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Enhancing nuclear safety

Impact of the Chernobyl accident on agriculture

Countermeasures on agricultural areas

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PRP-CRI/SESUC/BMCA

15/03/2016

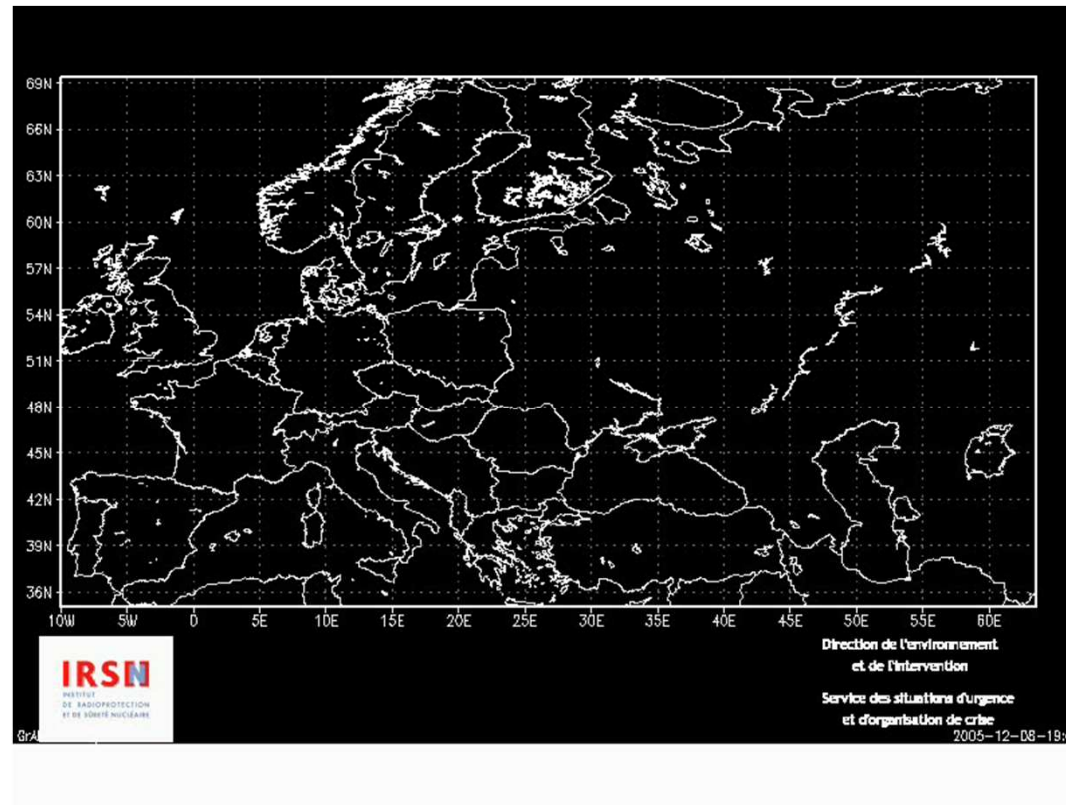
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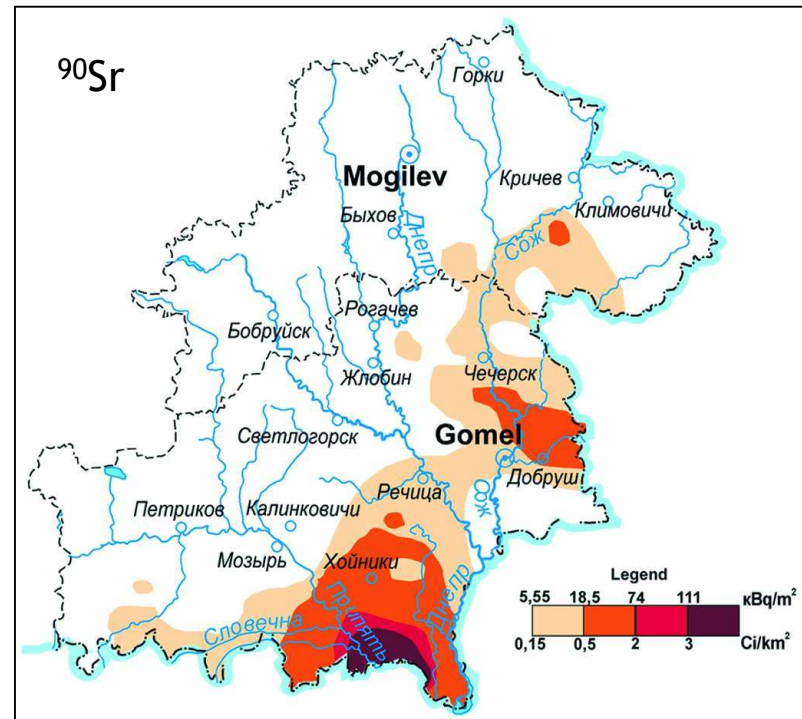
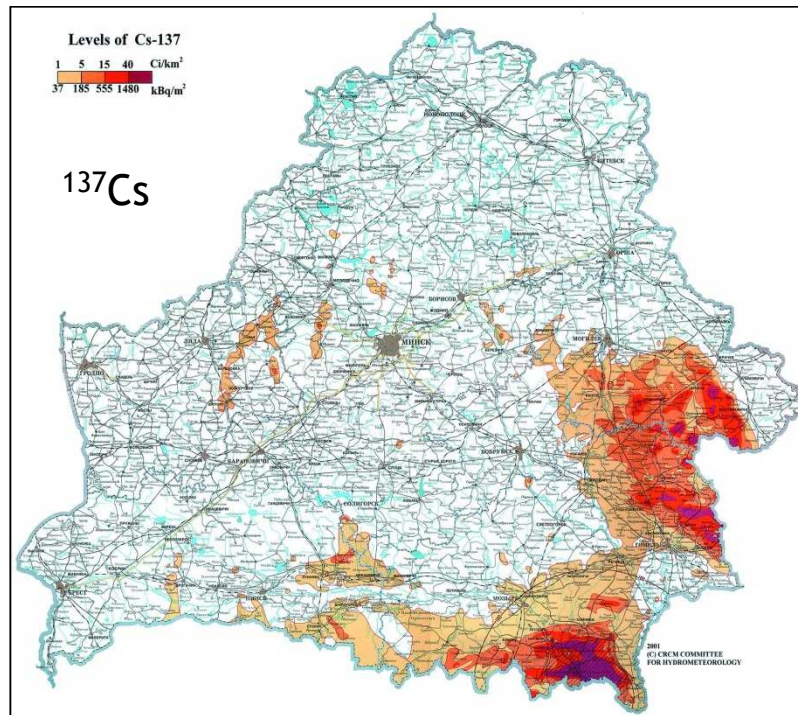
Context

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



➤ In 10 days, nearly 12 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

- The agriculture is fundamental for social and economic developments of the majority of the regions of Belarus which have been contaminated
- The quality of life and health of rural inhabitants are defined by the level of agriculture production and the radiological quality of produced foodstuff

Thus

- Agricultural countermeasures are a very important part of radiation protection of the population living on radioactive contaminated area
- International programmes : CORE, ETHOS...

Countermeasures during the early period after accident

➔ Countermeasures during the early period (1986-1991) after 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

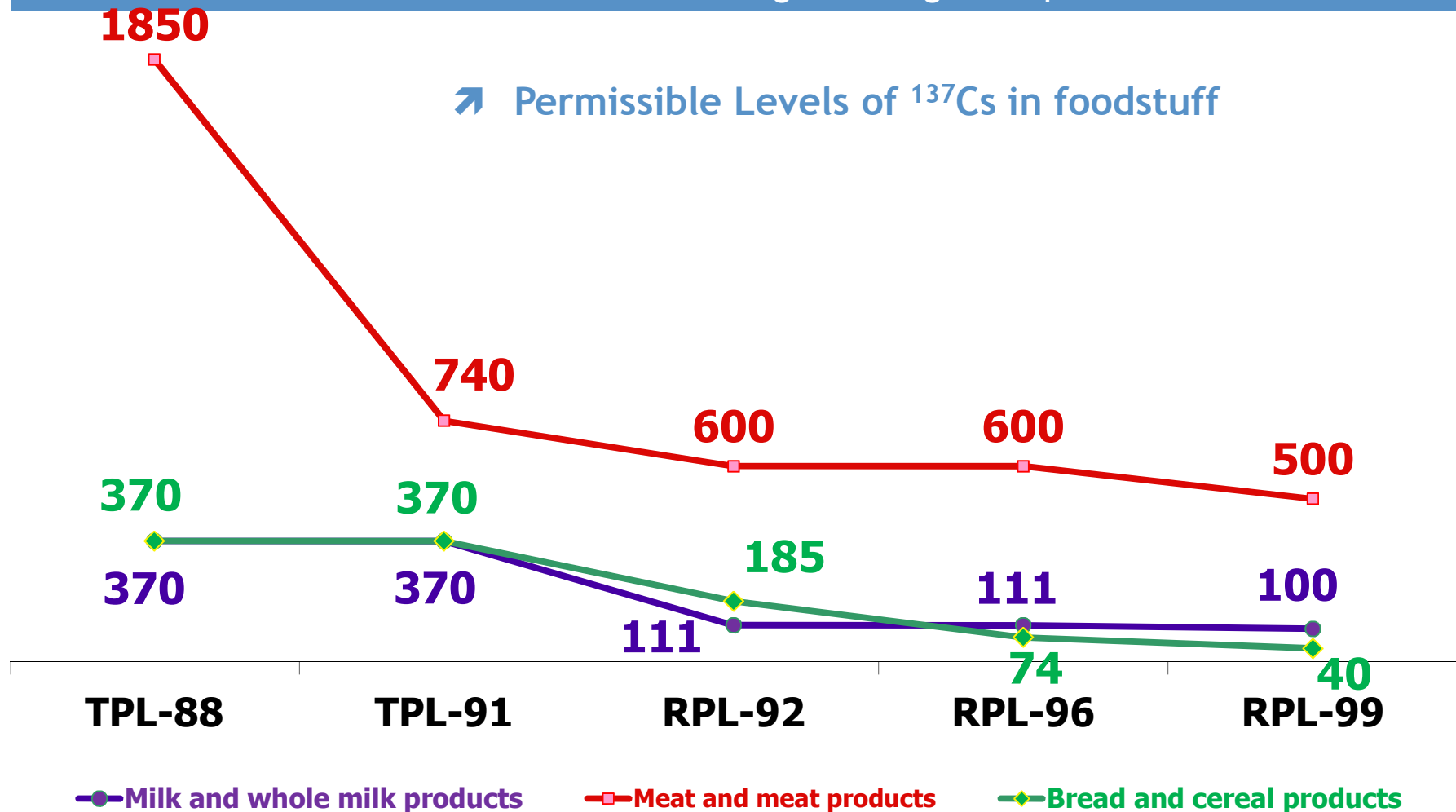
Countermeasures during the long term period after accident

➤ Countermeasures in agriculture of Belarus 1992-2000

- 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 of surface pastures and hayfields;
- Caesium-binding ferrocyanide supplemented mixed feed for dairy cows (Prussian blue);
- Separate feeding diets for animals according to their age etc.

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

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



TPL - Temporary Permitted Levels

RPL - Republican Permitted Levels (RPL-99 : current national permitted level for ^{137}Cs)

Source: L'efficacité des mesures de la liquidation des conséquences de la catastrophe de Tchernobyl sur le territoire Belarus. Andrey Mostovenko, Ministère des Situations d'Urgence - République du Belarus - Institut de la Radiologie -

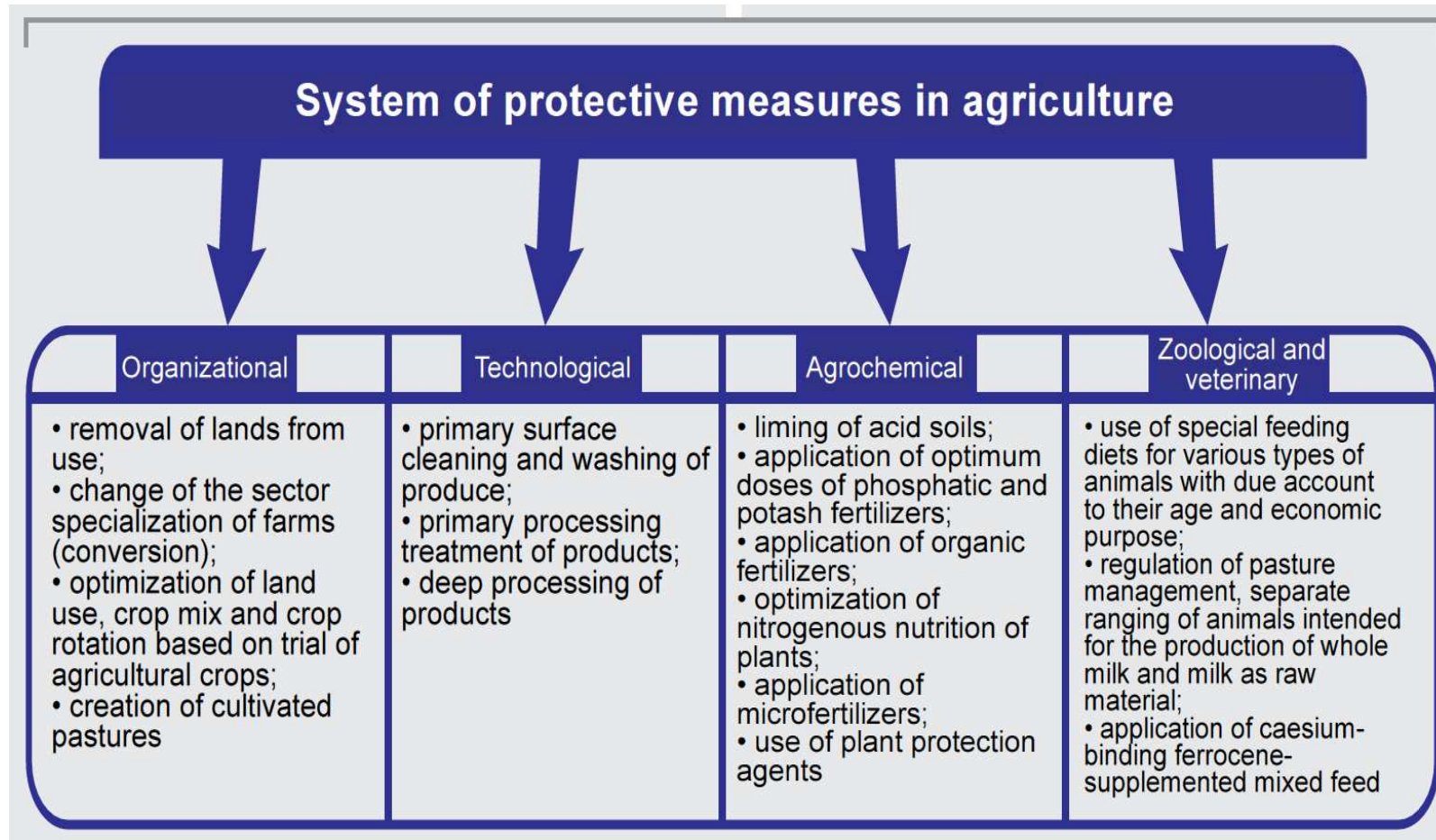
➤ Countermeasures in agriculture of Belarus since 2001

- 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 of surface pastures and hayfields;
- Caesium-binding ferrocyanide supplemented mixed feed for dairy cows (Prussian blue);
- Separate feeding diets for animals according to their age etc.

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

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

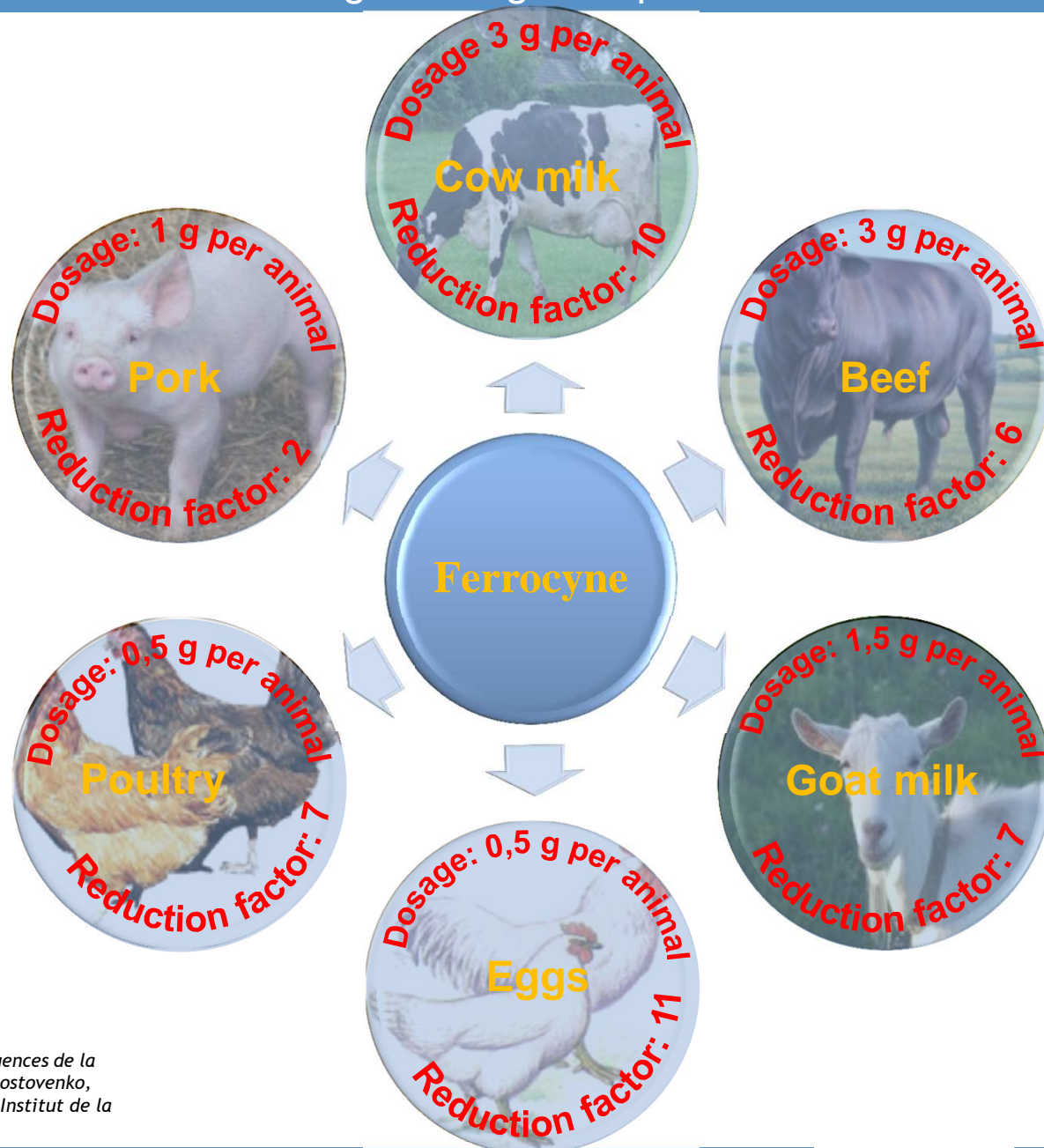
➔ Protective measures System in agriculture



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.

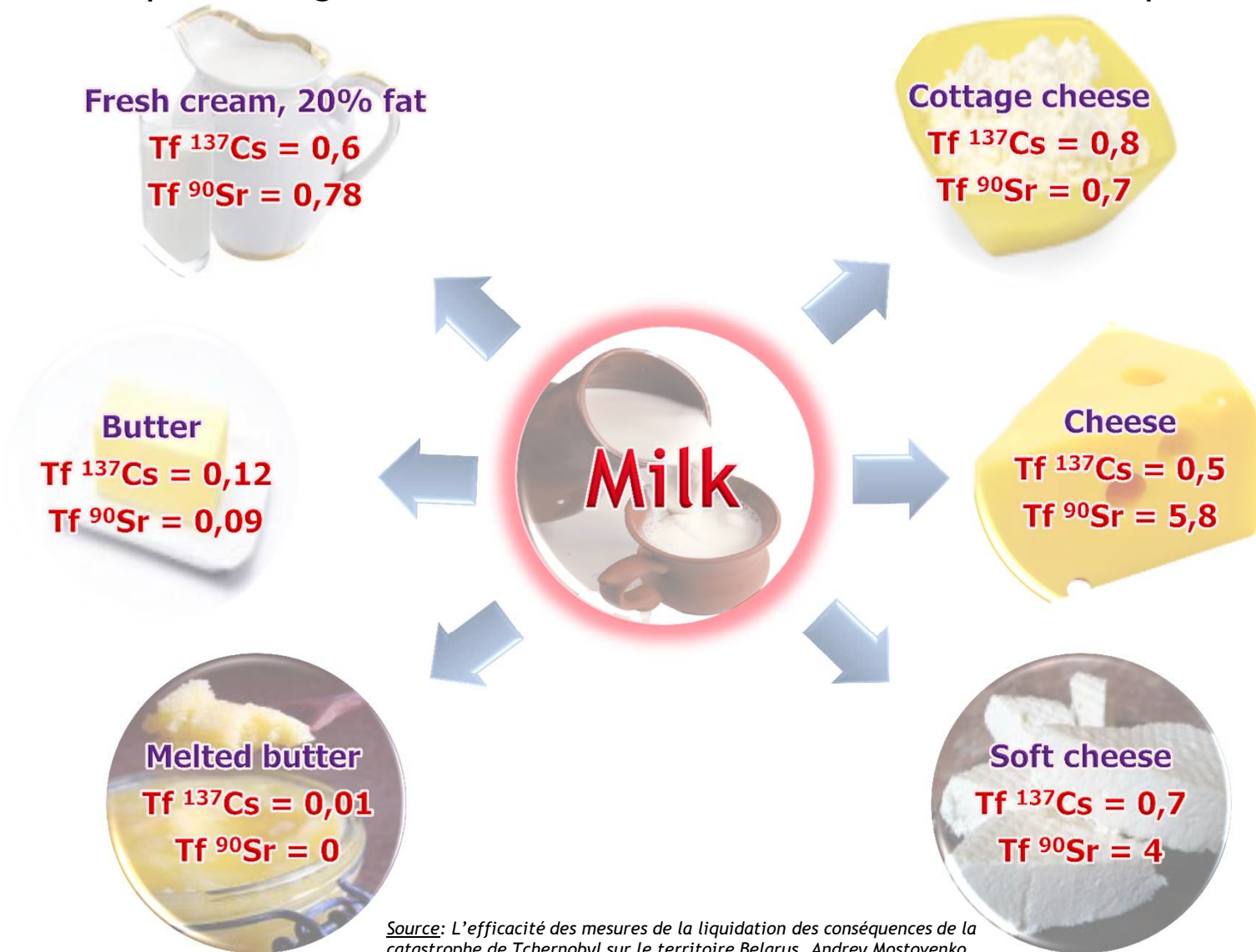
➔ Examples:

■ Means to block cesium



Source: L'efficacité des mesures de la liquidation des conséquences de la catastrophe de Tchernobyl sur le territoire Belarus. Andrey Mostovenko, Ministère des Situations d'Urgence - République du Belarus - Institut de la Radiologie -

Influence of processing of milk on the amount of Cs-137 in the final product



Source: L'efficacité des mesures de la liquidation des conséquences de la catastrophe de Tchernobyl sur le territoire Belarus. Andrey Mostovenko, Ministère des Situations d'Urgence - République du Belarus - Institut de la Radiologie -

International projects (ETHOS, CORE) on private fields:

Experimental technology included:

- high quality seeds of new crops varieties;
- application of special set of fertilizers;
- application of plant protection means.



➤ Modern technology has provided:

- increase the yields of potato & vegetable by a factor of 1.6 to 1.8;
- reduction on 20-30% of ^{137}Cs and ^{90}Sr concentration in products;
- 1 EURO invested ($430-9400 \text{ € ha}^{-1}$) has made 1.5-2.5 € of net return.
- Transition from private field to farmer's production

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

Management of the yield and radiological quality of potatoes cultivated by population on radioactive contaminated land in Belarus - practical application of ETHOS approach, S. Tarasiuk & al., Eurosafe, Berlin, 05/11/2002.

➤ Efficiency of some protective measures

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.

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.
- The remaining unsolved problems are concentrated on poor fertility sandy and peat soils with high deposition of ^{137}Cs 185-1480 kBq/m² and ^{90}Sr - 11-111 kBq/m².
- There are 8 settlements where milk exceeded the PL of ^{137}Cs activity. About 70000 ha of arable land is unsuitable for producing the food grade cereal grains.

Conclusions

- 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.

Thank you for your attention !