

HUMAN ECOLOGY ON RADIOACTIVELY POLLUTED TERRITORIES

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Abstract

The results of ¹³⁷Cs migration in forest ecosystems and internal exposure dose forming for people, living on the radioactively contaminated territories, are given. The tasks of international collaboration project aiming to reveal the statistical relation of cancer disease and territory contamination level, internal exposure dose etc are discussed.

Introduction

During the accident on Chernobyl Nuclear Power Plant (CNPP) about 90 MCu of radioactive wastes, from which ¹³⁷Cs and ⁹⁰Sr and been characterized by the huge activity were emitted to the environment. These radionuclides including in food chains can cause the significant dose loads to the population even in 30 and more years after the accident (1).

In fact self-cleaning of various types of ecosystems goes with different intensity. Thus the majority of researchers emphasize, that the period of remediation of natural forest ecosystems from radionuclides usually is longer than semi-natural. Besides, the forest ecosystems had played a role of "filters-stores" of radionuclides. In the most cases forests are more polluted by radionuclides, than located nearby forestless landscapes.

At once after the accident on the CNPP in the public sector of agriculture the active counter-measures were undertaken and resulted to the significant decreasing of radionuclides transfer to the agricultural production, and directly to the food products. At the same time population of villages (and partially of urban) actively uses natural and semi-natural ecosystems: cows of the rural citizen sector graze in forest, on the forest meadows, on the edges of forests, near the rivers on floodplains, etc. The population in rather large volumes collects the "forest gifts" – wild edible mushrooms, berries and medicinal plants, in smaller quantities – hunt the game. These food products have high levels of radio contamination, mainly by ¹³⁷Cs. It is necessary to notice; that it especially concerns the Polissya region, the most forested region of Ukraine. The listed above factors in conditions of radioactive pollution of forest can cause significant additional doses of the internal exposure of the population.

Traditionally in the diet of the population of Polissya the "forest gifts" are present in significant quantity. In particular, before the Chernobyl accident in this region one adult man consumed about 2,3 kg of mushrooms a year. After Chernobyl accident the consuming of forest products was significantly reduced due to the work of physicians and hygienists, spreading information about danger connected to the usage of radioactively contaminated meal. However at present the local population mainly has returned to "before accidental" diet and even uses mushrooms and berries more intensive, because of economical difficulties. On average from 1/3 up to 2/3 of population of the investigated region regularly consume "forest gifts".

The results of numerous researches of hygienists have allowed establishing, that between the use of forest foodstuff and ¹³⁷Cs content in the human body there is a close correlation.

As well as on the late phase of nuclear accidents the main source of an internal exposure to the man is meal and drinking water that transfer of long-lived artificial radionuclides to human body, it is necessary to investigate migration of radionuclides in forest ecosystems and radioactivity of forest food products at present and in the future.

Modeling of radionuclides migration in forest ecosystems and radioactivity of forest food

The mathematical model of ¹³⁷Cs migration in coniferous forests of Ukrainian Polissya has been created in Zhytomyr State Technological University. To automate the mathematical model creation,

validation and parameterization there was created the information system integrated into the system for mathematical tasks solving entitled "DSR Open Lab 1.0" (1).

To investigate the radionuclides migration the mathematical model is created on the basis of formal descriptions of the ecosystems compartments and functional relations between compartments characteristics. As the example it was taken the coniferous forest in the age of 55, located in the exclusion zone. For the purposes of mathematical modeling the long term monitoring data of ^{137}Cs total activity were used.

The detail analysis of the relations between compartments is investigated on the basis of the ecosystem lifecycle and radionuclides migration in it. The radionuclides fallout influenced the ecosystem been included into the exchange process.

Two related processes were modeled: 1) ^{137}Cs accumulation by forest litter fractions and upper soil layers; 2) ^{137}Cs accumulation by main forest products and forest food.

Thus, on the basis of the soil pollution density it was calculated the ^{137}Cs accumulation in the main forest food (dry and fresh) such as bilberry, mushrooms. It was taken into account that for mushrooms proportion was the following: (*Boletus edulis* Bull. ex. Fr.) – 60 %, (*Cantharellus cibarius* Fr.) – 30 %, (*Xerocomus chrysenteron* Bull. ex. Fr.) – 5 %.

Mathematical modeling testifies the fact of ^{137}Cs decreasing in a fresh litter (about 25 times) in the post accidental period (very intensive in the period of 1986-1990). For semi-humified layer of litter exist an increasing of ^{137}Cs specific activity in 1986-1990 and further slowly decreasing. The same situation is testified in the humified layer but with the peak in 1993-1994.

The increase of the ^{137}Cs accumulation in time is typical for mineral soil and is as longer as the layer is deeply located.

Results of mathematical modeling of ^{137}Cs accumulation in bilberries demonstrate the stable tendency to self-cleaning of the plant specie. It is very intensive in the initial period (1986–1992) when ^{137}Cs content decreased almost in three times and remain not very intensive in further period (1992-2002 in two times). This is mainly conditioned by the root location of the berry species in the layer of humified litter with high radionuclide availability and in the upper soil layer. For different edible mushrooms the dynamic of ^{137}Cs content can be drawn as following – maximal specific activity of ^{137}Cs in mushrooms: *Cantharellus cibarius* – in 1997; *Xerocomus chrysenteron* – 1996; *Russula paludosa* – 2000; *Boletus edulis* in 2005. These differences are conditioned by deep location of the mycelium of certain specie in mineral soil layer. The comparison of ^{137}Cs content in air-dry fruit bodies of mushrooms demonstrate that in 10 years after the Chernobyl catastrophe species mentioned above will be ranked in the following sequence: *Xerocomus chrysenteron* >> *Russula paludosa* > *Cantharellus cibarius* > *Boletus edulis*, and in 30 years – *Boletus edulis* will take the third place.

Comparison of results of mathematical modeling of ^{137}Cs accumulation in forest food with radiological monitoring data demonstrates the similarity of tendency. Particularly ^{137}Cs accumulation in forest food stocked by inhabitants of the village Chrystynivka in 1999 was the following: *Xerocomus chrysenteron* Bull. ex. Fr. – $6,5 \pm 2,0$ MBq/kg; *Boletus edulis* Bull. ex. Fr. – $0,6 \pm 0,2$ MBq/kg; *Cantharellus cibarius* Fr. – 110 ± 30 kBq/kg; in fresh bilberries – 22 ± 8 kBq/kg.

Prognosis of population internal exposure doses

As the object of investigation there were taken adult people of the village Chrystynivka, Narodichi district of Zhytomyr Region living in the exclusion zone. The aim of the investigations is to reveal the internal exposure dose of population from the forest food in 1996 and in 30 years (2016). Thus the investigation work consists of two parts: radiation hygiene – revealing the peculiarities of the diet and internal exposure dose from ^{137}Cs accumulated in forest food; mathematical modeling of ^{137}Cs content in forest food, influencing the internal exposure dose.

Joining up these two parts lets us to predict the internal exposure dose of population and risks investigations.

Ukrainian radioecologists divide the population of the rural village in 2 groups, which essentially differ in lifestyle:

- A. Lonely inhabitants, which have not private economy. The “forest gifts” are especially wide spread in the diet of this group.
- B. Population having private economy and poorly using both wild mushrooms and berries.

Thus, for critical groups of population of the village mentioned above the additional dose from food (agricultural plants, animals) is 2,16% from internal exposure dose of such groups eating all types of food. Forest food stipulates for 97,28% of the internal exposure dose and 70,85% of it belongs to mushrooms included into diet, 26,43% – to berries (see fig.1). Results of prediction are similar to monitoring data of dosage, especially 94% of dosage from the diet of group A are taken from forest food, particularly characterized the increasing in the second half of October with the peak in September – a consequence on mushrooms including into diet (2).

Our calculations showed that in 1996 in Chrystynivka, population of the group A received the dose 1046437 Bq/year/person or equivalent dose of 14,65 mSv/year in contrast to the population of the group B, received 101747 Bq/year/person or equivalent dose of 1,47 mSv/year. Total exclusion of the forest food from the diet results in the intensive decrease of the dose – up to 0,56 mSv/year.

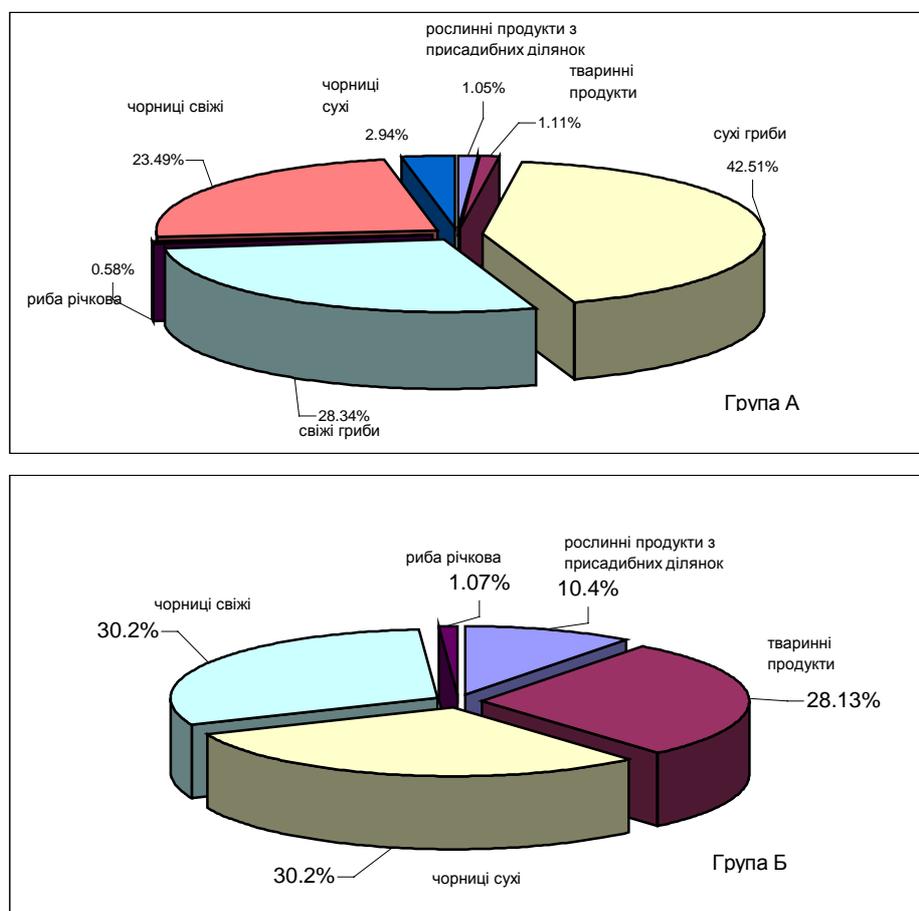


Fig. 1. The generalized data concerning the food distribution among the groups A and B regarding ¹³⁷Cs content in it, Chrystynivka, 1996.

Regarding the data of spectrometry investigations we can draw out the situation of dosage on the following examples: in the village Kopsysche, Olevsk District minimal and maximal dose were 0,01 and 1,01 mSv/year respectively; in the village Majdan Kopschansky – 0,01 and 2,07 mSv/year, in the village Perga – 0,03 and 1,9 mSv/year.

As the initial information for the modeling, we guessed the diet of the population will remain the same, ¹³⁷Cs accumulation in the forest ecosystems compartments will be changed according to the decay and vertical migration process. Thus, the role of the forest food in the dosage remained the same (see fig. 2)

The results testify that for critical group A relative deposit of the dry fruit bodies of mushrooms: *Boletus edulis* into the dosage will decrease in 2,20 times, *Cantharellus cibarius* – will decrease on 25%, *Russula paludosa* – will increase and *Xerocomus chrysenteron* will decrease. For fresh fruit bodies of mushrooms: *Boletus edulis* will increase in 2,19 times, *Cantharellus cibarius* – will decrease in 1,29 times, *Russula paludosa* – will increase in 1,12 times, *Xerocomus chrysenteron* will increase in 1,39 times. Bilberries deposit in the dosage will decrease in 3,5 times.

For the population of the group B the berries content in the diet will decrease from 60,4 % in 1996 to 33,44 % in 2016, i.e. in 1,81 times.

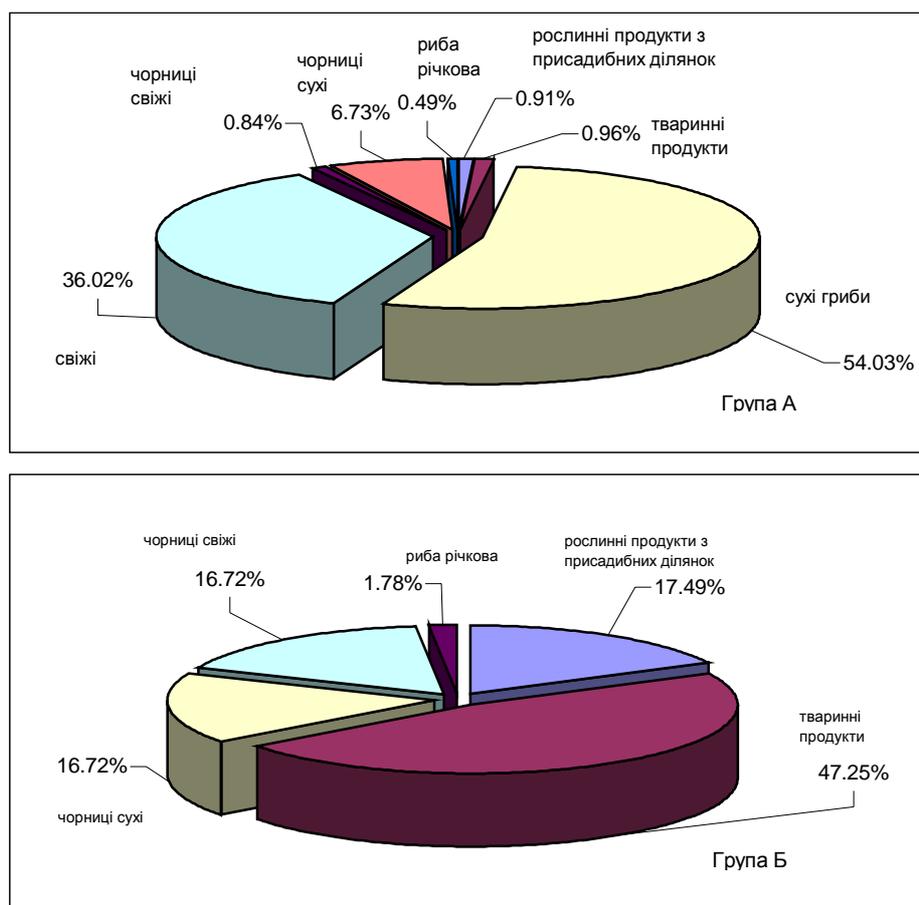


Fig. 2. Food deposit to the internal exposure dose of the groups A and B, village Chrystynivka in 2016.

Thus, for the population of the exclusion zone, living in the forested regions it is recommended to calculate the internal exposure dose not only taking into account the agricultural food but forest food as well. For these zones we cannot classify the forest food as the modification factor because for this region such types of food plays the primary role in dosage. Numerous investigations showed that deposit of the forest food into the dose can be 50% but for critical groups up to 80% and more. In this case, when the density of the contamination is spotted and ecological conditions are specific it is better to use the mathematical modeling for the purposes of dosage prediction for short-term as well as for long-term prediction. This procedure will help in calculation of the risk factors for the health of population living in contaminated regions, suffering from Chernobyl catastrophe.

Future Investigations

Contaminated territories can serve as the testing area for investigators in the field of radionuclides influence on people health. The problem of investigation of results of anthropogenic accidents is very important because such situation can happen as the result of explosion on nuclear power plants installed in the other region all over the world.

Results have a potential for EU, partly because country of EU also suffered from Chernobyl disaster and because of suffering from pollution by natural radionuclides in different regions of EU. On the other hand regions with high level of pollution are close to the borders of EU and naturally, radionuclides can migrate by the pathways of natural and semi-natural ecosystems (3).

The methodology we propose is to provide complex analysis of the environmental changes but not only by searching the complementary factors influencing the human organism as well as radioactive pollution by the artificial nuclides but natural as well.

On the basis of correlation of the contamination level and illness level changes it is planned to investigate the direct dependence of the illness increase with the change of environmental conditions etc. Thus, for the regions with natural radionuclides contamination it is possible to assess the correlation between the level of contamination and people health. For deep analysis of the situation in the regions of interest it is planned to create the mathematical models for investigation of the parameters changes and prediction of the illness for nearest future and then comparison with data received from regions monitoring as well as for long-term prediction.

Deep analysis of the situation will help in creation of the recommendations for people living in contaminated regions and reveal the age-dependent critical group of people liable to the cancer diseases. Creation of the recommendations on agriculture and forestry in order to decrease the internal exposure dose of people living on the territory with higher radioactive level, eating forest or agricultural food products, taken from the same territory. Investigation of the low doses are planned to be held on the basis of data of internal and external exposure dose measuring of people living on the polluted territory (4).

The project touches the problems of late radiation effects in different regions of Ukraine, Russia, Belarus where it is relatively easy to distinguish the increase of the tumor rate over the last 15 years after Chernobyl accident for different tumors of children and adult people. On the other hand, the results of the project will improve the conditions of medical care of the population in higher radioactive contaminated territories. Results of the project will help to improvement the screening on tumor or tumor like diseases for early detection of cancers. The effect of project implementing will give the possibility to optimize the strategies for diagnostic and treatment of cancers (imaging methods, biophysical and biochemical principles, histological analysis, staging of tumors, treatment strategies depending from the stage of tumor). Sanitary hygienic recommendations on culinary processing of forest food products with the purposes of decrease of internal exposure dose should be created. Additional risk of people health from different sources of irradiation are to be calculated and changes to lifestyle will be made.

References:

- 1 O. ORLOV, A. KOVALCHUK, V. LEVITSKY, V. YANCHUK Automation of modeling of ^{137}Cs migration in coniferous forests of Ukrainian Polissya / The third congress on radiological investigations – radiobiology and radioecology, Kyiv, Ukraine, 325, (May, 21–25, 2003).
- 2 A. KOVALCHUK, V. KRASNOV, V. LEVITSKY, O. ORLOV, V. YANCHUK The mathematical modeling of ^{137}Cs migration in forest ecosystems of Ukrainian Polissya, The bulletin of the ecological conditions of the exclusion zone, 2/20, 59–70 (2002).
- 3 B.SAMOTOKIN, Ed. Materials of the Joint European Project JEP–10435–98 “Environmental Sciences in Relation to the Implication of Radiation Exposure in Health Care”, Zhytomyr, Ukraine, 183–188. (2002).
- 4 V. YANCHUK, M. KOLODNYTSKY, A. KOVALCHUK, V. LEVITSKY, O. ORLOV The methods and tools of mathematical modeling of radionuclides migration in natural ecosystems, Zhytomyr, ZhIET (2002).