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Enhancing nuclear safety

Countermeasures on agricultural areas after the Chernobyl and Fukushima accident

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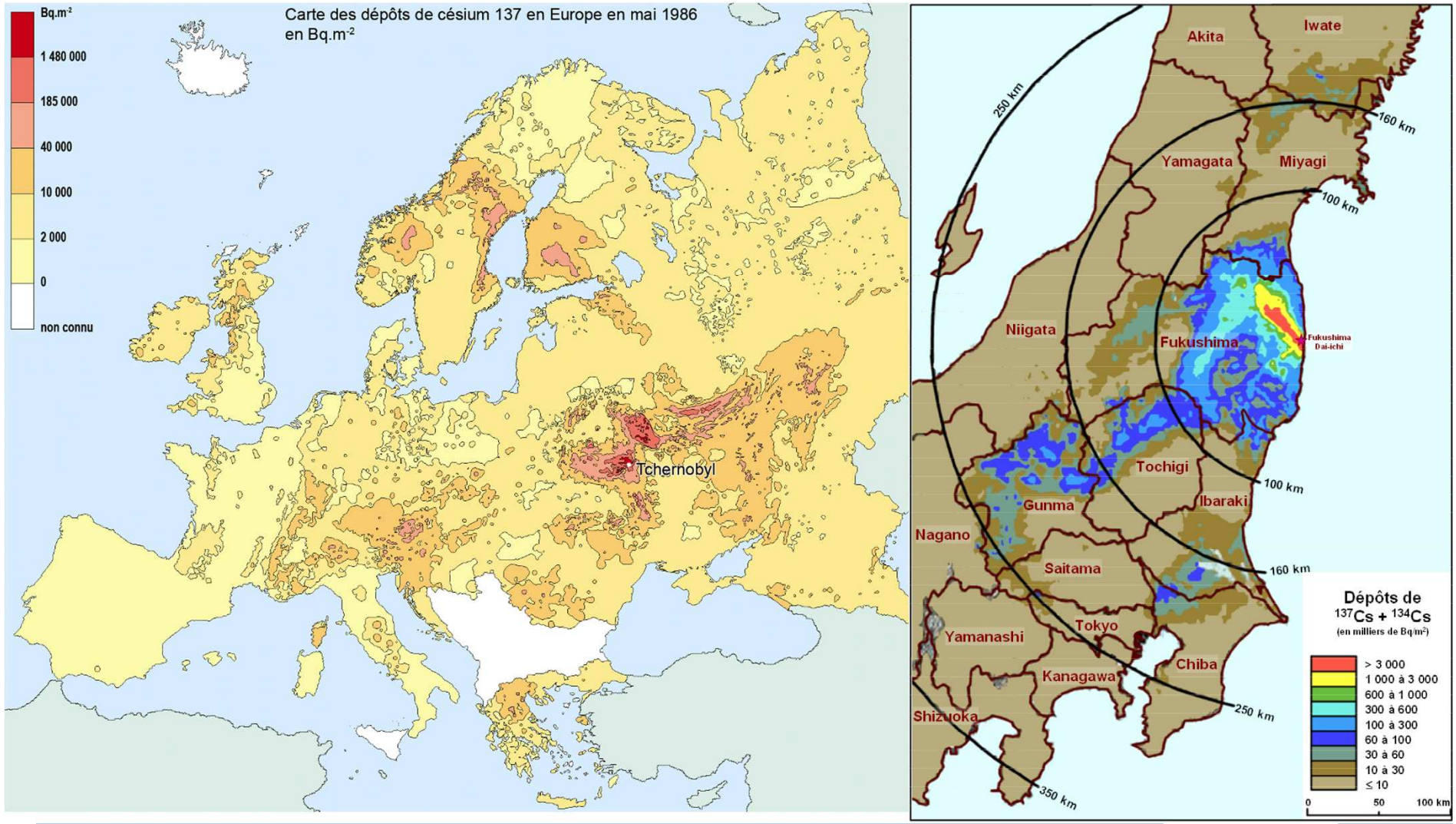
Objectives

- To describe quickly the main consequences of the Chernobyl and Fukushima accident for agriculture

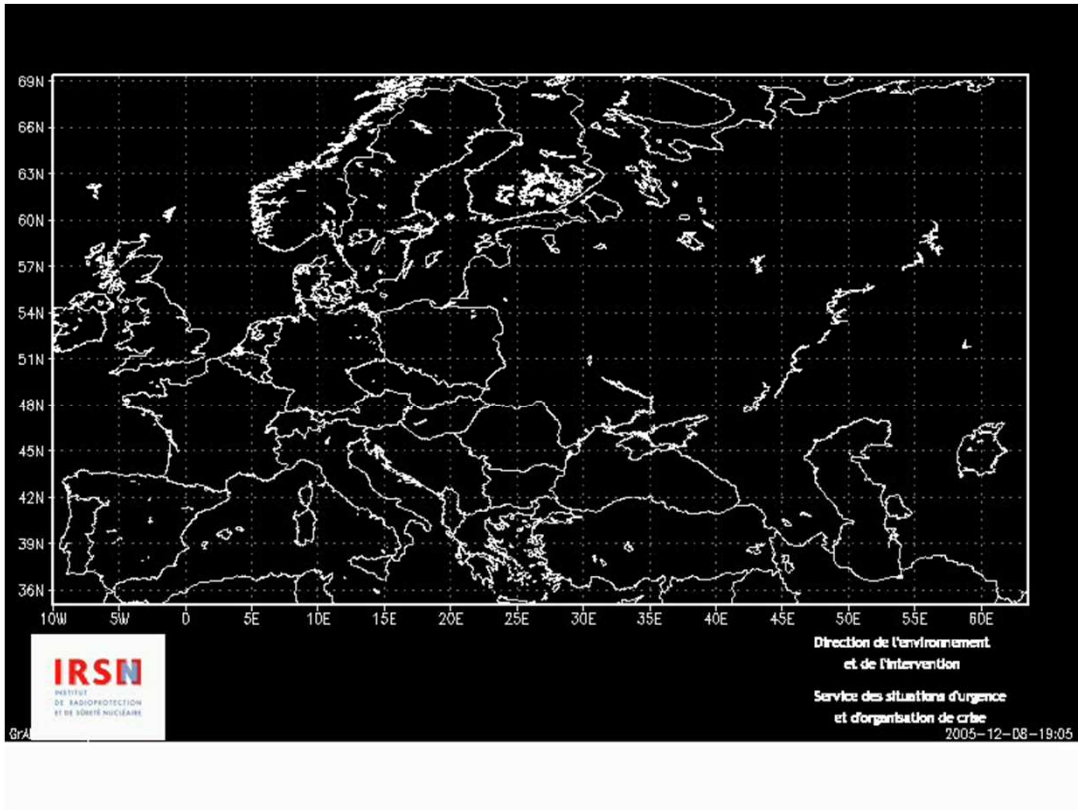
and

- To present an overview of countermeasures implemented in the affected regions

Context

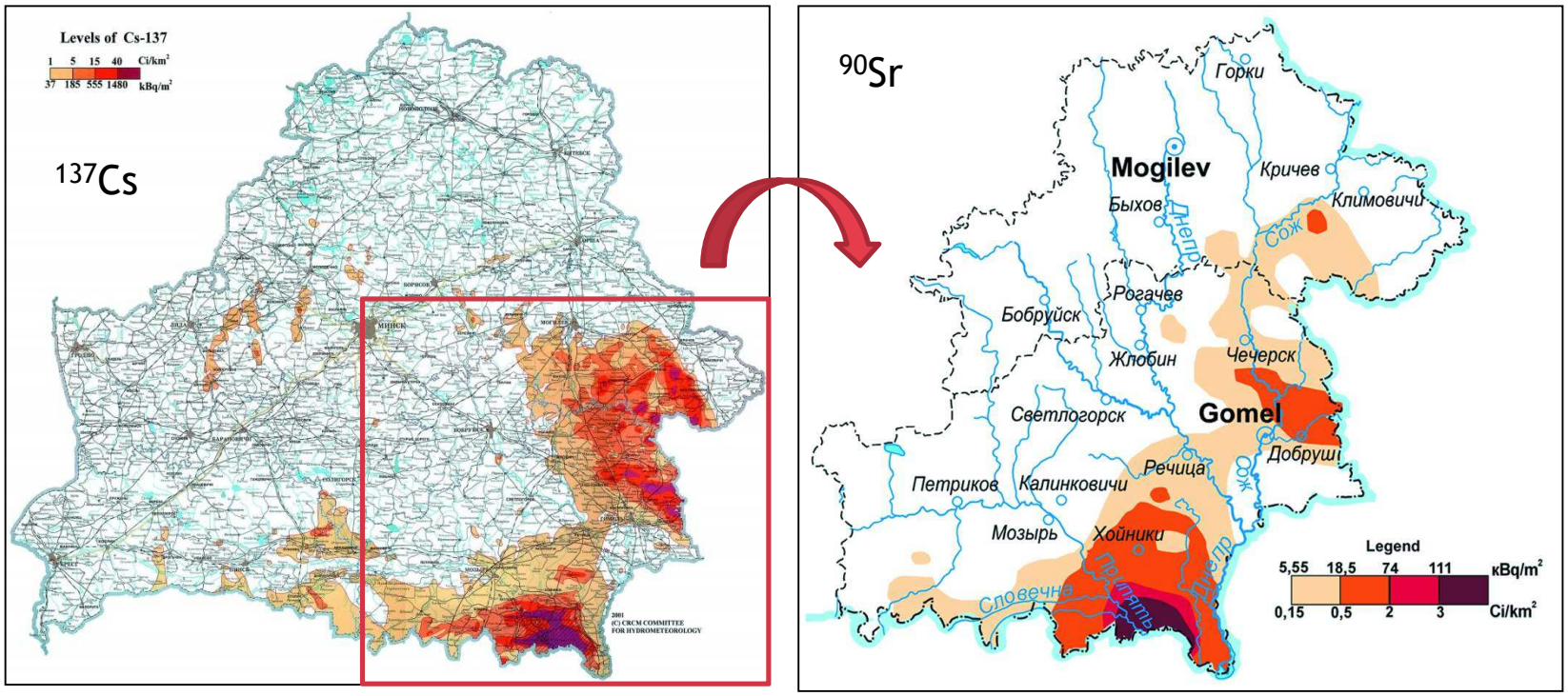

Bq.m-2
1 480 000
185 000
40 000
10 000
2 000
0
non connu
Carte des dépôts de césium 137 en Europe en mai 1986
en Bq.m-2
Tchernobyl
Akita
Iwate
Yamagata
Miyagi
Niigata
Fukushima
Fukushima Dai-ichi
Tochigi
Ibaraki
Gunma
Nagano
Saitama
Tokyo
Yamanashi
Chiba
Kanagawa
Shizuoka
250 km
160 km
100 km
100 km
160 km
250 km
350 km
Dépôts de
137Cs + 134Cs
(en milliers de Bq/m2)
> 3 000
1 000 à 3 000
600 à 1 000
300 à 600
100 à 300
60 à 100
30 à 60
10 à 30
≤ 10
0
50
100 km

↗ April 26, 1986: Unit 4 of the Chernobyl plant exploded



↗ In 10 days, nearly 12 billion billion becquerels were released in the environment

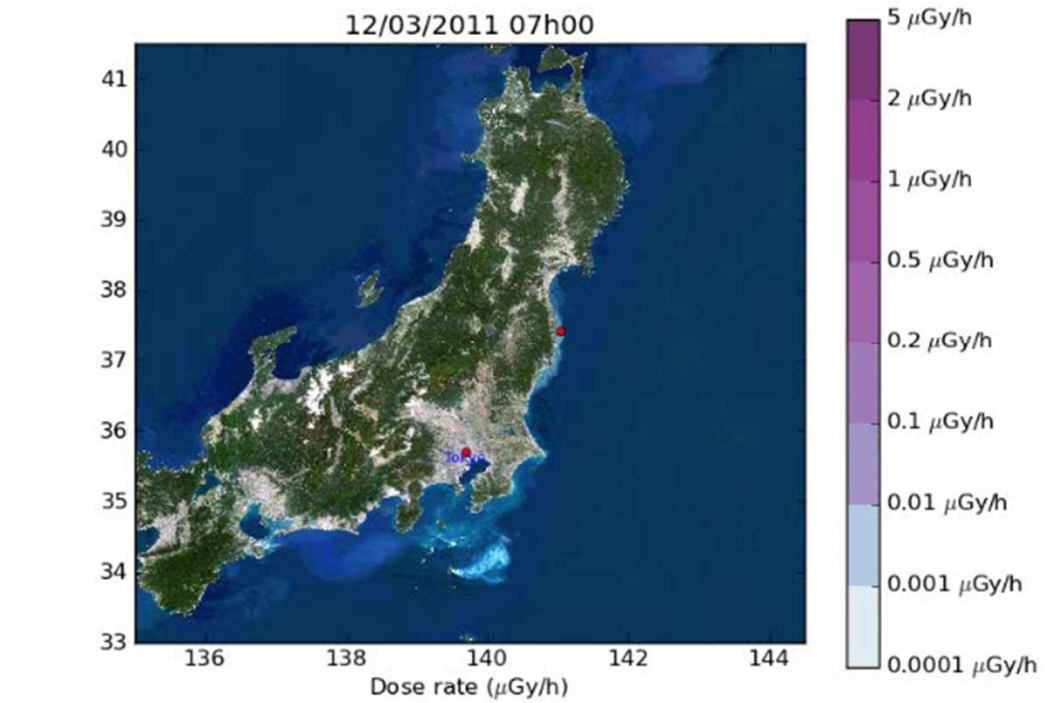
Contamination of Belarus with ^{137}Cs and ^{90}Sr (2001)



- 23 % of the agricultural land has been contaminated with ^{137}Cs (>37kBq/m²)
- 10% - with ^{90}Sr (>5.5kBq/m²)
- 2% - with Pu (>0.37kBq/m²)

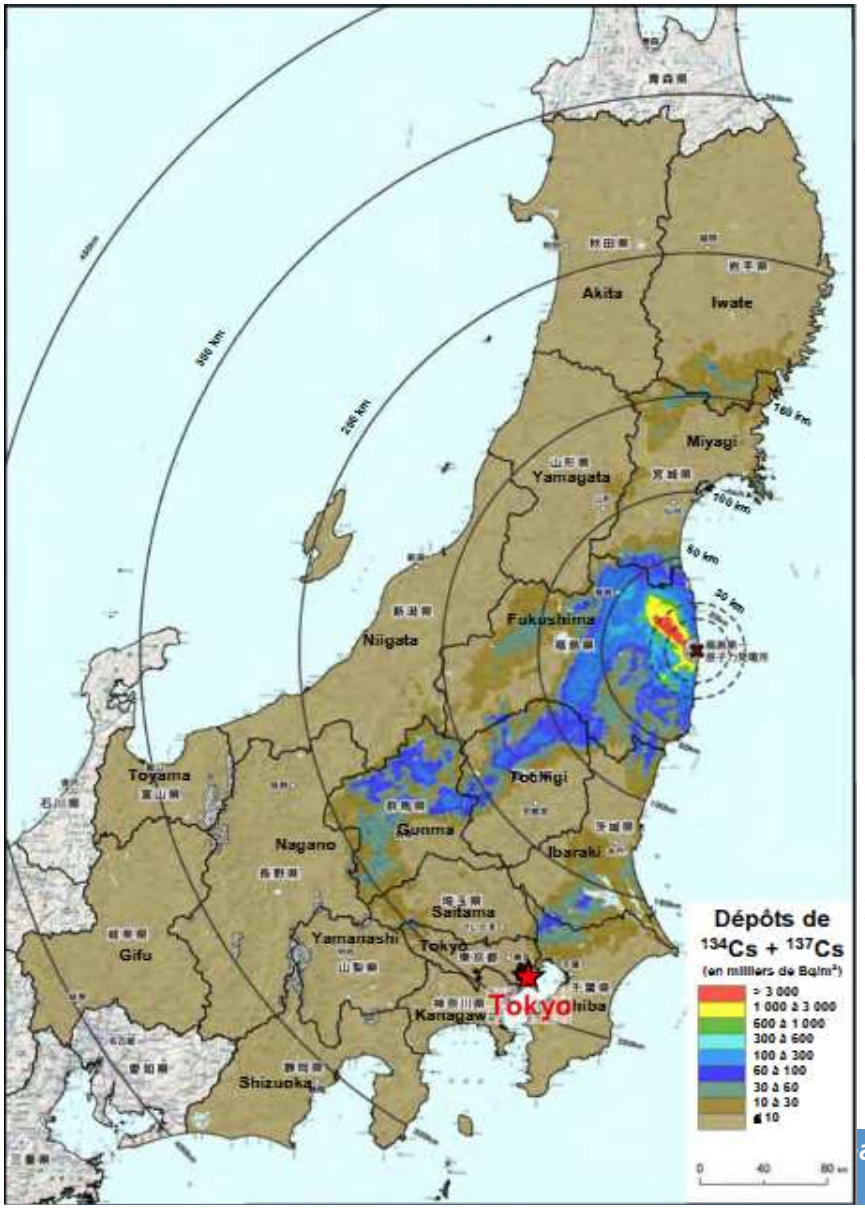
Source : Chernobyl consequences: contamination of land, food products and countermeasures in Belarus - I. Bogdevitch

↗ March, 2011: 3 melted cores at the Fukushima Daiichi plant exploded



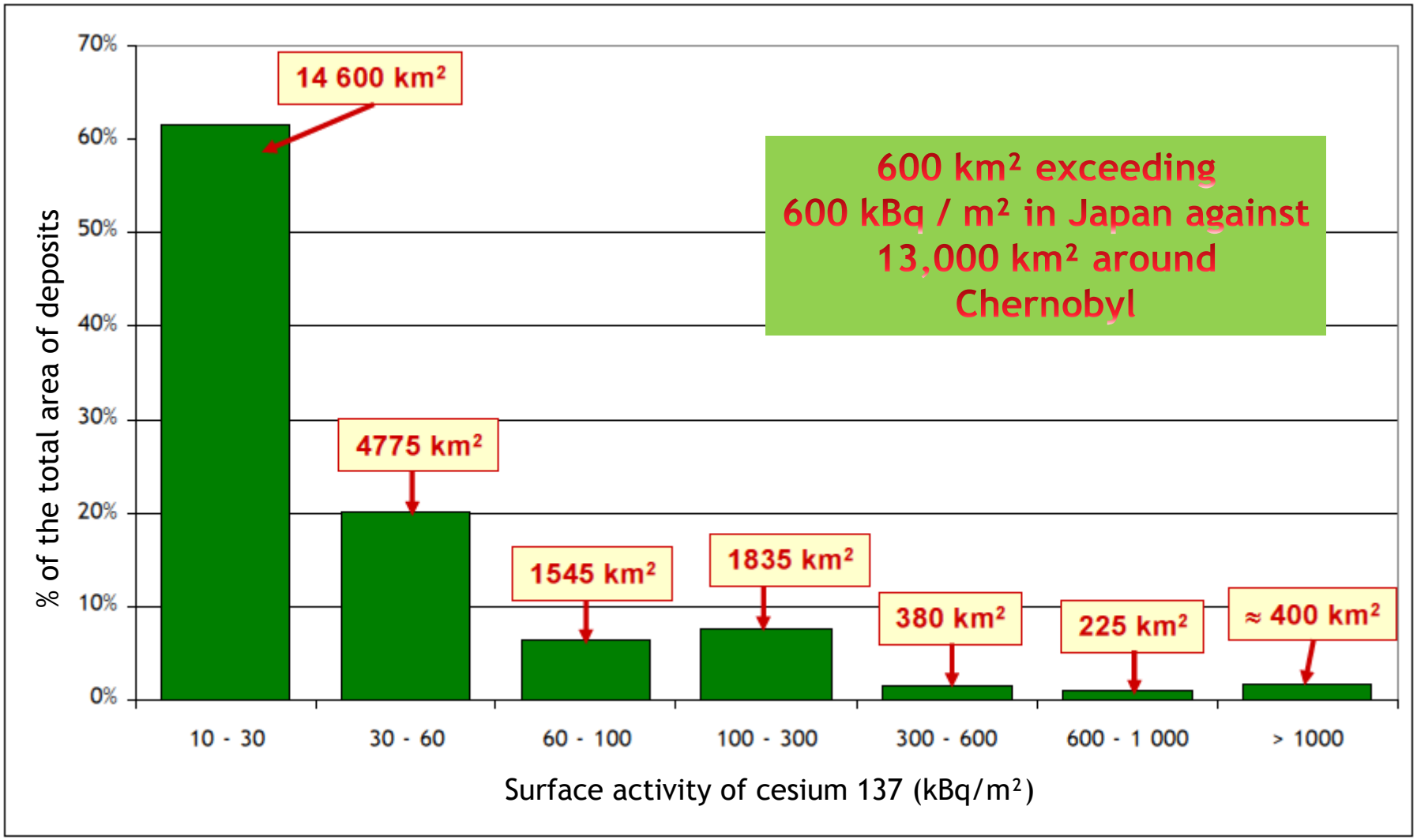
Modeling of the ambient dose rate due to the radioactive plume (excluding contribution from radionuclides deposits - model ldX IRSN)

↗ Contamination of Japan with ^{137}Cs (autumn, 2011) 1/2



- Map (published by MEXT) obtained using airborne measurement campaigns and supplemented by ground measurement campaigns
- the most contaminated area 29 million Bq/m² to $^{134+137}Cs$ immediately west of the central
- Deposits in “hot spots” up to 250 km (depending on the area of rainfall during the dispersion of releases)
- Strong local variations not visible on the map (runoff)

↗ Contamination of Japan with ^{137}Cs (autumn, 2011) 2/2



Countermeasures in agriculture areas

… in Belarus after the Chernobyl accident

Countermeasures during the early period (1986-1991) after the Chernobyl accident in Belarus

- Relocation of people (470 settlements, 138 000 people) and exclusion of heavily contaminated land from use (265 000 ha);
- Exclusion of crops with high accumulation of radionuclides (vegetables, buckwheat, etc).
- Liming & fertilization with P and K fertilizer;
- Minimizing external exposure and formation of contaminated dust by omitting some procedures normally used in crop production;
- Limiting the use of contaminated manure for fertilization;
- Preparation of silage from maize instead of using hay;
- Restriction on the consumption of milk produced in the private sector;
- Mandatory radiological monitoring of agricultural products and mandatory milk processing;
- Deep ploughing of meadows on peat soil (limited use).

Source : Chernobyl consequences: contamination of land, food products and countermeasures in Belarus - I. Bogdevitch

Countermeasures in agriculture of Belarus 1992-2000

Aim : the improvement of the quality of locally produced food to the expected internal dose <1 mSv/y

- Gradual change the Permissible Levels of ^{137}Cs and ^{90}Sr in foodstuff;
- Liming for optimization (pH – CaMg);
- Site specific fertilization P and K, slow release N fertilizer;
- Alternative land use (growing and processing rapeseed). Selection of crops and varieties;
- Radical improvement (land reclamation) of pastures and hayfields;
- Caesium-binding ferrocyne supplemented mixed feed for diary cows (Prussian blue);
- Separate feeding diets for animals according to their age etc.

Source : Chernobyl consequences: contamination of land, food products and countermeasures in Belarus - I. Bogdevitch

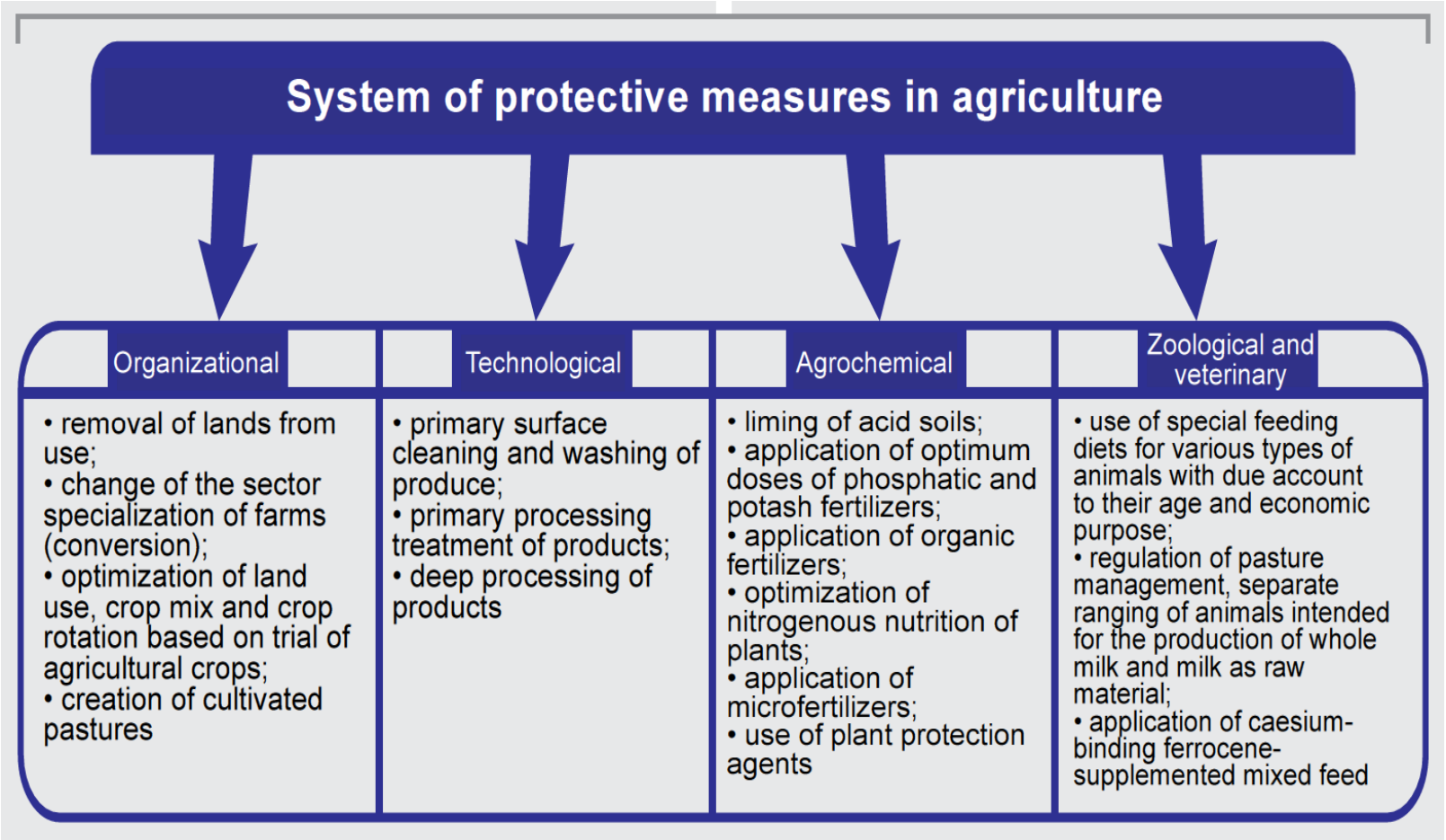
Countermeasures in agriculture of Belarus since 2001

Aim : Rehabilitation of contaminated territories, providing the safe living condition, economic and social development of rural settlements

- **Modernization and re-specialization of farms;**
- Liming for optimization (pH – CaMg);
- Soil fertility optimization and maintenance. Site specific fertilization P and K, slow release N and compound fertilizers;
- Selection of crops and varieties (vegetables, corn for grain, etc.);
- Radical improvement (land reclamation) of pastures and hayfields ;
- Caesium-binding ferrocyne supplemented mixed feed for diary cows (Prussian blue);
- Separate feeding diets for animals according to their age etc.

Source : Chernobyl consequences: contamination of land, food products and countermeasures in Belarus - I. Bogdevitch

↗ Protective measures System in agriculture in Belarus



Source : Department for Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP of the Ministry for Emergency Situations of the Republic of Belarus. A quarter of a Century after the Chernobyl Catastrophe: Outcomes and Prospects for the Mitigation of Consequences. National Report of the Republic of Belarus, 2011.

↗ Efficiency of some protective measures (in Belarus)

Working method	Efficiency
Combination of the primary and additional cultivation jobs, subsoil tillage (chisel, disk) and minimum cultivation, taking account of the soil type, moistening pattern, application of high-capacity equipment	Reduction of radionuclide accumulation in crops up to 1.3 times
Soil liming	Reduction of radionuclide accumulation in crops by 1.5-3 times
Application of organic fertilizers	Reduction of radionuclide accumulation in crops up to 1.3 times
Application of new forms of slow-acting nitrogen fertilizers	Reduction of radionuclide accumulation up to 1.4 times, nitrates in potatoes, vegetables and feed crops
Application of phosphorus fertilizers	Reduction of Cs-137 accumulation in crops up to 1.5 times, Sr-90 – by 1.2-3.5 times
Application of potash fertilizers	Reduction of Cs-137 accumulation in crops up to 2 times, Sr-90 – up to 1.5 times
Selection of species and varieties of crops with minimum accumulation	Reduction of radionuclide accumulation in crops depending on the plant species up to 30 times, depending on the variety – up to 7 times
Radical improvement of hayfields and pastures	Reduction of radionuclide accumulation in grass stand by 2.5–6 times
Surface improvement of hayfields and pastures	Reduction of radionuclide accumulation in grass stand by 1.5 – 2.9 times
Application of caesium-binding ferrocene-supplemented mixed feed for cattle	Reduction of Cs-137 accumulation in milk and meat by 2-3 times
Special feeding diets for various types of animals with due account to their age and other factors	Reduction of Cs-137 accumulation in milk and meat by 1.5 – 2.5 times

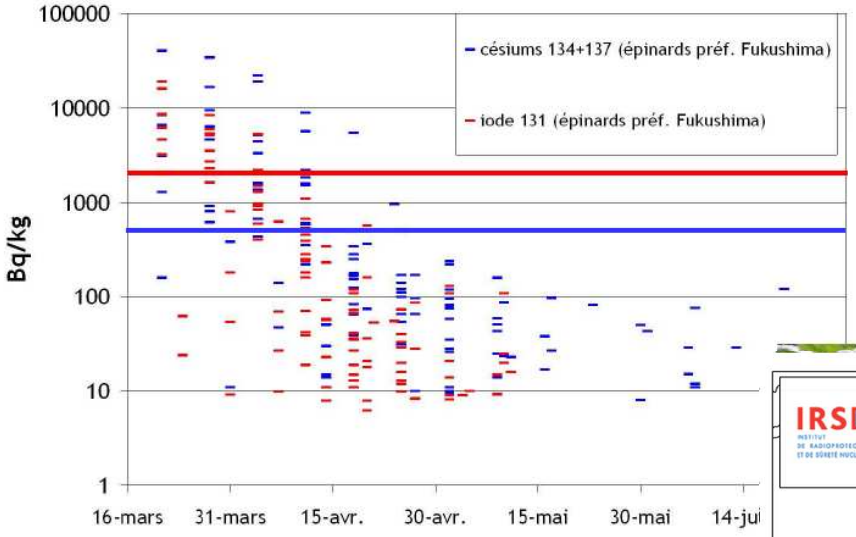
Source : Department for Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP of the Ministry for Emergency Situations of the Republic of Belarus. A quarter of a Century after the Chernobyl Catastrophe: Outcomes and Prospects for the Mitigation of Consequences. National Report of the Republic of Belarus, 2011.

Countermeasures in agriculture areas

… in Japan after the Fukushima accident

(Source : JAEA)

Countermeasures in agriculture of Fukushima (2011-2015) 1/3

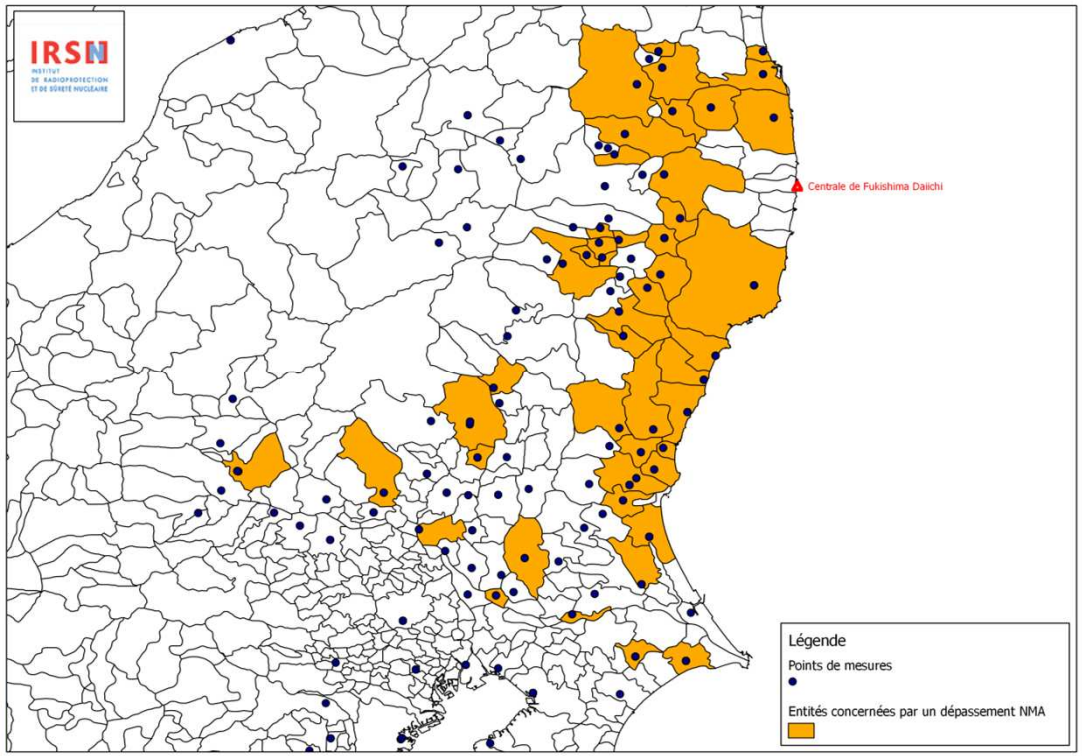


Standard limit for radioactive iodine = 2000 Bq/kg

Standard limit for radioactive caesium = 500 Bq/kg

Evolution of the contamination in iodine 131 and cesium 134 + 137 of the spinach of the prefecture of Fukushima (data MHLW)

Map areas where food items containing contamination above permissible levels were observed



Countermeasures in agriculture of Fukushima (2011-2015) 2/3

- The main types of remediation applied to farmland, applicable to both the Special Decontamination Area evacuated after the accident and the Intensive Contamination Survey Area where people live, depend on the radiocaesium activity concentration

Applicable techniques	Radiocaesium activity concentration in soil (Bq/kg dry weight)			
	<5 000	5 000-10 000	10 000-25 000	>25 000
Cultivation with reduced transfer of 134Cs and 137Cs using potassium, fertilizer	X			
Reversal tillage (fields, rice paddies, grassland)	X	X		
Soil suspension in waste and/removal with extracted water (rice paddies)		X		
Topsoil removal (fields, rice paddies, grassland)		X	X	
Soil removal using a solidification agent		X	X	X
Weed/grass/pasture removal		X	X	X

Source : IAEA. The Fukushima Daiichi Accident. Technical Volume 5/5 - Post-accident Recovery. IAEA Publication, 2015

Countermeasures in agriculture of Fukushima (2011-2015) 3/3

- Remediation measures taking into account the farmers 'opinion;
- Aim : to produce food below the action levels

- Decontamination of some fruits by high pressure washing and whittling of tree surfaces;
- Remove the upper layer of the land when caesium activity concentration was high (reduce the dose rate but generate a large amount of waste and impoverished the soil) ;
- Ploughing the soils (conserve the nutrients in the soil and reduce the amount of contaminated soil that should have been treated as radioactive waste)
- Support financially the loss of one production year;

Source : IAEA. The Fukushima Daiichi Accident. Technical Volume 5/5 - Post-accident Recovery. IAEA Publication, 2015

Conclusions

- The countermeasures applied in the agriculture of Belarus proved to be highly efficient. The ^{137}Cs flow into food chain has decreased by factor of 20-22, ^{90}Sr – by a factor of 4. The contamination of all foodstuff and raw materials produced in state and cooperative farms are with radionuclide content below PL-99.

- Soil fertility improvements through liming, manure and NPK application resulted in optimization of soil properties: reaction (pH) – on 85%, PK status – on 70-72% of cultivated area. These are the basic guarantee of minimization of radionuclide accumulation in farm products in the long-term period after Chernobyl accident.

- Rehabilitation programs need to consider not only radiological protection but also social and economic dimensions.

- The involvement of rural inhabitants in processes of self-rehabilitation and self-development could be a way to improve the people quality of life on radioactive contaminated territory as a common heritage.

Conclusions

- Overall, in Japan, the comprehensive implementation of food restrictions and monitoring has protected people and improved confidence in farm produce, as reflected to varying extents by the improving market price of some crops.

- The effectiveness of these measures and natural radiological decay processes have contributed to low internal doses to people compared with those from external pathways.

Thank you for your attention !