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Title

Countermeasures in agriculture in emergency and long-term phases of the accident at the Chernobyl nuclear power plant. Experience of Belarus.

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Text

Following a short-term period after the accident (3–5 days) when the most significant contribution to radiation doses is associated with external exposure and inhalation of radioactive aerosols, the dominant exposure pathway for the residents of rural areas and agricultural workers becomes via the food chain. In the longer terms after the accident, in case of the presence of ^{137}Cs and ^{90}Sr long-lived radionuclides, actinides and transuranium elements in the released substances, the contribution of internal exposure becomes even more significant.

In case there is no necessity in emergency evacuation of population, protective measures in the affected area may involve temporary restrictions on consumption of specific types of contaminated agricultural products, and in the following period – implementation of local measures designed to ensure safe food production suitable for consumption purposes.

The levels of contamination in foods and agricultural raw materials are derived based on the emergency annual dose limits of internal exposure to population. To provide an overall and rapid estimate of contamination in agricultural products, the standards are calculated to represent radionuclide content in a kilogram or a litre of a product, with reference to their validity period. Such standards are calculated, in the first place, for rural residents whose dominant part of total consumed foods originates from their private backyards (critical group of population). On the other hand, agricultural produce from contaminated areas will constitute a lesser danger to other groups of population (e.g. urban residents). This can be associated with reduction of its contamination levels due to radioactive decay in the process of procurement, storage or processing, or due to mixing it with products that are clean from radionuclide contamination.

The main task of this period is to determine contamination levels of the areas from long-lived radionuclides that will be safe for the longtime residence without any restrictions for agricultural production, or subject to implementation of specific protective measures.

Countermeasures can be implemented at different production stages and in different key segments of radionuclide transfer in ‘soil–plant’, ‘feed–animal’, or ‘raw material–end product’ chains.

Contribution of cow’s milk, being the most critical food product in terms of ^{137}Cs contamination, into internal doses of radiation received by population can reach 40–80 %. In order to reduce internal exposures to population, it is necessary to apply countermeasures that reduce transfer of radionuclides into animal fodders. One of the most popular protective measures in Belarus agriculture in the first months after the accident was feeding cattle ‘clean’ forages at the final fattening stage. Due to this countermeasure, production of contaminated meat was acutely and rapidly reduced to insignificant figures.

Replacing contaminated milk in the human diet with its derivates is an effective protective measure to reach more than 10 times reduction of radionuclide intake into human body. 8–10 times reduction of ^{137}Cs and ^{90}Sr concentrations in the end products can be reached through processing whole milk into butter and rennet cheese. Whole-milk processing for cream, sour cream and cottage cheese leads to 4–6 times reduction.

The most affective in dose reduction are countermeasures implemented on pastures and grasslands that are used for meat and milk production purposes (e.g. core improvement of natural grasslands, renovation of cultivated pastures). Disc harrowing and tillage of grasslands on mineral soils together with application of mineral fertilizers leads to 3–5 times reduction of ^{137}Cs and ^{90}Sr uptake by grasses.

Core improvement of cultivated meadows also reduces ^{137}Cs transfer grasses, but this approach is less effective in relation to ^{90}Sr. With the course of time however, increased

concentration levels of radionuclides in forage and hay may occur due to degradation of cultivated grass stands.

Therefore, it is important to ensure renovation of forage lands every 3–6 years, depending on the type of grassland and soil characteristics. At the first stage (i.e. during 1986–1990), half-life periods ($T_{1/2}$) of ^{137}Cs transfer to field crops were between several months and 1.5 years ($T_{1/2}$ 1.0–1.8 years for grain crops and 0.8–1.2 years for potatoes). During the second stage (1991–1998), $T_{1/2}$ was from 5 to 13 years.

Application of agricultural countermeasures in the first years after the Chernobyl disaster (1986–1992) had resulted in 3–8 times reduction of ^{137}Cs transfer to crop yields. In the following years after the accident (1992–2010), contribution of natural processes (cesium fixation by clay minerals and radioactive decay) prevailed over the effect of cesium-reducing countermeasures which dropped down to the average of 50–80 %.

In some cases it appears very hard or even impossible to implement core improvement of pastures. This is where special drugs are introduced into animal diets to prevent absorption of radioactive cesium in gastrointestinal tract and therefore its transfer to meat and milk products and further into the human body. The most widely known and used are such cesium-binding sorbents as Prussian blue, ferrocynes, Giese salt, Nigrovitch salt. Introduction of these drugs has been proved reliable countermeasures with sustainable effect, resulting in 2–5 times reduction of ^{137}Cs concentrations in milk and muscle tissues of dairy and beef cattle.

In cases when contaminated lands make it impossible to produce crops in compliance with the established standards, or when consumption of animal products contributes to high doses of internal radiation of population, an effective countermeasure would be to change the production purposes of a farm enterprise. For instance, a collective dose due to strontium and cesium contribution would be 28 times less, when contaminated feeds are used for the purposes of meat production instead of dairy purposes. Thus, by changing the purpose of the usage of grown farm crops it is possible to lower the levels of exposure to population by 20–30 times.