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The specificity of production and processing of agricultural raw materials in the radioactively contaminated territory (by the example of Chernobyl Nuclear Power Plant accident)

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Abstract. The article presents data on the specifics of production and processing of agricultural raw materials in a radioactively contaminated area. It is shown that in the remote period of development of the radio ecological situation after the Chernobyl accident, the total radiation dose of the population (95%) is still formed due to the consumption of crops in polluted territories. For this reason, in addition to economic feasibility, the technical specification for the production and processing of agricultural raw materials should clearly define environmental aspects, which include reducing the individual effective dose of radiation to the population by ensuring guaranteed radio ecological safety of agricultural products and raw materials, and collective - by reducing the consumption of radionuclide from the crop. Deep processing of agricultural raw materials is the most effective in the conditions of radioactively contaminated territory.

1. Introduction

After the localization of natural and man-made accidents and disasters, contaminated soil remains the main source of further long-term environmental pollution. The main routes of contamination in human's body are the production and consumption of agricultural raw materials in these territories. The Chernobyl accident that in its scale and consequences is considered an unprecedented disaster of the twentieth century, is no exception [1-3]. More than 145 000 m^2 of the territory with a density of more than 37 kBq / m^2 were polluted only in the Ukraine, the Russian Federation and the Republic of Belarus. In various zones of radioactive contamination, there were about five thousand localities, where more than five million people lived permanently [4-6].

Systematizing the dynamics of the radiation situation and the direction of anti-radiation measures, it is conventionally accepted to allocate early, intermediate and remote phases of their development, which in turn also have separate periods [7-9].

The remote phase is the longest. It can last tens or even hundreds of years. Radio cesium is one of the most biologically significant pollutants and determines the degree of radiation risk for the population [10-12]. The initial way of incorporating the radionuclide in trophic migration chains is

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their root penetration into plants. Thus, agricultural raw materials that are produced in a radioactively contaminated area make the main contribution to the formation of the radiation dose of the population [13-15].

Therefore, the investigation of specificity of production and processing of agricultural raw materials in the radioactively contaminated territory (by the example of Chernobyl NPP accident) as one of the main directions the radiation dose of the population to safe levels is a prerequisite for further recovery of industrial and social infrastructure radionuclide's contaminated area, that is extremely important and urgent task.

2. Materials and methods

The Investigation of the specificity of production and processing of agricultural raw materials in the radioactively contaminated territory (on the example of Chernobyl NPP accident) were carried out in 5 most contaminated regions of the Ukraine (Volyn, Zhytomyr, Rivne, Kyiv and Chernihiv).

The content of 137Cs in soil and plant samples were determined by spectrometric method on gamma spectrometry equipment with semiconductor detectors GEM-30185, Ge (Li), GMX Series «EG & G ORTEC» with multi-channel analyzer ADCAM - 300. Sampling and sample preparation for analysis was carried out by conventional methods with specific of researches in Agricultural Radiology. For evaluation of 137Cs accumulation in crops by different contamination densities of soil we used transfer factor (TF) of radio cesium from soil to plants – content of the radionuclide in the plant for contamination of soil, which is equal to one (Bq /kg air-dry weight of plant) / (kBq/m^2 soil).

3. The study of the specificity of production and processing of agricultural raw materials in the radioactively contaminated territory (by the example of Chernobyl NPP accident)

For investigation of the significance and criticality various aspects in formation of irradiation doses to population in the late period of development of the radiation situation it was appropriate to study its structure. The generalized data presented in Figure 1 shows that the dose of exposure of the inhabitants of critical settlements by 80-95% is determined by the internal irradiation of radioactive cesium coming to the body with food.

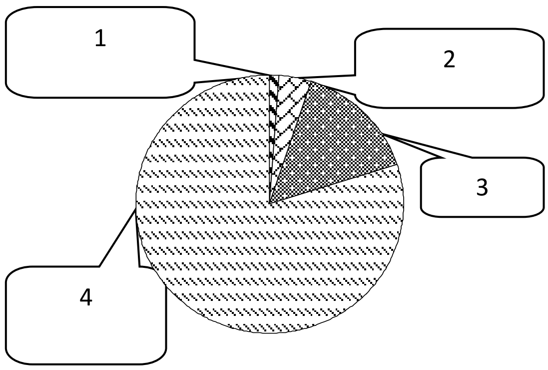

Figure 1. Structure of formation the radiation doses to population in the north-western regions of Polessye contaminated after the Chernobyl NPP accident.
1 - <0, 1% - internal exposure caused by inhalation of radio nuclides from the air;
2 - <2% - internal exposure from radio nuclides coming from drinking water;
3 – 5 - 20% - external gamma radiation;
4 - 80-95% - internal exposure from radio nuclides coming from food.

The proportion of external gamma irradiation ranges from 5-20%. The contribution of other ways of forming the total radiation dose (from radio nuclides entering the human body with drinking water and their inhalation) is negligible and does not exceed 2.5%.

Thus the most critical way of interring the ^{137}Cs to the men`s organism and forming radiation doses in the remote period after Chernobyl NPP accident is the food, particularly the agricultural products and agricultural raw materials that were produced in contaminated areas.

Given that external radiation in the remote period after the Chernobyl disaster has stabilized and will be determined, first of all, by natural processes (primarily by the physical decay of ^{137}Cs), the priority for overcoming the consequences of the Chernobyl disaster should be a series of measures aimed at growing and consumption person with radiological clean food. In this regard, special attention should be paid to agricultural products and agricultural raw materials in which the radionuclide content exceeded, or potentially could exceed the allowable levels.

The specificity of production and processing of agricultural raw materials in the radioactively contaminated territoury should take into account the potential ability of plants to accumulate radionuclides in the commodity par of the crops. According to the data presented in Figure 2, field crops can be divided into three groups depending on their potential ability to accumulate ^{137}Cs.

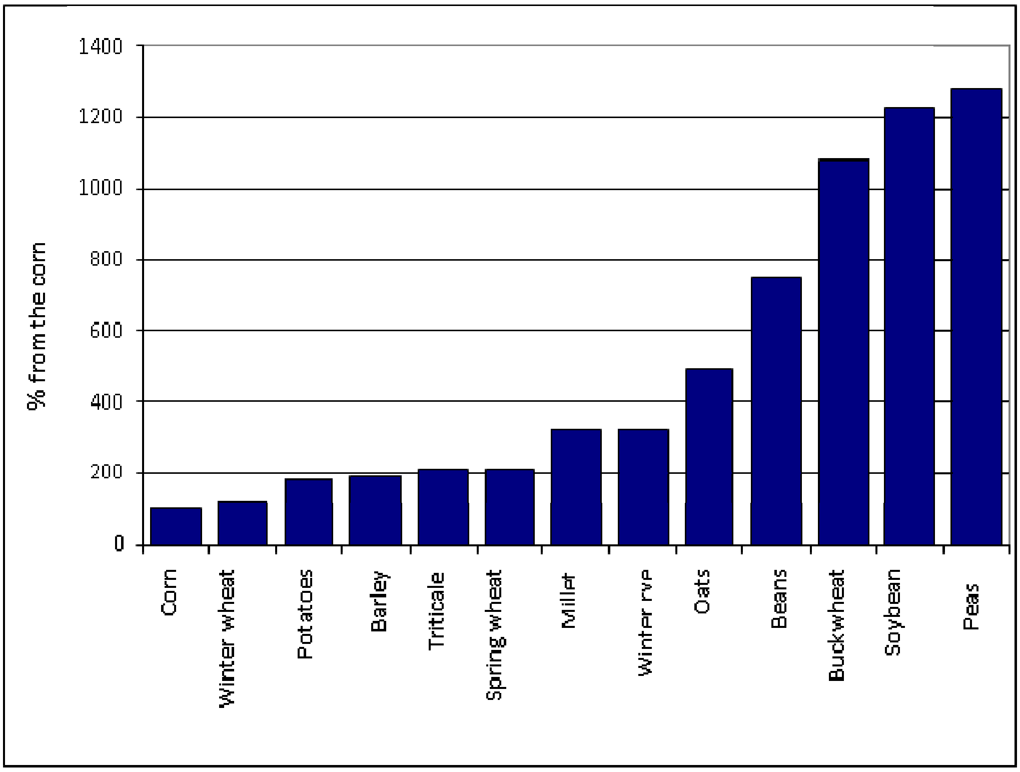

Figure 2. The relative accumulation of 1^{37}Cs in field crops harvest, % from corn.

The minimal 137Cs accumulation in the harvest was found in case of corn. The radionuclide accumulation factor in grains of this plant species was 0.07 (Bq•kg-1) / (kBq•m-2). The maximum radiocaesium concentration within the group of grain cereals was in oat grains. The concentration of 137Cs in oat grains was 5 times higher than that of corn.

The group of plants with potentially low ability to accumulate ^{137}Cs also includes potatoes. The radiocaesium accumulation factor in its tubers is intermediate between spring wheat and barley, but is 71% higher than that for corn. The group of groat cultures was characterized with higher potential accumulation of radiocaesium. Thus, the ^{137}Cs concentration in millet was nearly the same as in winter rye, but three times lower than in buckwheat (Figure 1). However, the maximum accumulation of

^{137}Cs is typical of group of grain legumes. In particular, in pea plants the radiocaesium concentration was 13 times higher as that compared to corn.

The specificity of agricultural processing also have an important role in reducing the specific activity of radionuclides in end products.

For different methods of grain processing, the distribution of activity between the source products is different. Long-term data on the decrease in the specific activity of ^{137}Cs in the process of technological processing of cereals for flour, feed and cereals are presented in table 1.

For various methods of grain processing, the distribution of activity between the source and final products is different. These changes in specific activity of 137Cs in the process of technological processing of cereals for flour, feed and cereals are presented in table 1.

Table 1. The transition of 137Cs from the grain in products of technological processing

Processed product	Share of the final product from the mass of input raw materials, %	Reduction of specific activity 137Cs, times
Grinding grain into flour		
Premium	40–45	1,4–1,7
Grade I	75–80	1,3–1,6
Grade II	80–85	1,1–1,3
Waste material	15–60	0,60–0,80
Processing for mixed fodder		
Mixed fodder	96–97	1,1–1,3
Waste material	3–4	0,20–0,55
Processing of buckwheat		
Unground	75–80	2,7–5,0
Chopping groats	20–25	0,20–0,25

The most effective way to reduce the specific activity of radiocesium in the final product is to grind the grain into Premium flour, which gives a reduction factor of 1.7 times. A slightly smaller amount of radioactive caesium-137 passes into grade 1 flour. At the same time, this type of grain processing can also be attributed to measures that reduce the activity of the final product and recommend its using in a radioactively contaminated territory. A positive effect occurs after processing the grain into grade 2 flour. But it will be much smaller.

The concentration of ^{137}Cs in mixed fodder after appropriate technological processing of grain does not significantly decrease, while in the waste that can also be used for feeding livestock in private farms of the population increases 2-4 times.

Buckwheat is a widespread culture in agriculture and occupies a significant place in the diet of the population of the regions contaminated after the Chernobyl accident. At the same time buckwheat belongs to the group of the most accumulating ^{137}Cs from soil. The results of long-term research, shown in table 1, can significantly (up to 5 times) reduce the content of the radionuclide in final product (unground). It should also be noted that severe restriction in the radionuclides content in bread and bakery requires mandatory monitoring of radionuclide content in agricultural raw materials and final products of its processing.

4. Conclusion

In the remote period of the radio ecological situation development after the Chernobyl accident up to 95% of the total population exposure dose is still formed due to consumption of agricultural harvested in contaminated areas. On this reason, in addition to economic feasibility, the specification for the production and processing of agricultural raw materials should have clearly defined environmental aspects, which include reducing the individual effective dose to the population by ensuring guaranteed radio ecological safety agricultural products and raw materials, and collective - by reducing the consumption of radionuclides from the crop. Deep processing of agricultural raw materials, mandatory monitoring of the content of 137Cs in agricultural raw materials and their final products of processing is one of the most effective anti-radiation measures in the contaminated area.

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