria	4 800	–	–	–
Switzerland	1 300	–	–	–
Greece	1 200	–	–	–
Slovenia	300	–	–	–
Italy	300	–	–	–
Republic of Moldova	60	–	–	–

a The ^{137}Cs levels include a small contribution (2-4 kBq m^{-2}) from fallout from the atmospheric weapons tests carried out mainly in 1961 and 1962.

UNSCEAR-2000 Report Annex J
Exposures and Effects of the Chernobyl accident

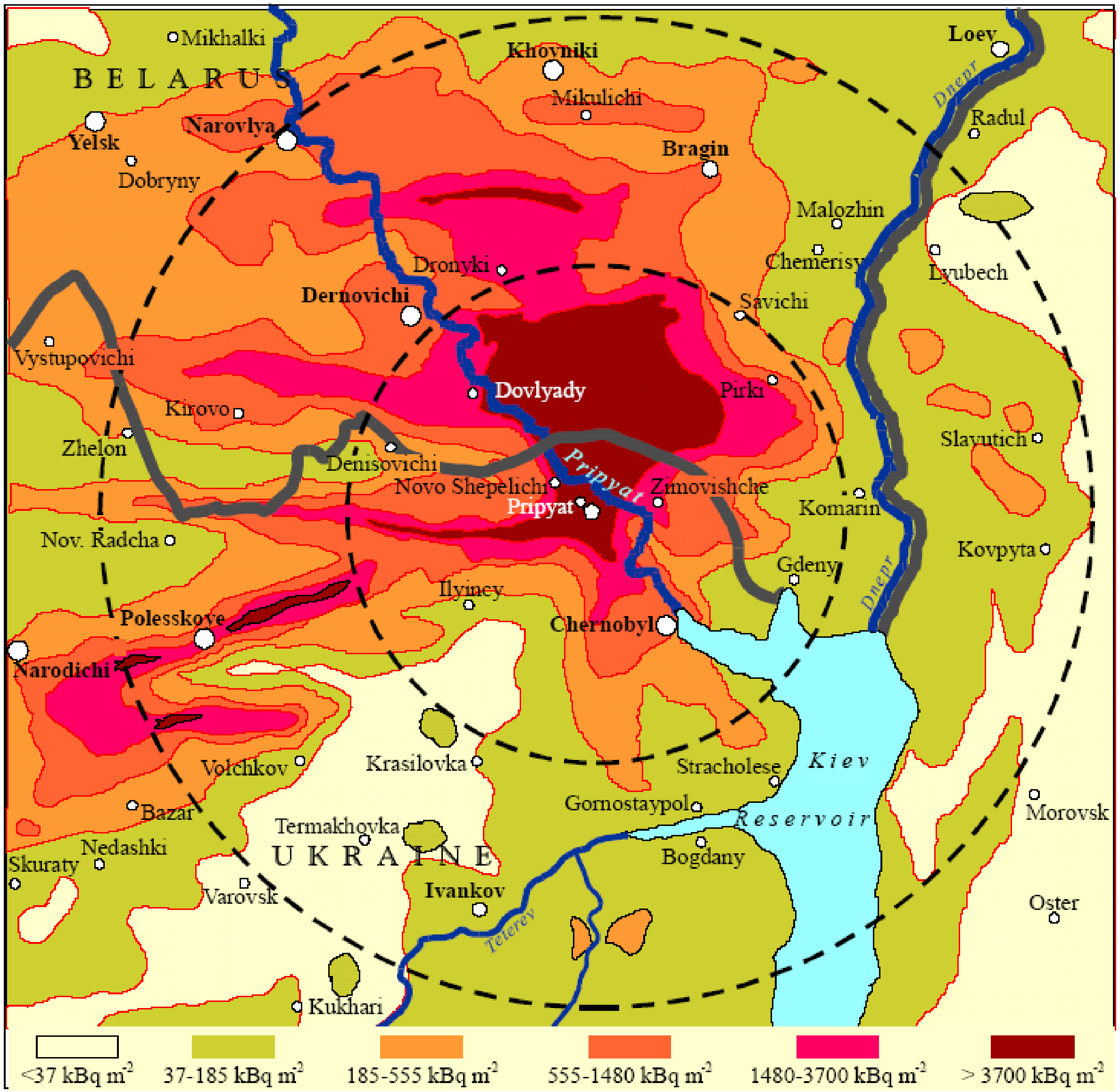
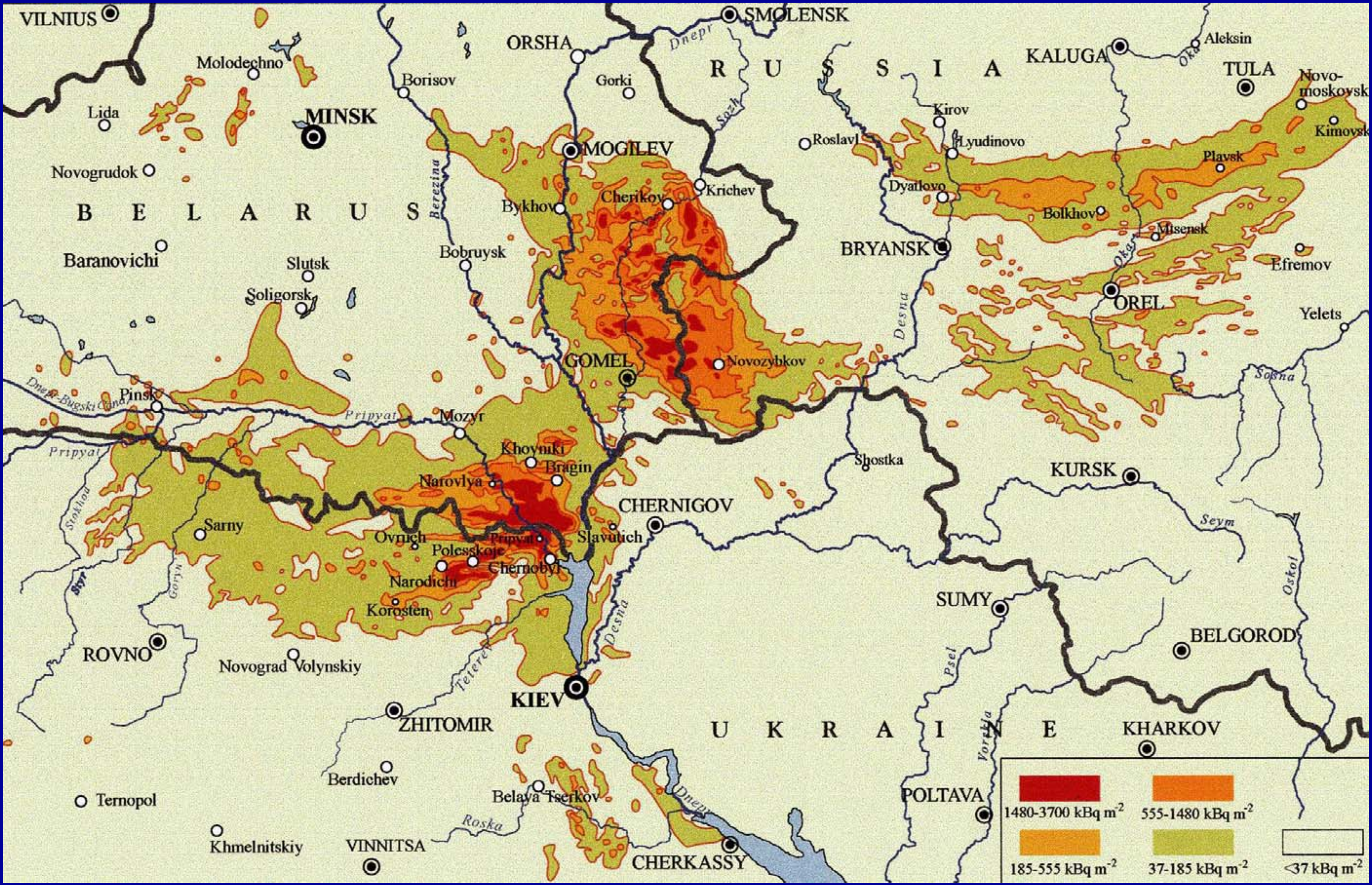


Figure VII. Surface ground deposition of caesium-137 in the immediate vicinity of the Chernobyl reactor [I1, I24].
The distances of 30 km and 60 km from the nuclear power plant are indicated.

UNSCEAR-2000 Report Annex J Exposures and Effects of the Chernobyl accident

Figure VI. Intensity levels of Cs-137 surface ground depositon.



One should not search for radiation-induced pathologies in Western Europe, that have not declared in heavily contaminated territories of Belarus and Ukraine.

Has there been an increase in the number of voluntary abortion ?

The news of spread of radioactivity over Europe generated much anxiety. The real impact of this anxiety among the public is difficult to assess. Some authors reported on a small increase in the number of induced abortions that temporally may have been partially due to fear and misinformation.

- *Spinelli A, Osborn JF. The effects of the Chernobyl explosion on induced abortion in Italy.*

  Biomed Pharmacother. 1991;45:243-7.

Radiation-induced pathologies in residents of contaminated territories of Belarus and Ukraine (excluding Emergency Workers and Liquidators).

Thyroid cancer

Chernobyl Forum

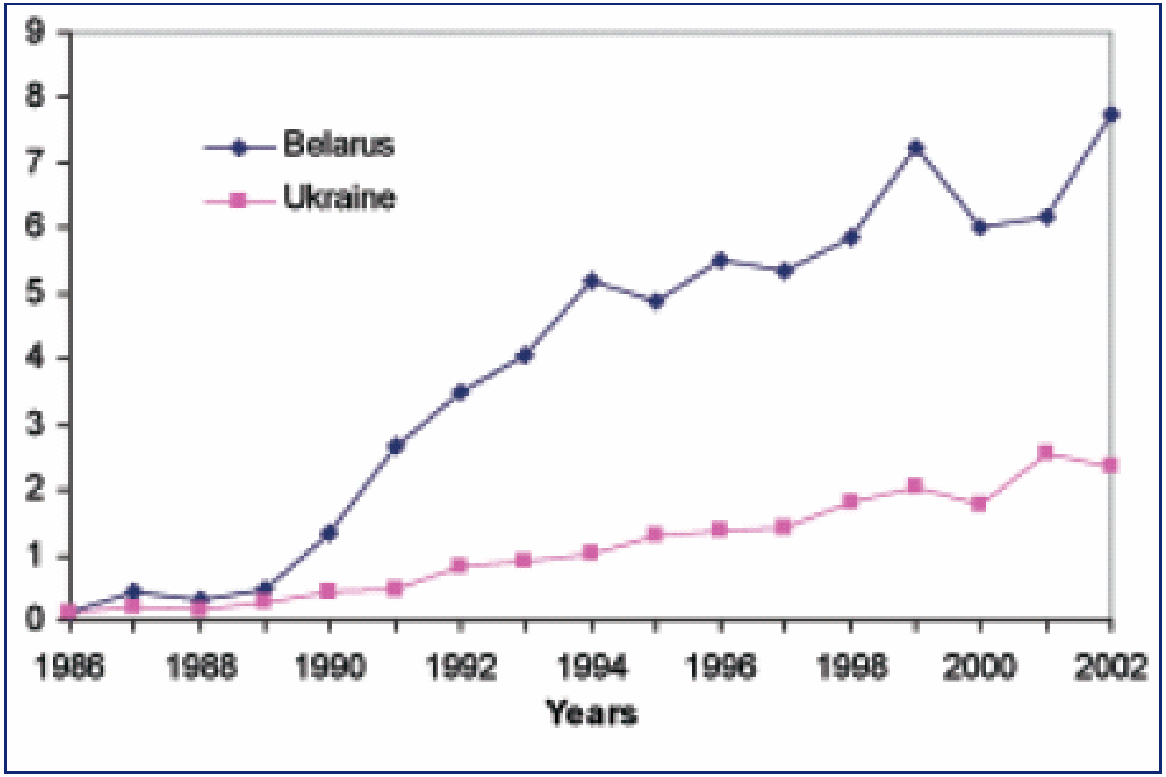


FIG. 3. Incidence rate of thyroid cancer in children and adolescents exposed to ^{131}I as a result of the Chernobyl accident (Jacob et al., 2005).

Leukemia

Chernobyl Forum

There have been many post-Chernobyl studies of leukaemia morbidity in the populations of areas contaminated with radionuclides in the three countries. There is no convincing evidence that the incidence of leukaemia has increased in children or adult residents of the exposed populations in Russia and Ukraine.

Other solid cancers

Chernobyl Forum

Because of the generally low doses received, however, there remains a lack of evidence of any measurable effect of Chernobyl radiation exposures on solid cancers in the general population except for childhood thyroid cancer, since higher doses to the thyroid gland were received by children in contaminated areas.

Congenital malformations

Chernobyl Forum

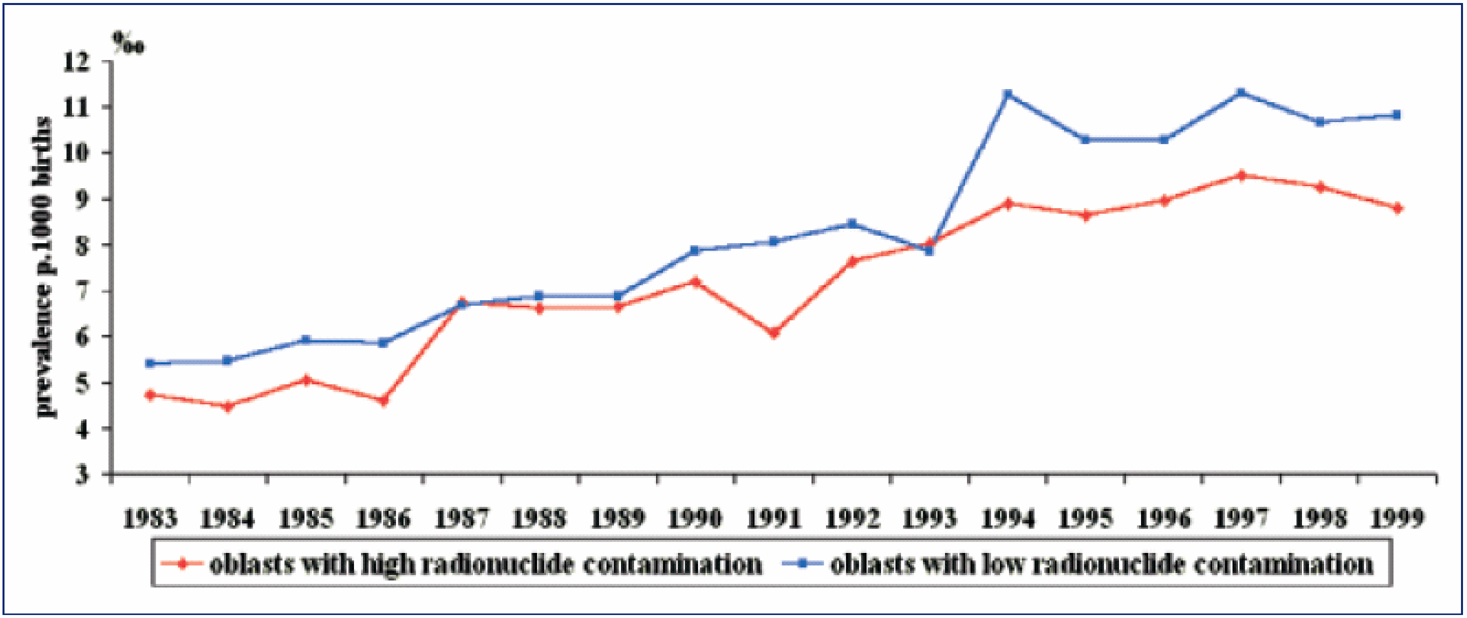


FIG. 4. Prevalence at birth of congenital malformations in 4 oblasts of Belarus with high and low levels of radionuclide contamination (Lazjuk et al., 1999).

We will focus on childhood thyroid cancer, examining respectively data from heavily contaminated regions and those from Western Europe.

Thyroid cancer and ionizing radiation: data before Chernobyl.

- The follow-up of survivors of atomic bombs has established that thyroid exposure during childhood increases the risk of thyroid cancer. No increase is clearly apparent below a radiation dose of 0.1 Gy.

Thompson DE, et al. Cancer incidence in atomic bomb survivors. Part II: solid tumors, 1958-1987. Radiat Res 1994;137:S17-S67.

Intervention levels for administration of stable iodine

- Before the Chernobyl accident, most countries would consider administration of stable iodine if internal thyroid radiation is expected to exceed 100 mGy (avertable dose).

Excess risk for thyroid cancer in atomic bomb survivors

Age at exposure (years)	Excess Relative Risk (per Sv)	Excess Absolute Risk (per 10 000 PY Sv)
< 10	~ 9.5	~ 4.4
10-19	~ 3	~ 2.7
> 20	~ 0.1*	~ 0.2

Data adapted from Thompson et al.
Cancer incidence in atomic bomb survivors. Part II: solid tumors, 1958-1987.
Radiat Res 1994;137:S17-S67.

Thyroid cancer in those exposed as children

A sharp increase in childhood thyroid cancer started four years after the accident.

In the years 1993-1997, the incidence of childhood thyroid cancer in areas of Gomel, south Belarus, were about one hundred times higher than usual incidence for this disease in children.

Why the thyroid gland ?

- The huge release of iodine radioisotopes, and the ability of the thyroid to avidly concentrate iodine as part of its normal metabolism, make the thyroid the critical organ.

- Doses received by the thyroid gland are about one to two orders of magnitude higher than those received by other organs.

Why children ?

- The thyroid of children is much more vulnerable to radiation. Vulnerability is highest in the younger age groups.

- Moreover, radiation doses to the thyroid (energy deposit per unit organ mass) were several times higher in children than in adults, and were highest in the younger age groups. (High iodine intake combined with small organ mass).

- Thus, in any region, the cohort of children aged less than 5 years at the time of the accident is the one most at risk.

Hindie E, Leenhardt L, Vitaux F, Colas-Linhart N, Grosclaude P, Galle P, Aurengo A, Bok B.
Non-medical exposure to radioiodines and thyroid cancer.
Eur J Nucl Med Mol Imaging. 2002;29 Suppl 2:S497-512. Review.

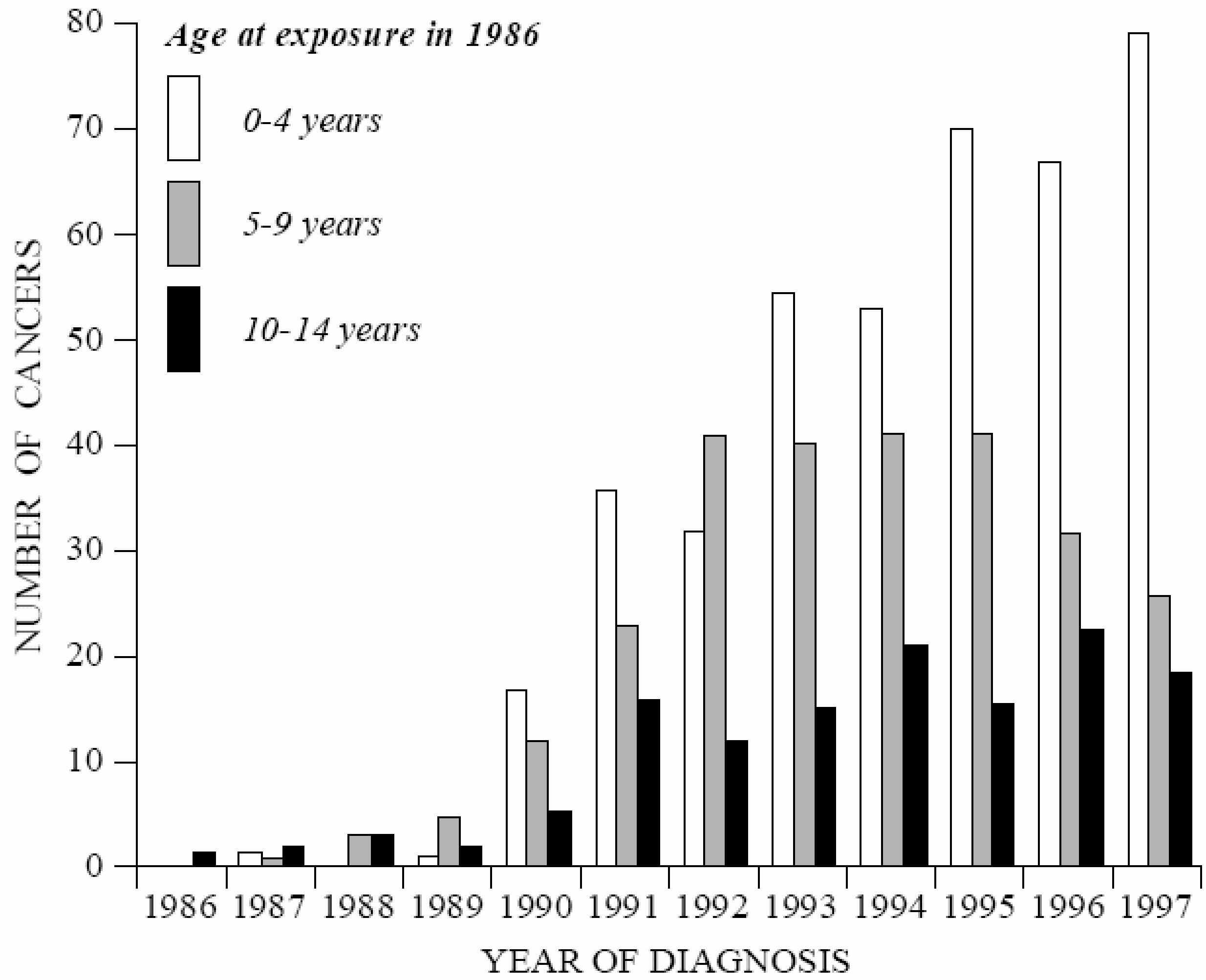


Figure XXVI. Number of diagnosed thyroid cancer cases in Belarus as a result of the Chernobyl accident [K41].

UNSCEAR-2000 Report Annex J - Exposures and Effects of the Chernobyl accident (Hofler et al)

Comparison of thyroid doses in heavily contaminated areas of Belarus and Ukraine and those in Western Europe.

Thyroid doses in heavily contaminated areas.

- Thyroid contamination occurred through several routes. During the first days, inhalation, and ingestion of contaminated water and raw vegetables, were the major sources. Later, ingestion of contaminated milk became predominant.

- Many uncertainties limit the accuracy of thyroid dose estimates. The respective importance of short-lived isotopes (133-I; 132-Te/132-I) and 131-I is also difficult to assess.

- The contribution of short-lived isotopes should have been maximal in evacuees, in whom it may have exceeded that of 131-I. In contrast, when contamination resulted from ingestion of cow milk, the contribution of short-lived isotopes would have been small.

Thyroid doses in Belarus and Ukraine.

- Thyroid doses were not uniform. In Belarus, more than half the collective thyroid dose resulted from exposure in the Gomel region. In Ukraine, a large part of the collective thyroid dose resulted from exposure in eight districts located around the Chernobyl reactor.

- Based on 27 000 measurements sampled from the contaminated districts of the Gomel region of Belarus, 30% of those aged less than 4 had received a thyroid dose higher than 2 Gy (2000 mGy).

- Similarly, in Ukraine, the average thyroid dose for children aged less than 4 from the evacuated 30-km zone (Pripyat city, and other settlements) exceeds 2 Gy.

Estimates of collective thyroid doses to populations of Belarus

Country/region	*Population*	*Collective thyroid dose (man Gy)*
Belarus [D1, G7]		
Brest	1 400 000	101 000
Gomel	1 700 000	301 000
Grodno	1 200 000	49 000
Minsk	3 200 000	68 000
Mogilev	1 300 000	32 000
Vitebsk	1 400 000	2 000
Entire country	10 000 000	553 000

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Table 22
Estimates of thyroid doses from intake of ^{131}I received by the evacuees of Belarusian villages [G15]

Age at time of accident [a] *(years)*	*Number of measured persons*	*Arithmetic mean thyroid dose (Gy)*	*Median thyroid dose (Gy)*	*Estimated number of residents* [b]	*Collective thyroid dose (man Gy)*
<1	145	4.3	2.3	586	2 519
1-3	290	3.7	1.7	966	3 573
4-7	432	2.1	1.2	1 199	2 517
8-11	460	1.4	0.86	1 105	1 548
12-15	595	1.1	0.61	1 392	1 531
16-17	221	1.0	0.59	704	704
>17	7 332	0.68	0.38	18 773	12 766
Total	9 475			24 725	25 158

a Derived from information on year of birth; e.g. age <1 includes children born in 1986 and 1985.
b Based on the age distribution available for 17,513 evacuees.

Table 21
Estimates of thyroid doses from intake of ^{131}I received by the Ukrainian evacuees of towns and villages within the 30-km zone
[G8, R12]

Age at time of accident (years)	*Pripyat town [G8]*			*Chernobyl town* [a]			*Evacuated villages* [a]			*Total collective dose (man Gy)*
	Number of persons	*Arithmetic mean dose (Gy)*	*Collective dose (man Gy)*	*Number of persons*	*Arithmetic mean dose (Gy)*	*Collective dose (man Gy)*	*Number of persons*	*Arithmetic mean dose (Gy)*	*Collective dose (man Gy)*	
<1	340	2.18	741	219	1.5	329	369	3.9	1 439	2 509
1-3	2 030	1.28	2 698	653	1	653	1 115	3.6	4 014	7 265
4-7	2 710	0.54	1 463	894	0.48	429	1 428	1.7	2 428	4 320
8-11	2 710	0.23	623	841	0.15	126	1 360	0.62	843	1 592
12-15	2 710	0.12	325	846	0.11	93	1 448	0.46	666	1 084
16-18	2 120	0.066	140	650	0.09	59	941	0.39	367	566
>18	36 740	0.066	2 425	9 488	0.16	1 518	21 794	0.40	8 718	12 661
Total	49 360		8 315	13 591		3 206	28 455		18 475	29 996

a Assumes same age distribution of population as Pripyat.

Thyroid doses in Western Europe.

- In Western Europe, contamination with iodine-131 occurred mainly through ingestion of contaminated milk, and raw vegetables. The contribution of short-lived isotopes is negligible.

- Some products considered to have a radioactive burden higher than a "safety threshold" were not approved for sale by local authorities.

- Thyroid doses are not always correlated with the level of radioactive deposit. They also depended on whether cows were on pasture, on dietary habits, and on the avidity of the thyroid for iodine, being higher in countries with low iodine in diet.

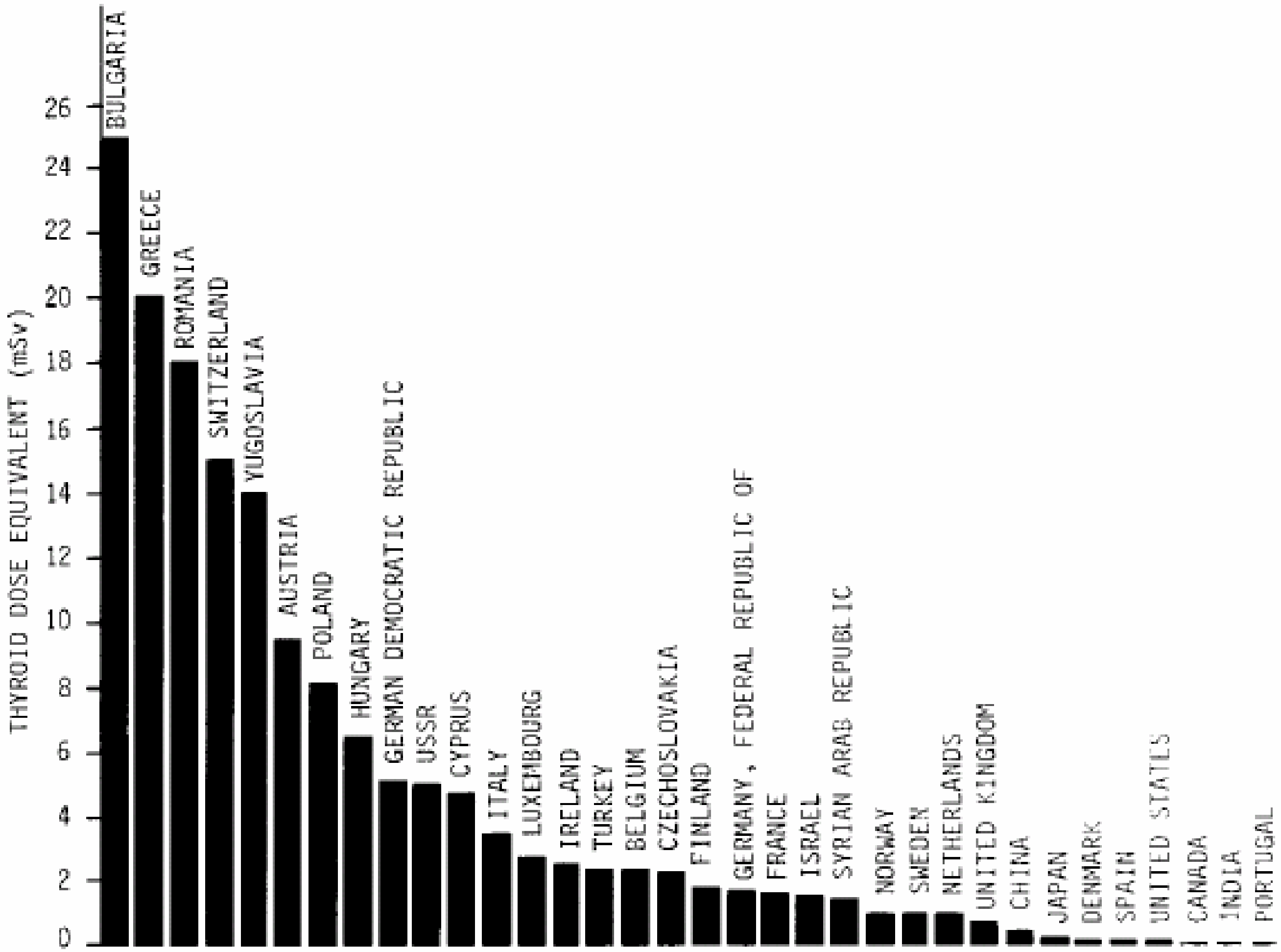

Figure XV. Country-wide average infant thyroid dose equivalents from the Chernobyl accident.

Thyroid doses in Western Europe.

- Estimates of thyroid absorbed doses to infants vary from one country to another and in different regions, from less than 0.1 mGy in Portugal and Spain to about 6 mGy in the south of Germany, and up to 30 mGy in the north of Greece.

- Even in the most affected regions, infant thyroid doses in Western Europe are one hundred times lower than those received by inhabitants of south Belarus and northern Ukraine.

- Adult thyroid doses were lower than infant doses by a factor of 5.

Childhood thyroid cancer in the heavily contaminated territories.

- Usual incidence rates of childhood thyroid cancer in Europe range between 0.4 and 1.5 cases per million.

- During the period 1993-1997, incidence rates of childhood thyroid cancer (under 15 years at diagnosis) in Belarus averaged 53 cases per million per year.

- As expected, the increase was not uniform. Incidence rates were as high as 150 in the Gomel region, while in the region of Vitebsk, they were close to natural incidence.

Table 57
Thyroid cancer incidence rates in children under 15 years old at diagnosis

Region	*Number of cases per 100 000 children*												
	1986	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
Belarus [P9]													
Brest	–	–	0.4	–	3.3	2.9	3.7	11.6	8.1	8.8	7.3	8.2	8.0
Vitebsk	–	–	–	–	0.5	1.4	1.4	–	1.0	–	–	1.2	–
Gomel	0.4	0.7	0.7	0.7	5.6	15.0	11.2	13.9	15.9	17.9	16.9	16.0	7.1
Grodno	1.1	0.6	0.5	1.1	0.6	2.2	3.2	2.7	2.2	2.8	2.4	3.1	3.3
Minsk city	–	–	0.4	–	1.5	1.9	2.7	3.5	1.2	3.9	0.5	2.0	3.7
Minsk	–	0.4	0.4	0.4	–	1.7	3.2	2.0	3.0	0.9	2.8	3.9	1.6
Mogilev	–	–	–	–	1.0	0.5	0.5	3.2	2.2	2.9	1.8	2.6	2.0
Total	0.2	0.3	0.4	0.3	1.9	3.9	3.9	5.5	5.1	5.6	4.8	5.6	3.9

UNSCEAR-2000 Report   Annex J - Exposures and Effects of the Chernobyl accident

Thyroid cancer in those exposed as children in the heavily contaminated territories.

- Increased incidence of thyroid cancer continues to be observed as the population exposed as children aged into adolescence and now adulthood.
- Between 1992-2000 in Belarus, Russia, and Ukraine about 4000 cases of thyroid cancer were diagnosed among those who were children and adolescents (0-18 years) at the time of the accident (Chernobyl Forum).
- **Not all these cases are due to radiation**.
- With the aging of the cohort, carefully controlled epidemiological studies will be required to estimate the excess cancer risk, as the natural incidence increases with age and as screening can strongly influence the results.

Jacob P, et al. Thyroid cancer among Ukrainians and Belarusians who were children or adolescents at the time of the Chernobyl accident.
J Radiol Prot. 2006 ;26:51-67. Epub 2006 Mar 7.

Thyroid cancer in Western Europe before and after Chernobyl.

- Even if the thyroid radiation was quite low, millions of young children in Western European countries have been exposed to these low levels of contamination. Patients with a new diagnosis of thyroid cancer may ask about a possible link with the accident.
- In order to detect a specific increase in thyroid cancer one should focus on age groups who are most at risk (i.e. children, and especially so those exposed below 5 years).
- When an increase in thyroid cancer occurs during childhood or adolescence it would be easy to differentiate (low natural incidence).
- Studies focusing on adults in Western Europe are not justified. Thyroid doses received by adults were very low, the adult thyroid is much less sensitive to radiation, and the extreme effects of screening on the incidence of thyroid cancer in adults renders any search for a small increase elusive.

Thyroid cancer in Western Europe before and after Chernobyl.

- Studies were initiated in several countries of eastern and southern Europe, outside the former USSR.

- An International Union against Cancer (UICC) review collated results from studies in Greece, Croatia, Turkey, and Poland and was reported by Sali et al, in 1996.

  Sali D, Cardis E, Sztanyik L, Auvinen A, Bairakova A, Dontas N; Grosche B, Kerekes A, Kusic Z, Kusoglu C, Lechpammer S, Lyra M, Michaelis J, Petridou E, Szybinskiz ?, Tominaga S, Tulbure R, Turnbull A, Valerianova Z.

  Cancer consequences of the Chernobyl accident in Europe outside the former USSR: a review. Int J Cancer 1996;67:343-352.

- The authors conclude to no increase in incidence attributable to radiation from Chernobyl.

- However, the duration of follow-up in most studies was less than 7 years, and most of them did not focus on the childhood population.

Table 52
Populations in Europe examined in epidemiological studies
[S12]

Country	*Study region*	*Age group*	*Average absorbed dose (mGy)* [a]
Thyroid studies			
Croatia	Whole country	All ages	15 [b]
Greece	Whole country	20-60 years	5
Hungary	Whole country	All ages	3 [b]
Poland	Krakow, Nowy Sacz	All ages	4 [b]
Turkey	Five most affected areas on Black Sea coast and Edirne province	All ages	1.5 [b]

Several more reports were recently published

- One study from England
- One study from France
- One study from Italy
- One study from Austria

The study from England

- **Cotterill et al, reported on an increase in childhood thyroid cancer in the North of England.**

  Cotterill SJ, Pearce MS, Parker L.

  Thyroid cancer in children and young adults in the North of England. Is increasing incidence related to the Chernobyl accident?

  Eur J Cancer. 2001;37:1020-6.

- **The authors noted that 4 cases have been diagnosed in the period 1987-1997, while only 3 cases were registered in the period 1968-1986.**

- **The comparison stands on very small numbers.**

- **Moreover, two of the four cases occurred in the period 1987-1990, where no increase is expected.**

- **The incidence was actually lower in 1991-1997 (2cases) than in 1987-1990 (2 cases).**

The study from France

- **In France, cases of childhood thyroid cancer (under 15 years) are registered in pediatric, or specialized cancer registers.**
- **The incidence studied by age and by period show no significant change with time that could be related to the Chernobyl accident.**
- **Incidence rates were lower in the years 1993-1997 (0.79 per million) than in the years 1987-1992 (1.06 per million).**

Leenhardt L, Grosclaude P, Cheri-Challine L et al. Mise en place d'un dispositif de surveillance épidémiologique nationale des cancers thyroïdiens, rapport intermédiaire. InVS, 9745 Paris November 20001.

Hindie E, Leenhardt L, Vitaux F, Colas-Linhart N, Grosclaude P, Galle P, Aurengo A, Bok B.
Non-medical exposure to radioiodines and thyroid cancer.
Eur J Nucl Med Mol Imaging. 2002;29 Suppl 2:S497-512. Review.

Evolution of the incidence of childhood thyroid cancer in France by period

Incidence per million (number of cases)

Age at discovery (years)	**Years 87-92**	**Years 93-97**
0-4	0.0 (0)	0.15 (1)
5-9	0.96 (8)	0.55 (4)
10-14	2.23 (18)	1.62 (12)
Total	**1.06 (26)**	**0.79 (17)**

Hindie E, Leenhardt L, Vitaux F, Colas-Linhart N, Grosclaude P, Galle P, Aurengo A, Bok B. Non-medical exposure to radioiodines and thyroid cancer.
Eur J Nucl Med Mol Imaging. 2002 Aug;29 Suppl 2:S497-512.

- ***With the permission of B Lacour « Registre des Tumeurs Solides de l'Enfant ».***

The study from Italy

- **Chiesa and colleagues examined in 1996-1997, 3949 children born in 1985 or 1986, and attending school in Milan.**
- **In total, 1% had palpable thyroid nodules. Based on ultrasound findings, ten of the palpable nodules were submitted to further investigation.**
- **All proved benign.**
- **The authors conclude that the high costs of their study, in relation to the finding of no increase in thyroid disease indicate that further population studies in areas that received only low radiation after Chernobyl are not justified.**

Chiesa F, Tradati N, Calabrese L, Gibelli B, Giugliano G, Paganelli G, De Cicco C, Grana C, Tosi G, DeFiori E, Cammarano G, Cusati A, Zurrida S.

Thyroid disease in northern Italian children born around the time of the Chernobyl nuclear accident.

Ann Oncol. 2004;15:1842-6.

The study from Austria

- **Gomez Segovia et al, reported data from Carinthia, a region of Austria where thyroid doses may have been higher than average Europe, based on somewhat higher contamination, and also because relative iodine deficiency was prevailing at the time of the accident.**

- **The authors do not comment specifically on childhood thyroid cancer.**

- **However, from the figures presented, the incidence of thyroid cancer in children and adolescents (0-20 years) during the period 1990-2001 appears to be normal.**

- **The incidence was less than 1 case per million per year for boys, and less than 2 cases per million per year for girls. Thus, as of 2001, the specific cohort most at risk, (age <5 at the time of the accident), has shown no increase.**

Gomez Segovia I, Gallowitsch HJ, Kresnik E, Kumnig G, Igerc I, Matschnig S, Stronegger WJ, Lind P.

Descriptive epidemiology of thyroid carcinoma in Carinthia, Austria: 1984-2001. Histopathologic features and tumor classification of 734 cases under elevated general iodination of table salt since 1990: population-based age-stratified analysis on thyroid carcinoma incidence.

Thyroid. 2004;14:277-86.

Thyroid cancer in Western Europe after Chernobyl “preliminary conclusions”.

- Infant thyroid doses in Western Europe generally ranged from 1 to 30 mGy.
- From follow-up of atomic-bomb survivors, there is no evidence that irradiation at levels below 100 mGy leads to an increase in thyroid cancer.
- *So far published data do not point to a specific increase in childhood thyroid cancer in Western Europe, that could be linked to the Chernobyl accident.*
- It is unlikely that follow-up beyond this age provides useful information, due to extreme effects of screening on the incidence of thyroid cancer in adults.
- It is my opinion that predictions through formulae of an excess number of thyroid cancer cases, and number of thyroid cancer deaths in Western Europe related to Chernobyl are not justified.

Lessons from the accident

Age at exposure

- The thyroid gland is known to be increasingly sensitive to external radiation with decreasing age.
- In the case of a power-plant accident, the importance of age is amplified, as the level of thyroid irradiation itself increases with decreasing age.
- Protecting children should be the priority.

Nutritional iodine deficiency

- Ukraine and Belarus are areas of iodine deficiency. Efforts at salt iodination slackened in the decade that preceded the accident.
- The relation between dietary iodine status and thyroid uptake of radioactive iodine is well known.
- The risk induced by iodine deficiency is probably not only due to the resulting higher thyroid uptake. Higher TSH levels, resulting from iodine deficiency, may act as an epigenetic factor, accelerating the onset of cancer.
- Many European countries have borderline or low iodine intake, and are thus at an increased risk in case of a nuclear accident. One mean of protection should be eradication of iodine deficiency.

Contribution of short-lived radioisotopes of iodine

- The role of short-lived radioisotopes deserves further investigation. Indeed, the respective responsibilities of 131-I and short-lived iodines have not yet been fully clarified.

Hindie E, Leenhardt L, Vitaux F, Colas-Linhart N, Grosclaude P, Galle P, Aurengo A, Bok B.

Non-medical exposure to radioiodines and thyroid cancer.

Eur J Nucl Med Mol Imaging. 2002;29 Suppl 2:S497-512. Review.

Improving communication

- The diversity of local situations, dissenting opinions among experts, as well as political and psychological factors, made that the reactions of national authorities in various EU-Member countries have been extremely varied and uncoordinated, thereby leading to confusion among the public. This is clearly an area where European harmonization is needed.

- Many efforts has been made :
  - The Europen Commision established the “European Community Urgent Radiological Information System” (ECURIE) through which the EU Member states are required to promptly notify the Commission on radiological emergencies and provide all information relevant to minimizing the foreseen radiological consequences.
  - The AIEA developed the “International Nuclear Event Scale” (INES) to facilitate communication on the severity of nuclear accidents,
  - etc.

Establishing uniform intervention levels for administration of stable iodine

- The Chernobyl accident pointed to a necessity of a uniform legislation for food monitoring and established “safety thresholds” processing.

- Uniform European legislation should also be adopted considering the administration of stable iodine:
  - The level of contamination (the threshold) that should trigger the administration of stable iodine.
  - The proper timing and duration of such protection.
  - The amount to be given for each age group, including new-borns and pregnant women.
  - The daily amount to be given in case of repeated administration.

Thank you

Psychological Factors Affecting Health after the Chernobyl Disaster: A 20-Year Review

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Amsterdam
March 24, 2006

The psychological impact of the Chernobyl disaster

- Disaster: Latin “ bad star” or “ill fate”
- From the beginning debate about the extent of psychological damage
- Chernobyl disaster viewed as a worst case scenario, associated with nuclear energy production
- The general public regards nuclear power with almost apocalyptic awe

2006 Report of the Chernobyl Forum

"The mental health impact of Chernobyl is the largest public health problem caused by the accident to date."

What is the evidence that documents this conclusion?

Psychological consequences of disasters

- Over the past 100 years, many descriptive epidemiologic and clinical studies of the psychological impact of natural and human-made disasters

*high risk groups

*general population

Psychological impact of disasters

- Depression (suicide)
- Anxiety (especially post-traumatic stress)
- Medically unexplained physical sx (MUPS) (fatigue, weakness, headaches, joint and muscle pain)
- Substance abuse
- Changes is health related behaviour
    - Increased medical service utilization
    - Changes in attributional style

Common risk factors for adverse emotional outcomes after disasters:

- Personal:
  female; having young children; prior psychiatric or alcohol history; poverty; low social support; poor physical health
- Disaster:
  magnitude & severity of exposure; number of deaths; evacuation; death of a loved one; physical threat
- Post-disaster:
  inadequate practical or emotional support; inadequate or inappropriate professional interventions; media coverage

Two post-disaster risk factors unique to toxic disasters

Stigma

&

Fear of cancer and congenital abnormalities

Radiation events and stigma

- Japanese survivors – hibakusha (explosion-affected people)
- A-bomb neurosis – excessive anxiety about health and fear of cancer

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- Chernobyl evacuees - “glow worms”
- Vegetative dystonia – weakness, headaches, fatigue (non-specific physical sx and stress reactions)
- Radiophobia – excessive anxiety (derogatory & non-scientific)

Features that Chernobyl a "high-risk" disaster (1)

- Widespread exposure
- Death toll??
- Delayed, chaotic and permanent evacuation
- Abortion assembly-lines
- Battle for residency permits
- Increase in thyroid disease in exposed children

Chernobyl features (2)

- Incomplete disclosure by authorities
- Prolonged contradictory reports by news media
- Distrust in government authorities
- Wide array of symptoms attributed to event by medical community
- <u>Intensive</u> health monitoring by international community

Chernobyl features (3)

- Followed by political and social upheaval
- Decline in standard of living
- Periods when food and electricity were not available
- Shortening of life expectancy in men
- Broken promises in terms of benefits to evacuee pop.
- Locally referred to as “second Chernobyl”

Evidence on psychological “fall-out”

cautionary comments

1. Context of the research

- Prior to Chernobyl, no tradition of: epidemiology or of western psychiatry
- No baseline data on prevalence of mental illness, mental retardation, dementia, or alcoholism
- Suicide data unreliable
- No experience adapting standardized tools for studying well-being used in other parts of the world

2. Disentangling the effects of multiple stressors

- Socio-economic conditions and political turmoil also contributed to pop. mental health
- Chernobyl itself entailed multiple stressors
- Complex web of exposures whose effects are inseparable

3. Reliable psychological research began 6 years later

Acute psychological effects, and effects during first 5 years, were not documented at the time they occurred

Areas of research

1. Population-based morbidity studies
2. Cognitive impairment in at risk children
3. Mental health of liquidators

Four population-based morbidity studies

- Finnish/Russian community study
- Dutch/Belarus epidemiologic study
- US/Kiev high risk group study
- Ukraine national survey findings

Population-based morbidity studies: conclusion

- Significant adverse psychol consequences – prolonged (anxiety, MUPS)
- - increased use of medical services
- No apparent rise in diagnosable disorder
- Risk factors – female, having young children, poverty, risk perceptions

Consistent with research on TMI and Hiroshima/Nagasaki, and toxic disasters

(2) Cognitive Impairment in Children

International Pilot Study of Brain Damage In-Utero (WHO) (age 7)
- Additional follow-up in Belarus
- Additional work in Kiev RCRM

Stony Brook/Kiev research (age 11)

Israeli study of children expo < age 4 (+ in utero)

Cognitive Impairment in Children

Each study involved:

- a battery of neuropsychological tests of memory, intelligence, attention
- standard psychological evaluations
- non-exposed control group
- Separate evaluation of children *in utero*

Cognitive Impairment in Children

No exposure effects:

- WHO sample (age 7, from all 3 republics)
- Stony Brook/Kiev (age 11)
- Israeli sample (from Gomel (hi expo; N=667), Mogilev & Kiev (mild expo; N=408), and non-expo regions (N=564)

GGZ buitenamstel

Cognitive Impairment in Children: Conclusion

Highest levels of exposure in exposed children were lower than the levels at which mental retardation was found in the offspring of Hiroshima/Nagasaki survivors

Tentative conclusion: no compelling evidence suggesting adverse effects of radiation exposure

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(3) Mental health of liquidators

2 issues:

Effects of exposure on neurocognitive impairment (3 reports)

Emotional or alcohol-related consequences

Suicide: Estonia

Rahu et al. 1997

- Cohort of ~5,000 cleanup workers assembled in 1992; ave. age at arrival at C. = 32 yrs
- No significant excess of cancer deaths (1986-1993)
- Significant excess of suicide (SMR=1.52; 95% CI=1.01-2.19)

Mental health of liquidators: conclusion

- Mental health effects are unknown, but findings on neurocognitive effects are dubious (or reflect excess alcoholism)
- Suicide findings are worrisome
    - *Dropped the ball in this area:*
- Occupational stress research→significant diff's in alcoholism and depression between C-expo and other work forces

Does the evidence support the WHO conclusion about public mental health impact of Chernobyl?

Conclusions

- Psychological impact is long-term, protracted
- Anxiety, depression, MUPS
- Increased use of medical services
- High risk groups (women, mothers, evacuees)
- No evidence of brain effects or diagnosable psychiatric disorders
- Psychological effects not only in area of mental health, but also in health-related behaviours

Are the findings from Chernobyl unique?

- Findings are consistent with research on other toxic exposures
- Consistency of the basic findings with other research is crucial aspect of one's ability to generalize (Rothman & Greenland 1998)

TMI	A-bomb
Bhopal	Tokyo gas attack
Chemical spills	Persian Gulf
Toxic waste leaks	Occup. Exposures

Future directions

- Descriptive studies of clean-up workers
- Analytic epid. studies of risk and protective factors for psychiatric problems
- (testable) interventions to reduce the level of psychological morbidity:
  - Medical professionals/health authorities
  - Local research communities
  - Participants in ongoing research studies
- Public health community must take other health impacts seriously

Thank you for your attention

GGZ buitenamstel

Non-Governmental Humanitarian Support to South-east of Belarus

Vlamingen helpen Tsjernobylkinderen vzw (VHTK)

Parents d'accueil pour Tchernobyl asbl (PAT)

Vzw DOMA

Chernobylkinderen vzw

Accueil, Renaissance, Renouveau pour Enfants de Tchernobyl (ARRET)

Accueil Tchernobyl asbl

Les Enfants de Tchernobyl asbl

Veliki Bor

Bel-Bel vzw

OKIN vzw

1. The aim of the non-governmental organizations.

- <u>Objective</u> :

  to give humanitarian help to the east and south east region of Belarus

1. The aim of the non-governmental organizations (cont.).

- Priority :
  - Provide a health holiday in Belgium for weakened children of the affected area
    - One or two months vacation with host parents
    - Children aged from 7 to 17 years
    - Healthy food
    - Vitamins

1. The aim of the non-governmental organizations (cont.).

- Advantages :
  - Better health and less sickness
  - Cs137 diminishes with 27%
  - Social contact

- In 2005 : 1120 children
  - 300 by train
  - 820 by coach

- A couple of Flemish NGO's subsidized by Flemish government for this project

1. The aim of the non-governmental organizations (cont.).

1. The aim of the non-governmental organizations (cont.).

1. The aim of the non-governmental organizations (cont.).

- Provide medical assistance to hospitals and medical centra
- Provide assistance to schools and universities

2. Health care supporting projects in Belarus.

- Contrast Minsk – South East of Belarus
- Medical staff are trained to a high standard
- Medical equipment is outdated
- Medicins are in poor supply
- Medical care is free but …

2. Health care supporting projects in Belarus (cont.).

2. Health care supporting projects in Belarus (cont.).

- Contrast Minsk – South East of Belarus
- Medical staff are trained to a high standard
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2. Health care supporting projects in Belarus (cont.).

- Contrast Minsk – South East of Belarus
- Medical staff are trained to a high standard
- Medical equipment is outdated
- Medicins are in poor supply
- Medical care is free but …

2. Health care supporting projects in Belarus (cont.).

- Several NGO’s have started medical projects :
  - Supplying of medical equipment tools
  - Shipment of health care materials and medicins
  - Blood pressure monitors,blood analyzers, syringes
  - Exchange of knowledge
  - Supplying of clothes, shoes, gloves

2. Health care supporting projects in Belarus (cont.).

- The theme through all the projects :
  - Short absence of subsidized means
  - Sponsoring
  - Activities

2. Health care supporting projects in Belarus (cont.).

- Project 1 :
  - Laparoscopy for the hospital of Gomel
    - Budget : € 12,000.00
    - Sponsoring and activities
    - A 3 years project

2. Health care supporting projects in Belarus (cont.).

- Project 1 (cont.):
  - Fitting out of an infants playroom
    - Children ill for long time
    - Social reason
    - Toys donated by host families and supporters

2. Health care supporting projects in Belarus (cont.).

- Project 1 (cont.):

2. Health care supporting projects in Belarus (cont.).

- Project 2 :
  - Medicins and medical material for children’s and veterans hospital in Mogilev
    - Medicines
    - Syringes, sterile bandages
    - Head ware and gloves
    - Operating tables

2. Health care supporting projects in Belarus (cont.).

- Project 2 (cont.):
  - Budget : € 4,000.00 / transport
  - Problems :
    - Very strict rules and regulations
    - Quality certificates
    - Import of medicins

2. Health care supporting projects in Belarus (cont.).

- Project 3 :
  - Röntgen equipment for the general hospital in Rechitsa
    - Multix chamber
    - Portable röntgen appliance
    - Two röntgen c bows

2. Health care supporting projects in Belarus (cont.).

- Project 3 (cont.):

2. *Health care supporting projects in Belarus (cont.).*

2. Health care supporting projects in Belarus (cont.).

- Project 3 (cont.) :
  - Budget : € 50,000.00
  - Benefit concert and doubled an equal grant
  - Gastro-, colon- and endoscopie
  - Operating tables
  - Second-hand in perfect condition
  - Cost : transport, installation, after sale service

2. Health care supporting projects in Belarus (cont.).

2. Health care supporting projects in Belarus (cont.).

- Project 4 :
  - Exchange of know how
    - Work experience with western technology
    - Doctors from Bobrousjk
    - 14 days in Andreas Vesalius hospital (Tilleul)
  - Costs : € 500,00 /doctor covered by NGO
  - Accommodation by host families

2. Health care supporting projects in Belarus (cont.).

- Project 5 :
  - Supporting of children’s hospitals
    - Minsk : treatment of respiratory problems
    - Mozir and Klimovitchi
    - Medicines, compresses, syringes, sterile bandages
    - Materials for babies
    - Heating equipment and detergents
  - Budget : sponsoring and activities
  - Problem : import of medicins

2. Health care supporting projects in Belarus (cont.).

- Project 6 :
  - Supporting medical centre Veliki Bor
    - Necessary supplies
    - Initial treatment
    - Electrical central heating
  - Costs : financed by efforts of volunteers
  - Another initiative : registration of health problems

2. *Health care supporting projects in Belarus (cont.).*

- Project 6 (cont.)

2. Health care supporting projects in Belarus (cont.).

- Project 7 :
  - Medical materials for the Polyclinic of Novy-Barsouk
    - Dispensary of the very poor village
    - Most elementary care : thermometers, blood pressure meters, dosimeters, medicins, hospital beds
  - Costs : financed by efforts of volunteers
  - Problems :
    - Import of medicins
    - Low budget ➔ daily basic care is not guaranteed

2. *Health care supporting projects in Belarus (cont.).*

2. Health care supporting projects in Belarus (cont.).

- Many questions remain unanswered
  - Modern medicines
  - Modern medical appliances

2. Health care supporting projects in Belarus (cont.).

– Incubators

– Materials for maternity hospitals

– Diabetic supplies

2. Health care supporting projects in Belarus (cont.).

- Problems
  - Laws of Belarus get stricter
  - New regulations imposed
  - Impossible to import medicines
  - Hospital beds not older then 5 years
  - Complete specifications in Russian
  - Operating manuals in Russian
  - Quality control certificates

2. *Health care supporting projects in Belarus (cont.).*

- Our experiences

3. Education support projects in Belarus.

- The need for education in the village schools is great

- NGO’s support schools in :

  Gomel, Rechitsa, Choiniki, Mogilev, Bouinichi, Bobrousjk, Novy-Barsouk, Veliki Bor, Minsk

3. Education support projects in Belarus (cont.).

- Goods are collected in Belgium or bought locally
  - Books, pens and pencils
  - Copiers and second-hand computers
  - Knitting yarns
  - Sports clothing
  - School benches and furniture, curtains and wallpaper

3. Education support projects in Belarus (cont.).

3. Education support projects in Belarus (cont.).

- Overview of the projects :
  - Purchasing warm clothing and shoes for children living a long distance from school
  - Supplying a sewing shop for handicapped with materials and necessary tools
  - Work experience in Belgium for students from a school in Bobrousjk

3. Education support projects in Belarus (cont.).

- Students of the French language faculty of Minsk rehears and perform a play of theater
- The nursey and infant school in Veleki Bor is supported with :
  - Didactic materials, video, copy machines, tools for manuel work
  - Installation of IT classroom with second-hand PC's
  - Prize for the best equipped school in the region

3. Education support projects in Belarus (cont).

3. Education support projects in Belarus (cont.).

- Generally :
  - Schools in small villages have a shortage of didactic material
  - School buildings have a dire need of repair:
    - From interior decoration
      - Floor covering, showers, toilets, painting, kitchen utensils
    - To a complete roof
  - **Not financed NGO's cannot possibly fullfil this task**

3. Education support projects in Belarus (cont.).

3. Education support projects in Belarus (cont.).

– Supporting the French and Dutch language faculty of the Language University in Minsk

3. Education support projects in Belarus (cont.).

- New and second-hand study books for students and professors
- In 2005 the author Ward Ruyslinck donated his oeuvre to the Dutch Language Faculty

4. Conclusion.

- **The projects of Belgian NGO's in Belarus are significant:**
  - The health of the children is influenced favourably
  - There is a great need for medical help and education support

- **Continuation of our projects must be guaranteed no matter what it costs …**

4. Conclusion (cont.).

- **The NGO’s call upon the appropriate institutions to exercise their influence in Belarus to achieve :**
  - To free the import of medical supplies and medicines
  - A flexible attitude towards the NGO’s
  - A relaxing of customs formalities for all goods and especially for medical goods
  - More support of local authorities

4. Conclusion (cont.).

- **Our goal :** receive subsidies from the European Union

- **Only then will this most welcome drop in the ocean today, will create the growth of the humanitarian help for the whole population of the affected areas tomorrow**