THE MANAGEMENT OF INTERNAL AND EXTERNAL EXPOSURES
IN POST-ACCIDENT SITUATIONS

Countermeasures, radiological surveillance and evolution of regulations in Belarus, after the Chernobyl accident

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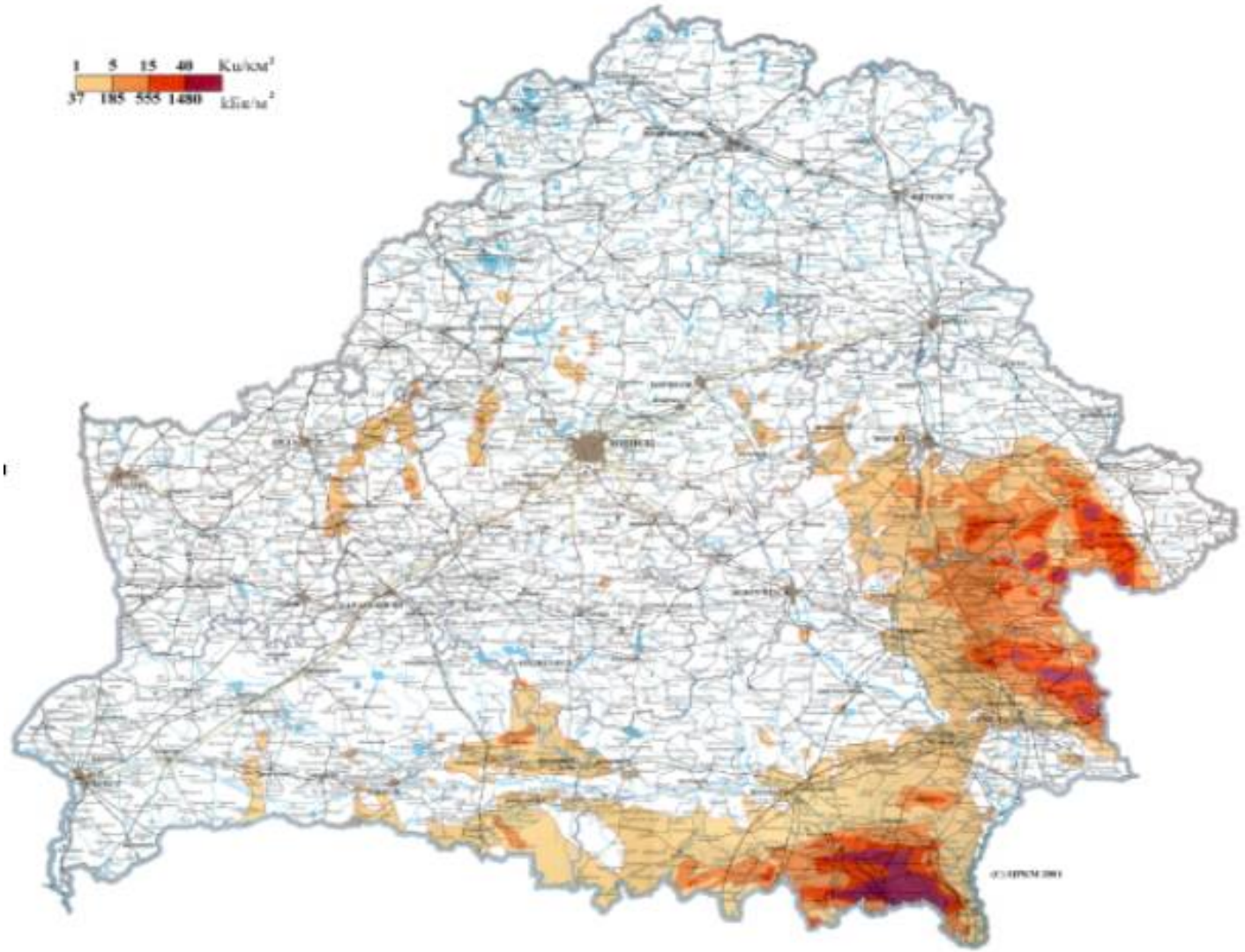
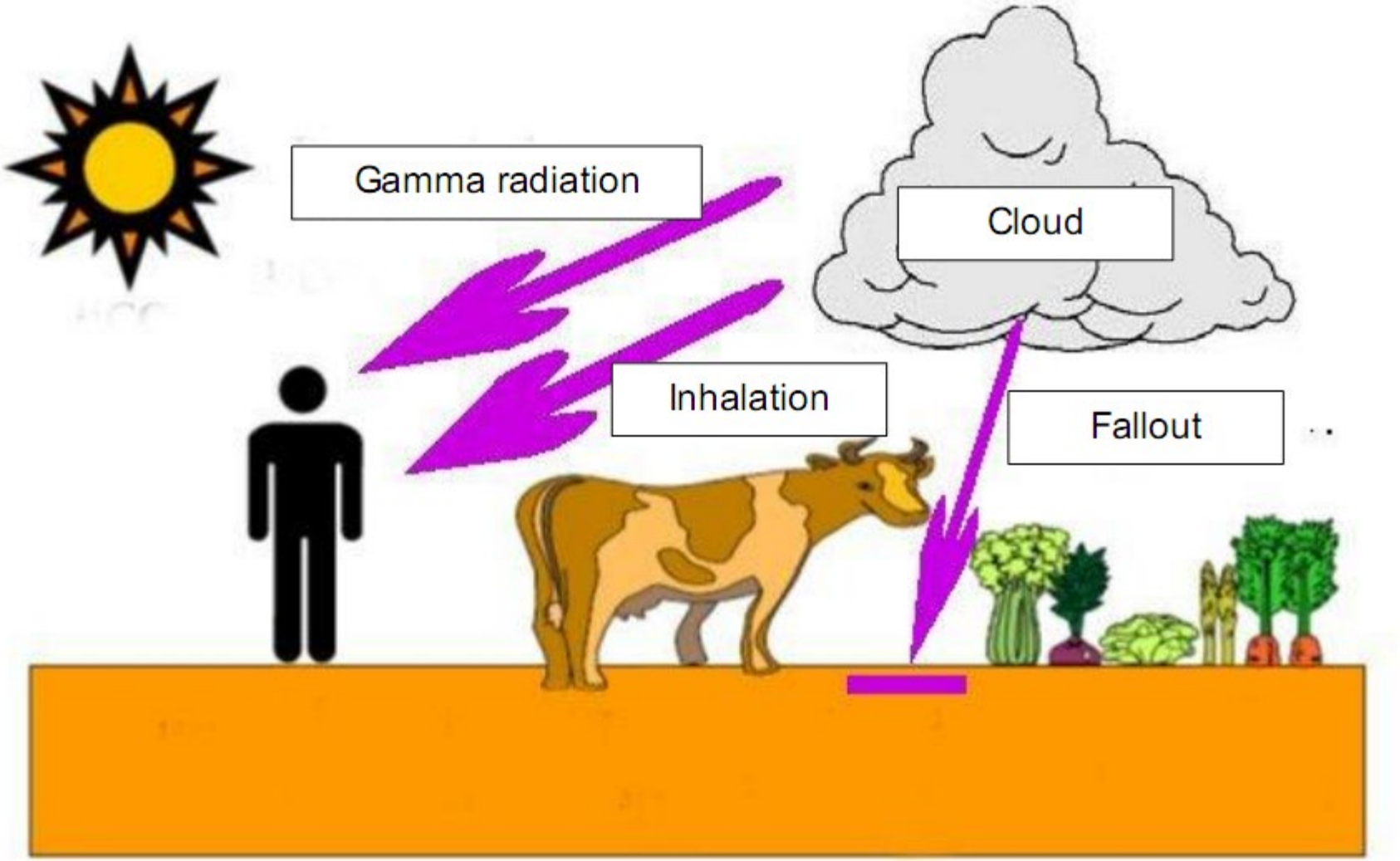
Damaged reactor of Chernobyl NPP

Contamination of Belarus by Cs-137



Radiation impact at the early stage after the accident



Protective measures at various post-Chernobyl stages

Emergency measures 1986-1991

- Evacuation
- Resettlement
- Large-scale decontamination

Protective measures 1991-2000

- Legislation
- Mass resettlement
- Health and social protection
- Countermeasures in agriculture

Long-term rehabilitation 2000–present

- Re-specialization in agriculture
- Rehabilitation of residential areas
- Radiological protection culture

STAGES OF PUBLIC PERCEPTION AND UNDERSTANDING OF RADIATION PHENOMENON AND RADIOACTIVE CONTAMINATION

1 1986-1989

- Fear of deadly health effects and especially of the safety of children;
- Can we live here and consume the food we produce?
- Confusing variance of information

2 1990-2000

- Steady belief that living under such conditions is possible;
- How to reduce the radiation levels in locally produced food? What recommendations should be used?
- What food products should be produced to assure their good sale?

3 2000-present

- Confidence in food safety (compliance with the standards);
- Improved credibility to the affected areas;
- Radioecological education of all local residents through children and youth;
- Direct access to measuring radionuclide concentrations in food

Initial phase of the early stage after the disaster

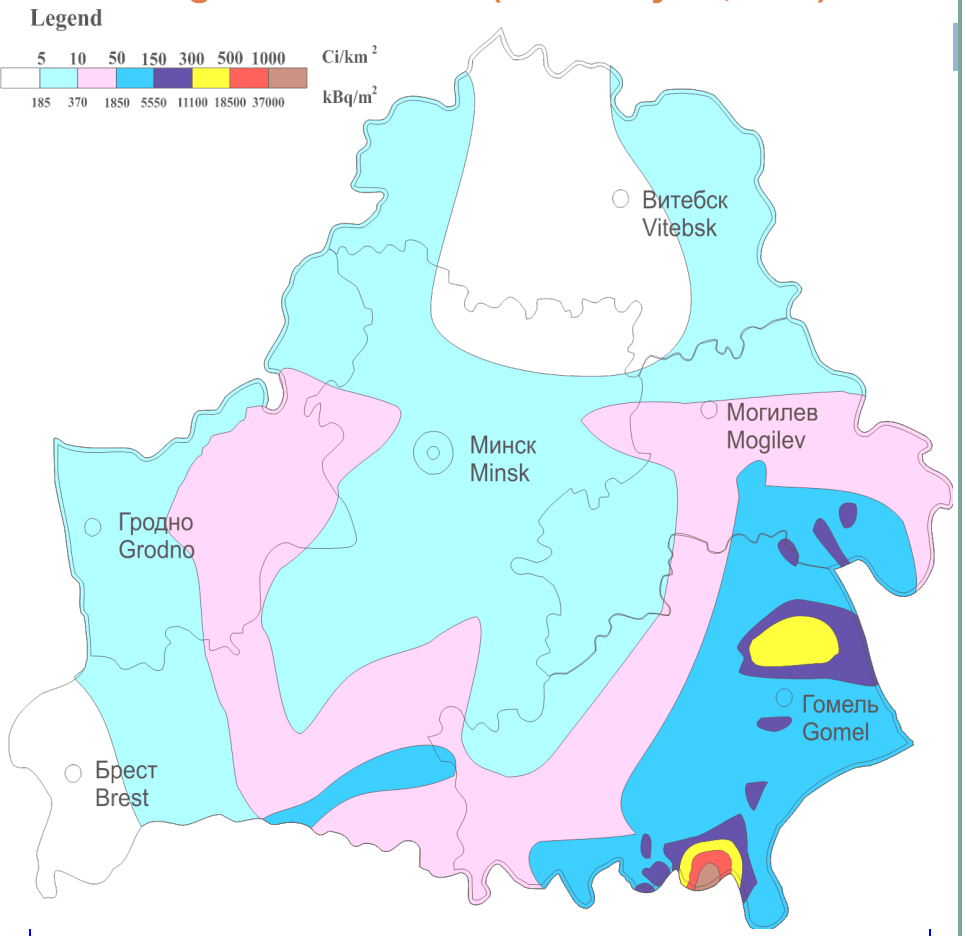
Primary actions at the early stage after the disaster:

1. External gamma radiation from radioactive cloud – **sheltering**
2. Inhalation uptake of iodine – **thyroid blockade**
3. Contact exposure – **sanitary treatment**

PRAVDA newspaper clipping dated April 30, 1986

Countermeasures in emergency phase (1986-1991)

Reconstruction of ^{131}I deposition density in regions of Belarus (as of May 10,1986)



Temporary permissible levels for ^{131}I concentrations in foods were adopted in 12 days after the accident on 6th May 1986

Evacuation of 24.7 thous. people from 30-km zone from 2nd May till august 1986, resettlement of 110 thous. people in the following years (1991-2005).

Rushed slaughter of cattle from evacuated areas. Processing of milk with ^{131}I, ^{134}Cs, ^{137}Cs, ^{90}Sr.

Abandoning of agricultural lands (265 thous. hectares).

Radiological management of foods and soil surveys (first map was ready by June 1986, large-scale map of contaminated soils was done by 1991).

2-stage cattle fattening and slaughter after 'clean' feeding (lands with ^{137}Cs contamination >555 kBq/m^2).

Deep plowing on peat soils. Liming (682 thous. ha), increased rates of fertilizers (1.2 mln tons K2O and 0.6 mln tons P2O5, plus 58 mln tons manure).

'Radical' improvement of hayfields and pastures.

Dire shortage of timely information, equipment, specialists and recourses.

Emergency actions in 1986 – 1989

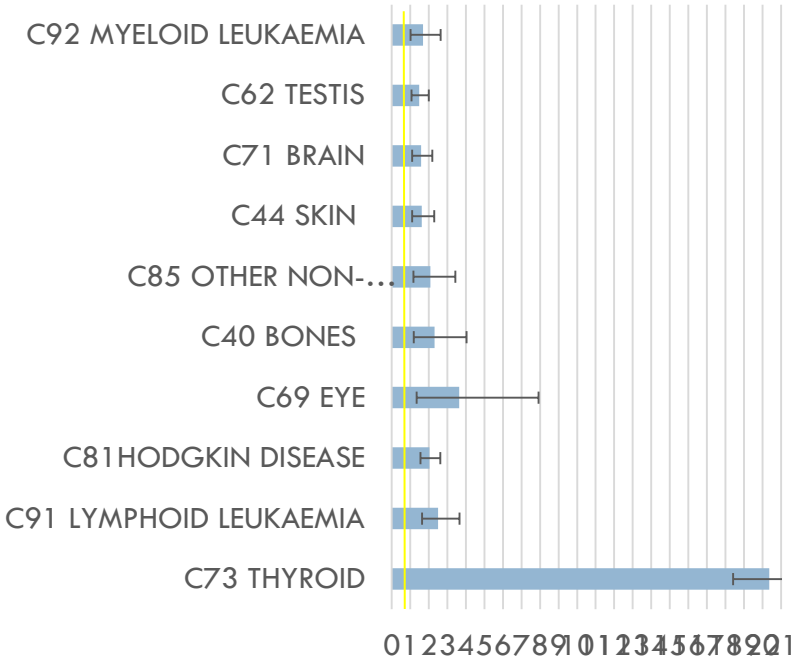
In total, **333 thousand people** were evacuated or voluntarily moved away from highly contaminated areas.

Evacuation allowed to :

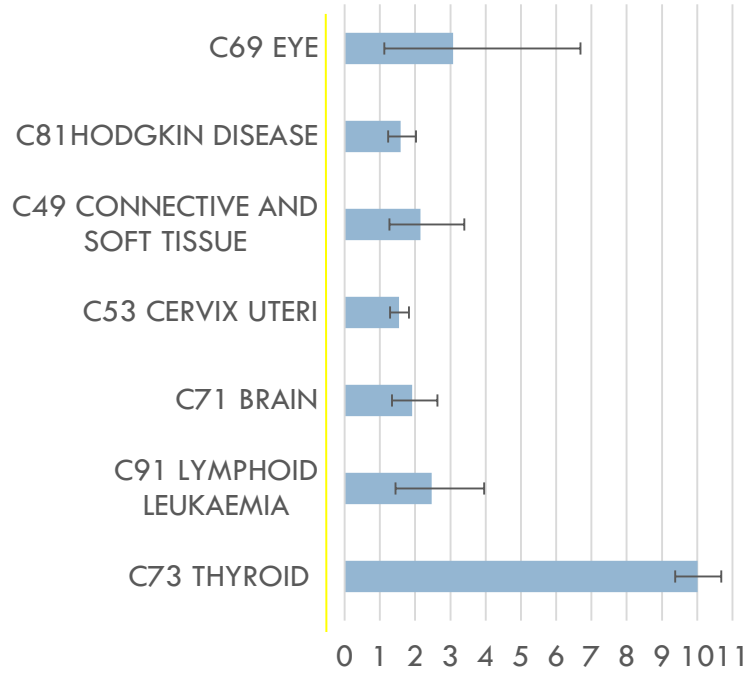
- **reduce collective dose** by 10000 man-sieverts, and
- following the threshold principle, **avoid mass deterministic effects**

SIGNIFICANT SIR
GIRR B

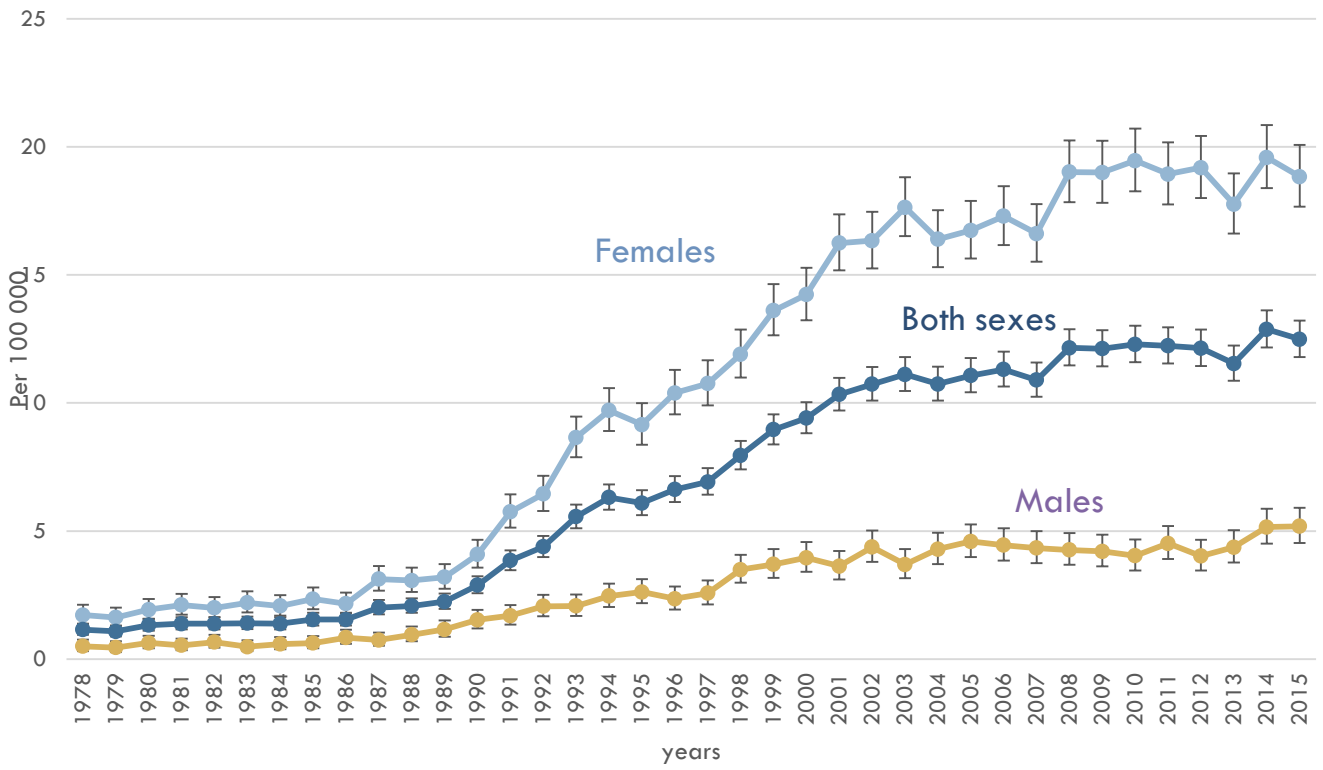
MALES



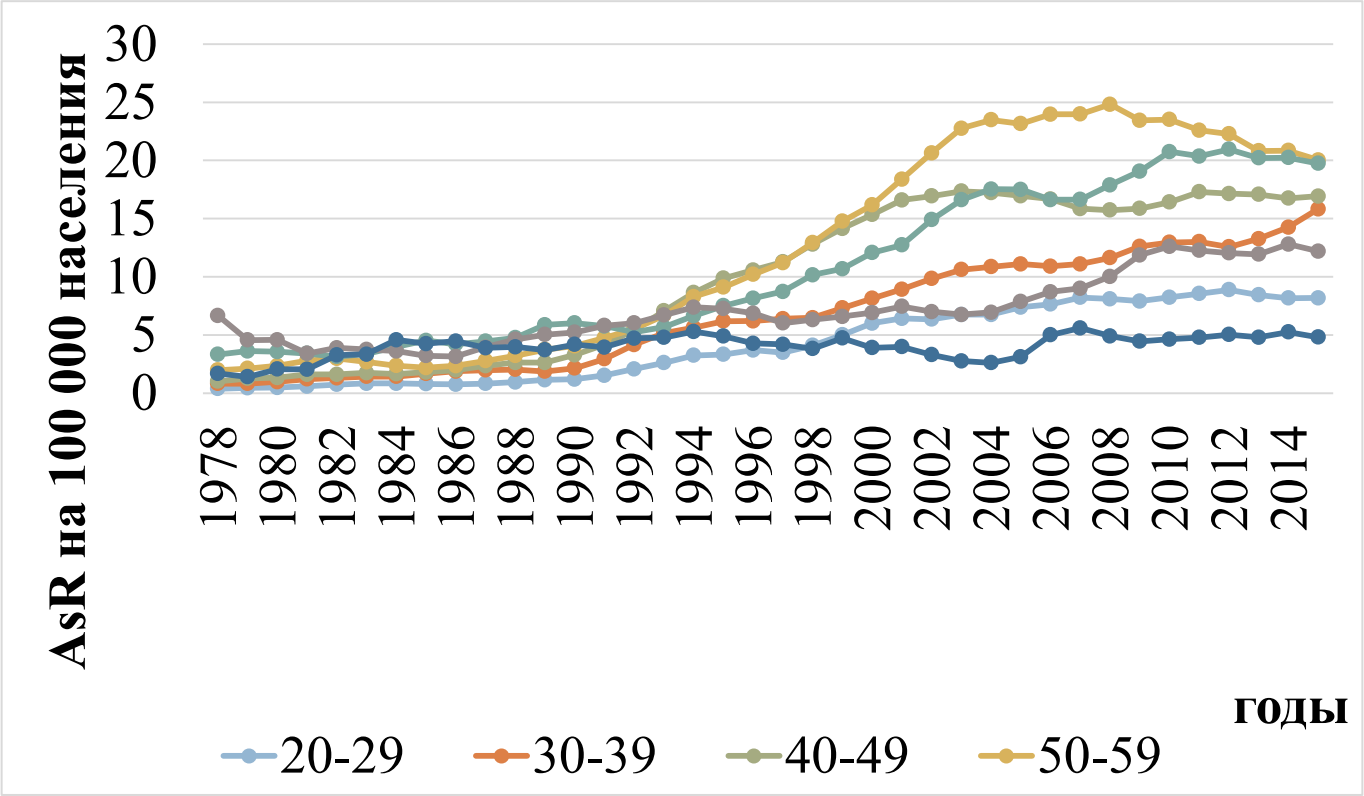
FEMALE



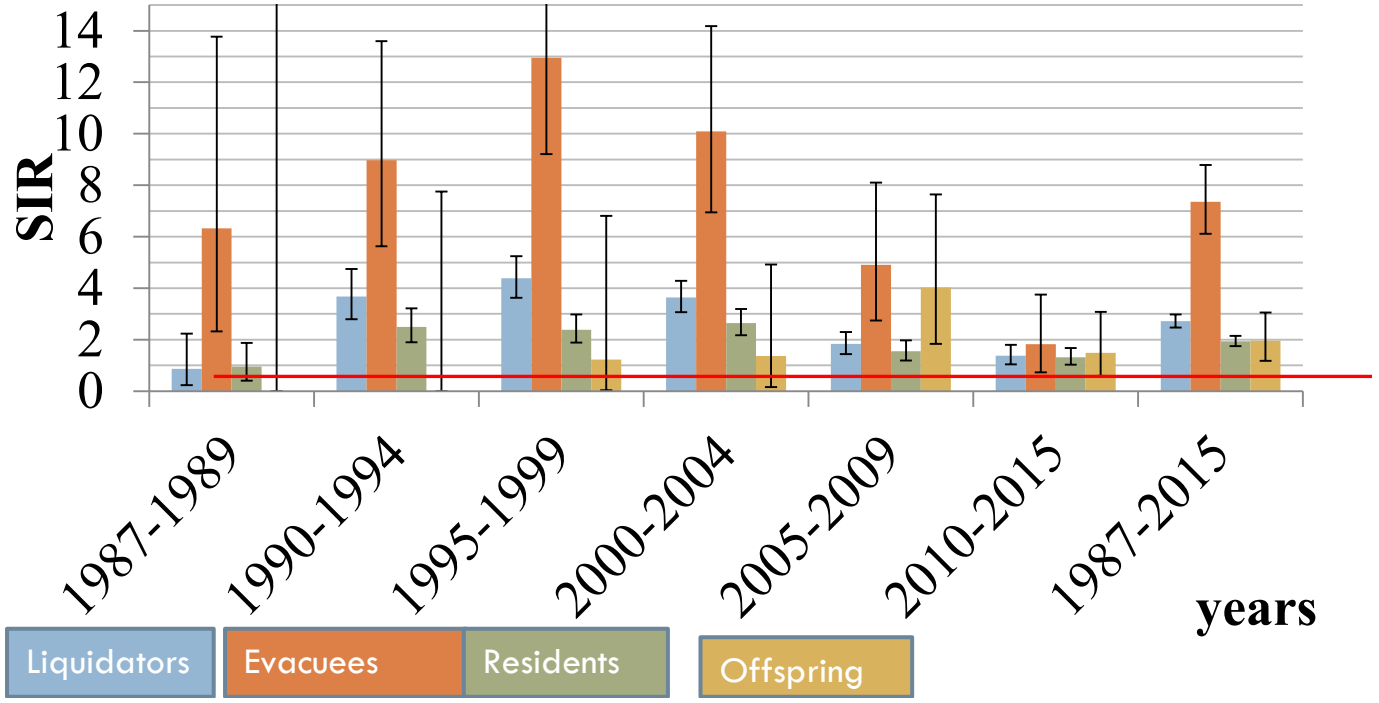
Crude Incidence rates, Thyroid Cancer, 1978-2015



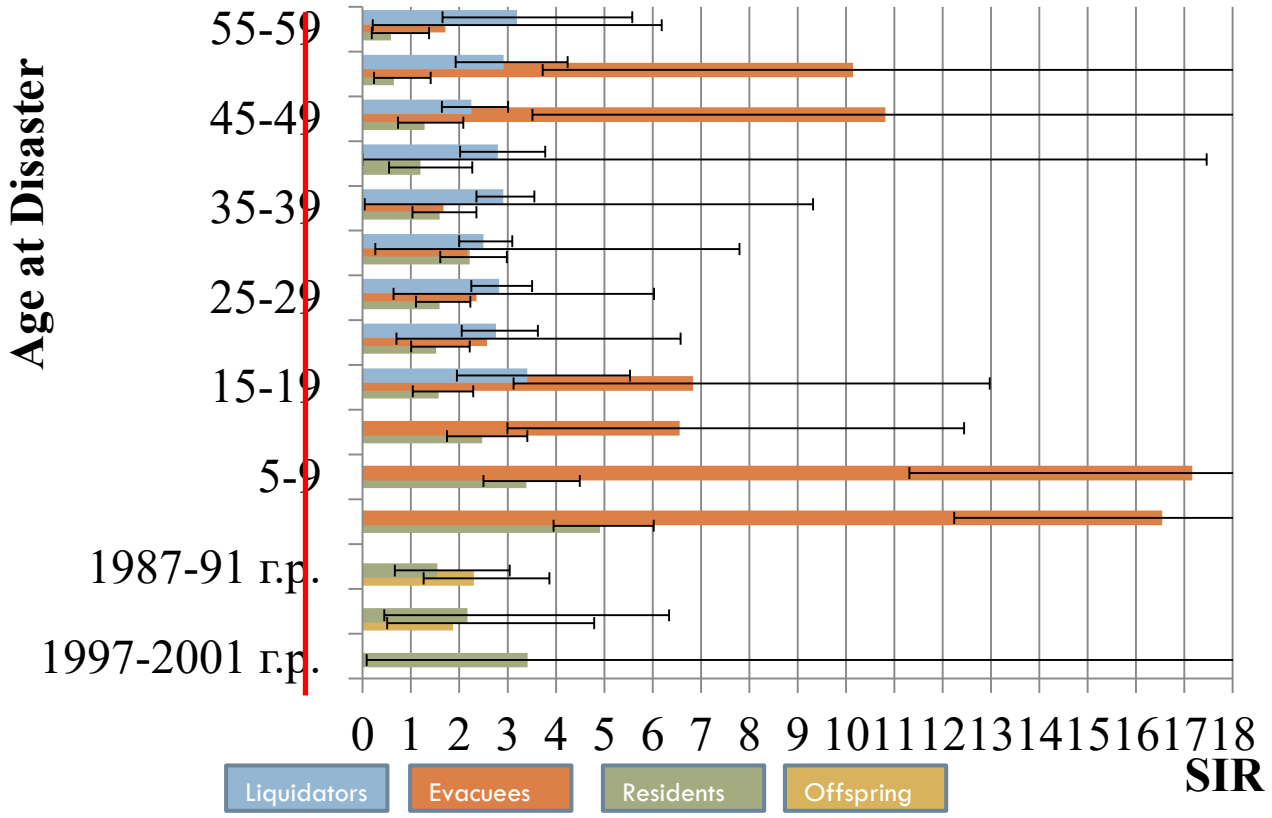
Observed Age-specific Thyroid cancer Incidence rates, 1978-2015



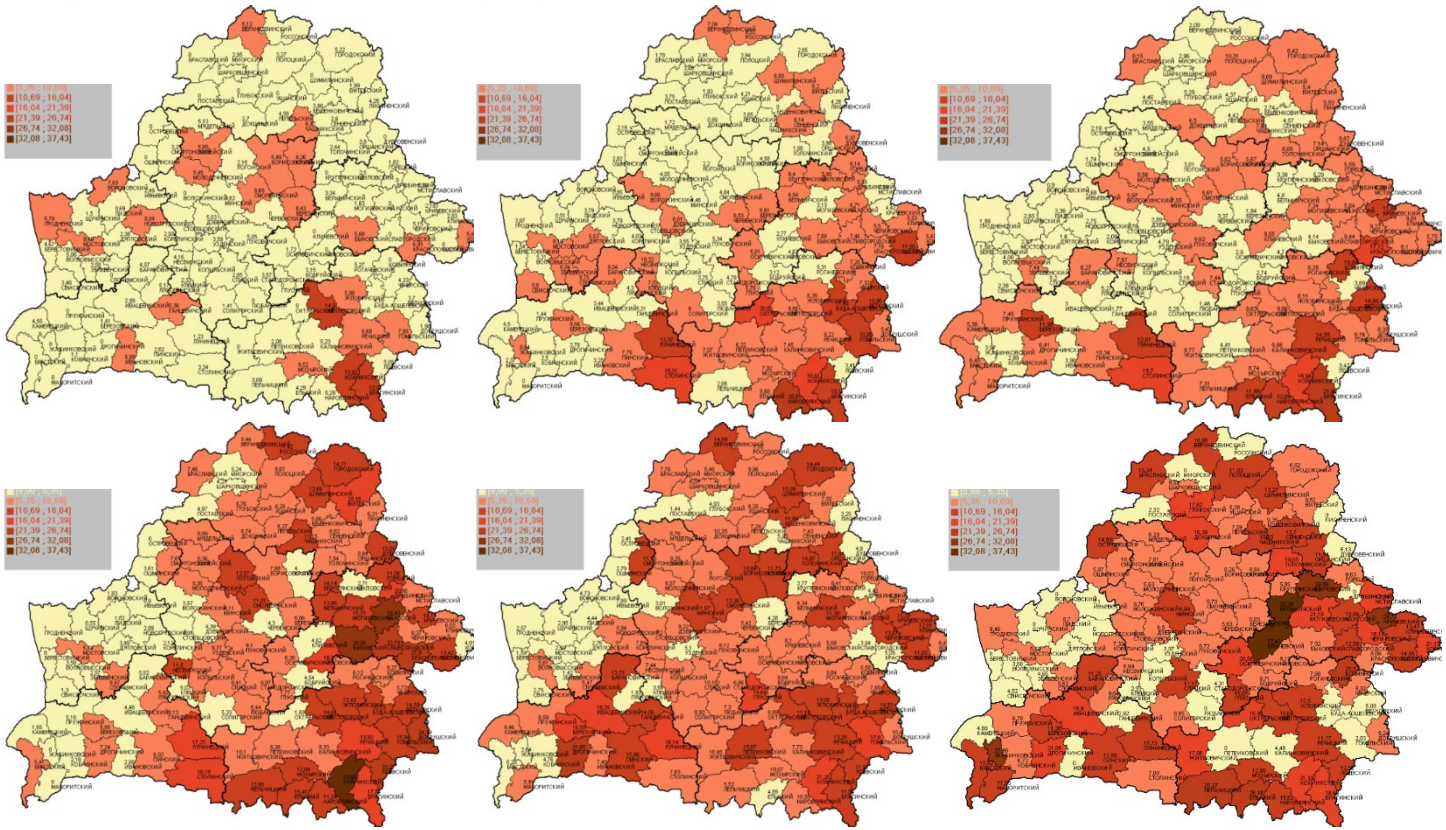
Standardized Incidence Ratios for thyroid Cancer by GPR 1-4, 1987-2015 гг.



Standardized Incidence Ratios for thyroid Cancer by Age at Disaster GPR 1-4, 1987-2015 гг.

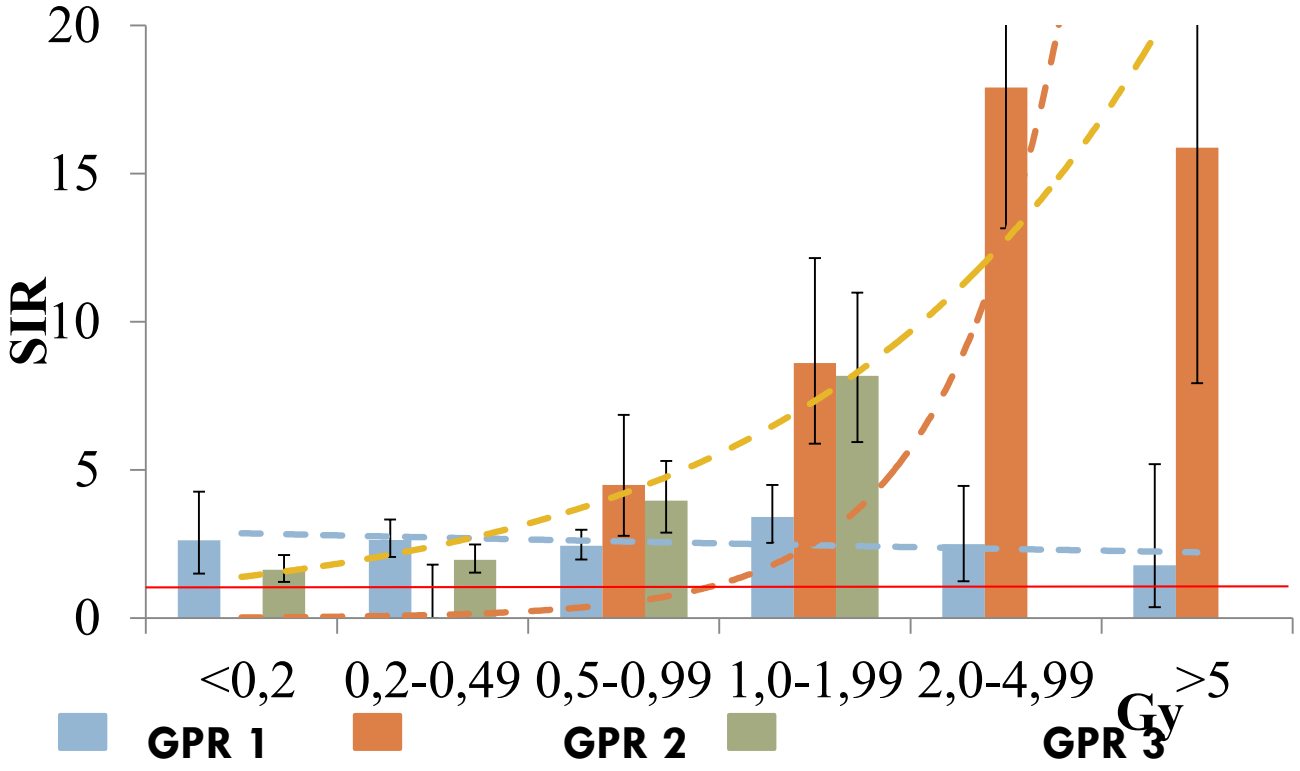


Thyroid Cancer Incidence



The contamination of the territory of Belarus with iodine-131 (reconstruction) estimated 10 May, 1986

Dose-Response curve



Decontamination

Decontamination should be **based on dose limits** established for this purpose.

1986 : ambient dose 5-20 mR/h → Evacuation

In the initial period of decontamination in the USSR external radiation dose limits changed over time and depended on the category of personnel involved in the post-accident response actions.

In 1986 a dose limit was established which insured no deterministic effects of exposure. The pre-determined emergency standard was that of 250 mSv. Later it was changed down to 50 mSv, and after that, the life-span dose limit was set at 35 mSv.

Decontamination in Belarus

Object of Decontamination	INTERVENTION LEVELS Gamma Radiation, μR/h, *or* Beta Radiation, particle/min·cm^2	Action
Territories of pre-school facilities, schools and private houses	35-40 μR/h	Removal of 25-cm soil layer
Working office and operational places: - permanent being - temporary being	50 μR/h 100 μR/h	Cleaning with detergents and water
Open areas within settlements (stores, public places)	60 μR/h	Removal of 25-cm soil layer
Inner surfaces of houses; transportation means	20 particle/min·cm^2	Cleaning with detergents and water
Roofs of buildings	40 particle/min·cm^2	Cleaning with detergents and water

ベラルーシにおける除染

除染対象	除線対象の基準 ガンマ線, μSv/h, *или* ベータ線, particle/min·cm^2	除染方法
幼稚園、学校、集合住宅周辺の土地	0,35-0,40 μSv/h	25cmの表土を除去
職場 - 常駐の場所 - 一時的滞在場所	0,50 μSv/h 1,0 μSv/h	洗浄剤や水による洗浄
公共施設、店舗など	0,60 μSv/h	25cmの表土を除去
住居の外壁、乗り物	20 particle/min·cm^2	洗浄剤や水による洗浄
住居の屋根	40 particle/min·cm^2	洗浄剤や水による洗浄

Decontamination

500 settlements of Belarus were decontaminated during 1986-1989 period, 60% – in 2-3 stages.

- removal of contaminated soil and "clean" refilling;
- dismantling of objects not subjected to decontamination;
- asphalting of streets, roads and pavements;
- roof replacement;
- waste disposal.

7.3 million m^3 of soil **was cut off** and replaced with 1.57 million m^3 of clean soil.

除染

1986年から1989年にかけて、ベラルーシでは500の居住地で除染が行われた。そのうち、60%の居住地では２、３回に分けて行われた。

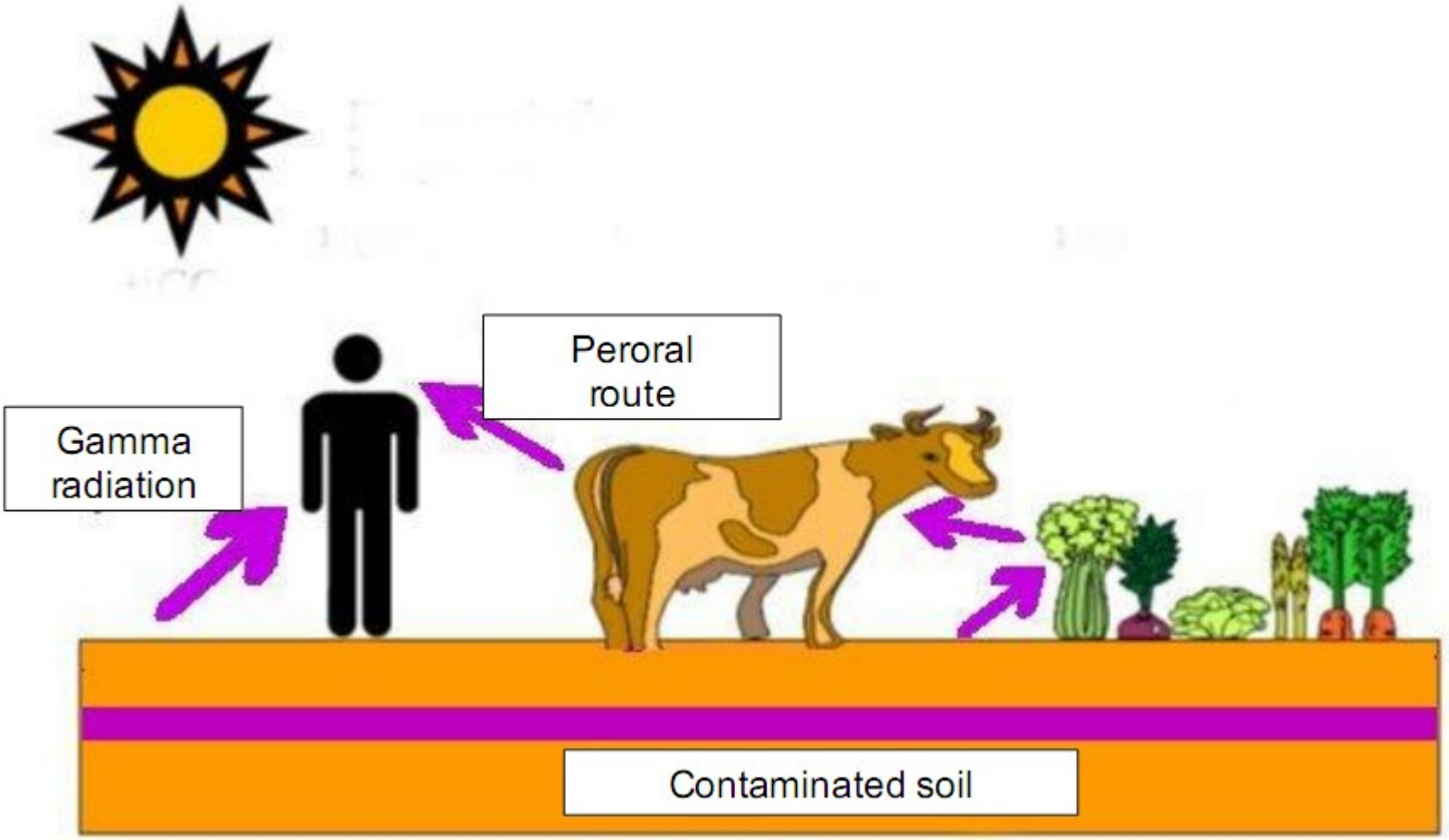
- 汚染土の除去、非汚染土との入れ替え
- 除染不可能な建造物の解体
- 道路、歩道のアスファルトによる舗装
- 屋根の葺き替え
- 除染後の残留物の埋立処理

730万㎥ nの土が埋立処理され、157万㎥の非汚染土が使用された。

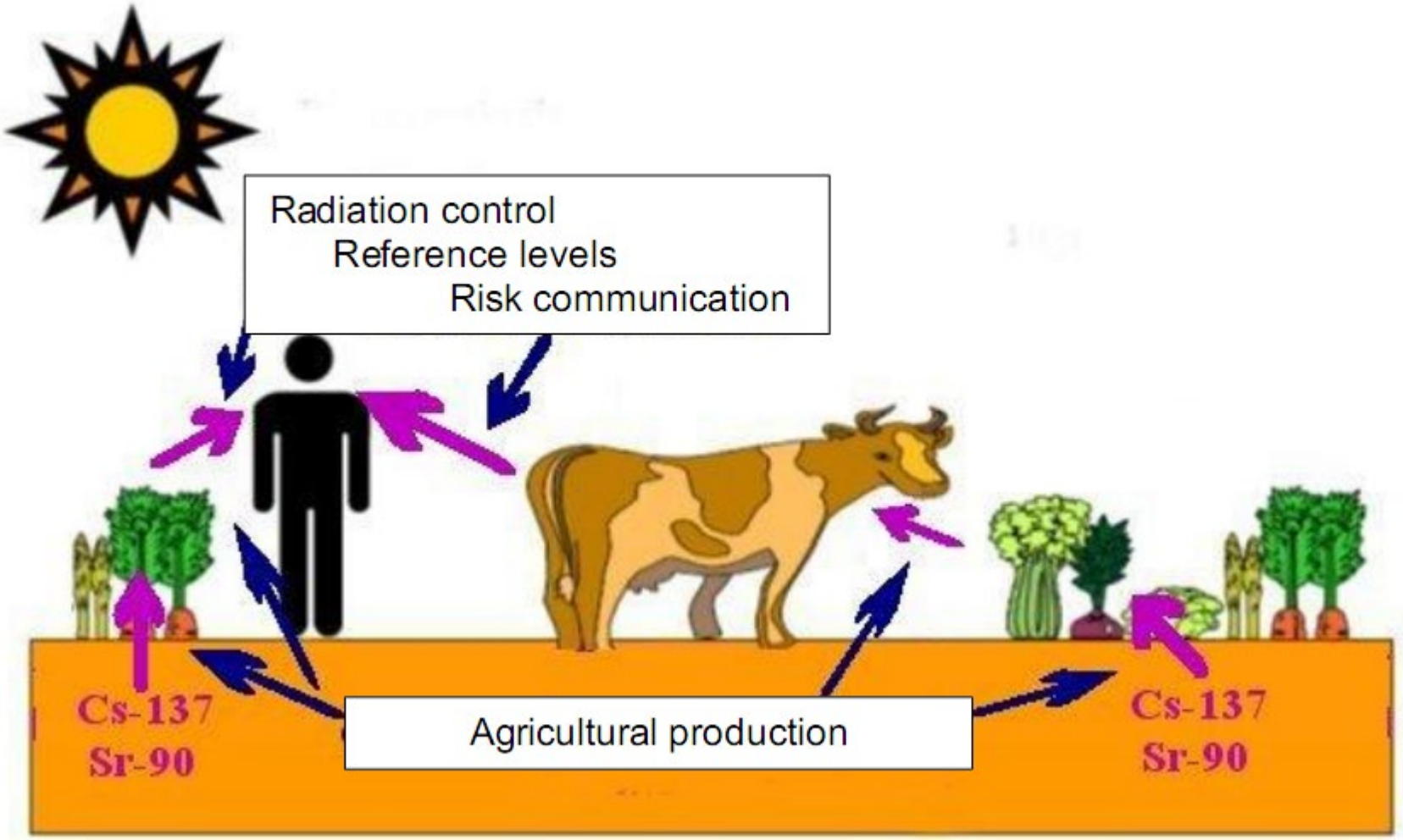
Radiological zoning criteria adopted in Belarus in 1990s

Zone of **residence with periodic radiation control**	annual effective dose to population should not exceed D_{eff} < 1 mSv·year^{-1} 37< ^{137}Cs < 185 kBq·m^{-2} 5.55 < ^{90}Sr до < 18.5 kBq·m^{-2} 0.37 < ^{238,239,240}Pu < 0,74 kBq·m^{-2}
Zone with the **right for resettlement**	1 mSv·year^{-1} < D_{eff} < 5 mSv·year^{-1} 185 < ^{137}Cs < 555 kBq·m^{-2} 18.5 < ^{90}Sr < 74 kBq·m^{-2}, 0.74 < ^{238,239,240}Pu < 1.85 kBq·m^{-2}
Zone of **primary resettlement**	D_{eff} > 5 mSv·year^{-1} ^{137}Cs > 1480 kBq·m^{-2} ^{90}Sr > 111 kBq·m^{-2} ^{238,239,240}Pu > 3.7 kBq·m^{-2}
Zone of **subsequent resettlement**	555 < ^{137}Cs < 1480 kBq·m^{-2} 74 < ^{90}Sr < 111 kBq·m^{-2} 1.85 < ^{238,239,240}Pu < 3.7 kBq·m^{-2}
Zone of **evacuation** (exclusion zone)	Territories evacuated in 1986 and territories of additional resettlement (deposition densities ^{90}Sr > 111 kBq·m^{-2}, ^{238,239,240}Pu>3.7 kBq·m^{-2})

Radiation exposure at the late post-accident phase



Internal exposure pathways



Measures to reduce internal radiation doses

- **Radiation control and monitoring** of agricultural products and raw materials
- **Disuse** of agricultural areas
    - **Re-specialization** of production
- Use of **fertilizers**
    - Lowering **soil acidity**
- Use of special additives in **animal feeds**
    - **Risk communication**

Radiation Control System

is developed and implemented in order to:

Assess the radiation situation and determine the levels of ionizing radiation exposure

Exclude production and storage of foodstuffs and raw materials with radionuclide concentration levels above the specified limits

Evaluate the effectiveness of protective measures, provide their optimal and targeted implementation

Develop a sound *strategy* of recovery actions

放射線管理

目的:

放射線環境を知ること

食品中の放射性物質の含有量をコントロールすること

防護対策の有効性の評価

土地の回復の戦略を立てること

Why Radiation Control?

Vegetables & Fruits

Meat & Milk

Seafood

Gifts of Forest

Consumption

Disposal/Recovery

放射線管理

食物の摂取

処分

Measures in forest management

- **Reforestation** and **afforestation**
  - Forest **protection** against **wild fires**
    - **Radiation control** and **monitoring**
      - **Risk communication** including special education and training programs for foresters and informational interaction with the local residents

Forest activities in contaminated areas are subject to **regulations** and **recommendations**.

Forest zoning system is based on Cs-134 contamination density:

1 zone: **1–5** Ci/km^2

2 zone: **5–15** Ci/km^2

3 zone: **15–40** Ci/km^2

4 zone: **>40** Ci/km^2

Within the scope of the principal Program directions the solution to the following tasks will be provided

In the framework of design and implementation of special projects towards modernization and efficient utilization of production capacities, natural, primary and human recourses (2)

- **Development of the infrastructure required to provide safe living conditions in radioactively contaminated areas;**
- **Production of non-food products (woodwork produce, forest planting stock, grass and flower seeds, grain, breeding stock etc.);**
- **Establishment of farm businesses for advanced agricultural processing;**
- **Development of integrated set of actions for quality control system implementation on milk/meat production/processing enterprises which provide significant contribution to GDP;**
- **Design and implementation of integrated measures for human resource development in affected regions;**
- **Accurate planning, implementation and revision of economic development measures on affected territories.**

Performance evaluation of the Program activities (1)

Social effects in the course and upon completion of the Program implementation will be valued with regard to:

- Arrangements towards medical and demographic improvement in the affected areas and implementation of targeted medical assistance system;
- Creating conditions favourable for sustainable social and economic growth and safe habitation on the affected territories;
- Effectiveness of information support on recovery issues provided to the population and authorities at all levels.

Public health surveillance

- **Screening** /regular **health examinations**
  - Specialized **registers/databases**
    - **Dose load reduction** by using state-of-the-art low-dose diagnostic equipment
      - **Radiation-epidemiological research**

食品中のセシウム137の基準値

Bq/kg, Bq/l

食品名	日本 （新基準値）	ベラルーシ共和国 （99年）
飲料水	10	10
牛乳・乳製品	50	100
チーズ	100	50
牛肉、羊肉、豚肉、鶏肉	100 100	500 180
パン・パン製品		40
野菜		100
果物		40
乳児用食品	50	37

Rus-Eng translation by Aliona Mikhailova, RIR

THANK YOU FOR YOUR ATTENTION !

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Dean of Biology Faculty
Gomel State University named after Francisk Skorina

Member of ICRP Task Group 93
"Update of ICRP Publication 109 and 111"