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Radioactivity of ^{137}Cs and ^{90}Sr components of the environment in the post-Chernobyl period in 2024

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Abstract. The aim of the study was to determine the specific activity of environmental components and forestry products in the Bilokorovychi Village, Korosten District, Zhytomyr Region, for the content of radionuclides ^{137}Cs and ^{90}Sr, which entered them as a result of the accident at the Chernobyl Nuclear Power Plant. The study was conducted in accordance with the research topic "Monitoring studies of the biosphere of the Ukrainian Polissya" from September to November 2024 using dosimetric and radiometric methods. It was established that the exposure dose rate of gamma radiation complies with the radiation safety standards of Ukraine for populated areas: 18.3 ± 1.6 18.3 ± 1.6 μR/h was recorded in the forest, 12.7 ± 0.7 μR/h on agricultural land, and 14.7 ± 3.4 μR/h in the residential part of the village. The stems, leaves and dry fruits of blueberries exceed the requirements of DR-2006 for ^{137}Cs content by 1.7 times and by 300 Bq/kg, respectively, while the activity of ^{90}Sr is within the normal range. The specific activity of chaga, Viburnum and rosehip fruits complies with the requirements of DR-2006 and is 48.5 ± 3.6 Bq/kg, 13.7 ± 1.2 Bq/kg for ^{137}Cs content, 27.9 ± 1.7 Bq/kg, and ^{90}Sr activity is 89.9 ± 6.7 Bq/kg, 0.1 ± 0.01 Bq/kg, 0.1 ± 0.02 Bq/kg, respectively. The samples of honey mushrooms are suitable for consumption, since the specific activity of ^{137}Cs is three times lower than the standard, and that of ^{90}Sr is four times lower. The specific activity of porcini mushrooms for ^{137}Cs is 2.1 times higher than the standard, and the accumulation of ^{90}Sr is 15.7 times lower than the standard. The specific activity of moss for ^{137}Cs is almost 5 times lower than the specific

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activity of soil, which was 893.9 ± 91.3 Bq/kg for ^{137}Cs. Water from artesian wells in the village is suitable for consumption in terms of radiation indicators. Acorns moderately accumulate ^{137}Cs and ^{90}Sr (372.1 ± 17.2 Bq/kg and 143.9 ± 10.4 Bq/kg, respectively). Thus, studies have established that dry blueberries and dried porcini mushrooms are unfit for consumption

Keywords: specific activity; permissible levels of radionuclide content; nuclear power plant accident; gamma radiation exposure dose rate; radiation safety; environmental components

Introduction

All citizens residing in Ukraine must be protected from ionising radiation. Law of Ukraine No. 15/98-BP (1998) regulates the exposure of the population without taking into account the dose received from local natural background radiation. Changes in the natural radiation background occurred in 1986 after the accident at the fourth power unit of the Chernobyl Nuclear Power Plant (ChNPP). The Chernobyl disaster led to radioactive contamination of a significant part of Ukraine. Depending on the presence of long-lived radionuclides and their activity in a particular area, the territory was zoned as follows: exclusion zone, zone of unconditional (mandatory) resettlement, zone of guaranteed voluntary resettlement, zone of enhanced radioecological control (Law of Ukraine No. 791a-XII-BVR, 1991). According to Law of Ukraine No. 2697-VIII (2019), radioecological monitoring is an important component of ensuring not only environmental but also national security.

The content (activity) of radionuclides was determined in environmental components in accordance with Resolution of the Cabinet of Ministers of Ukraine No. 391-98-p (1998): atmospheric air and precipitation, water bodies (surface, marine, underground, in nature conservation areas), soil. Research on the presence of radionuclides was also conducted in industrial emissions into the atmosphere, wastewater, landfills, and radioactive waste disposal sites. The background amount of radionuclides is determined in terrestrial and marine ecosystems and landscapes. The Ministry of Environmental Protection and Natural Resources organises the study of the radiation situation at stationary points. As noted by scientists G. Cannon & J.G. Kiang (2020), the search for radiation biomarkers in ecosystems continues 34 years after the global accident. Scientists G.M. Chobotko *et al.* (2024) have developed measures to reduce the radiation dose to the population and the content of radioactive substances in soil, water, and food, and have analysed data from 38 years after the Chernobyl accident. Researchers L.M. Oleshchenko & M.O. Ilyin (2023) and E. Nagornyi (2024) concluded in their works that it is important not only to determine the current state of radionuclide contamination, but also to establish migration mechanisms and distribution patterns, all of which should be used to predict the state of the environment. As noted by researchers O. Dunaievska *et al.* (2024), in connection with the armed aggression of the Russian Federation, changes have occurred in the environment, especially in areas of combat operations, where military, sabotage and terrorist actions can lead to additional release of radionuclides into the environment, posing a threat to the population. Loss of control over the source of ionising radiation and ignorance of the algorithm of actions in such situations lead to a negative impact on the environment and exposure of people to radiation. To prevent this, according to scientists O. Sitnikova & A. Melnyk (2022), it is necessary to constantly study the issue of the vulnerability of sources of ionising radiation. However, as discussed in the work of K.O. Krushelnytska (2022), effective physical protection must be developed for employees who perform their duties in areas with increased radiation levels, such as law enforcement officers. As noted by V.P. Kovalskiy *et al.* (2021), such physical protection can be provided by the rational use of building materials.

In order to ensure rapid response and information gathering, a Strategy for an Integrated Automated Radiation Monitoring System was developed in April 2022, which will enable timely measures to be taken to protect people and the environment (Order of the Cabinet of Ministers of Ukraine No. 323-p, 2022). Such a system will make it possible to inform the international community about the radiation status of Ukraine's territory and to receive similar data from partners. After all, a radiation accident also occurred in Japan, the consequences of which are being studied by scientists who are providing recommendations on how to manage the situation (Drebot & Zamula, 2020). Therefore, as summarised by G.S. Kalda *et al.* (2022), studying the state of radiation contamination of territories is relevant not only for Ukraine but also for all countries of the world and is carried out in accordance with national monitoring programmes. The radiation safety of humanity is considered a global problem. After all, sources of ionising radiation are used not only in atomic energy and nuclear weapons, but also in medicine, agriculture, various industries, and scientific research. The number of such technologies is increasing, their scope of use is expanding, and therefore, according to Y. Kozubenko (2022), there is a need to assess the cumulative effect of ionising radiation sources.

V. Tiutiunyk *et al.* (2020) concluded in their work that it is important to develop a dynamic model of radioactive contamination of any component of the ecosystem, and that a comprehensive approach will allow conclusions to be drawn about the amount of radiation exposure of the population. It is also important to establish the distribution and content of radionuclides in the environment 38 years after the Chernobyl accident. Therefore, the aim of the study was to determine the specific activity of ^{137}Cs and ^{90}Sr in soil, water, forestry products and the exposure dose of gamma radiation in the air in the Bilokorovychi Village, Korosten district, Zhytomyr region, since the villagers constantly harvest, consume and use berries and mushrooms that grow in the forest and undergrowth. The scientific novelty lies in obtaining reliable and comprehensive information about the state of radiation safety, radionuclide contamination of the area and plant products of a particular settlement, since the population, despite warnings, consumes such products, which are available and can be harvested within place of residence.

Materials and Methods

The research was conducted in accordance with the research topic "Monitoring Studies of the Biosphere of the Ukrainian Polissya", approved by the Ministry of Education and Science of Ukraine (state registration number 0124U000645) in September-November 2024. Radiological studies and sampling were carried out in the Bilokorovychi Village, Korosten District, Zhytomyr Region. According to Law of Ukraine No. 791a-XII-BVR (1991), the village is classified as a zone of guaranteed voluntary resettlement. Soil sampling was carried out in accordance with DSTU 4287:2004 (2004). Spot samples were obtained using a BP-25-15 drill at a depth of 0-25 cm. Sampling was carried out at a distance of more than 50 m from roads. Spot samples were formed into a nest sample weighing at least 1 kg. Visibly noticeable foreign impurities, such as fauna elements and vegetation residues, were removed from the sample. The selected samples were placed in bags, labelled, transported to the laboratory, and dried at room temperature in a well-ventilated dry room for 24 hours. Water samples were taken in accordance with DSTU ISO 5667-11:2005 (2005) from wells with a volume of at least 2 litres each.

Food samples (porcini mushrooms, honey mushrooms, blueberries, *Viburnum*, rosehips) were collected in accordance with State Hygienic Standards "Permissible Levels of Cs^{137} and Sr^{90} Radionuclides in Food and Drinking Water" (2006). To determine the activity of radionuclides in products, spot samples were first selected and combined into a composite sample, from which a portion was taken to form a mean sample. It was the mean sample from the crushed raw material that was used for radiological studies, from which a counting sample was weighed. Using a similar method, spot samples were taken and a counting sample was formed from moss, acorns, and chaga.

All radiological determinations were carried out in the Measurement Laboratory of the Polissya National University, which underwent an audit of the measurement system in 2022. The specific activity of the samples was determined using an MKS-AT1315 gamma-beta spectrometer (manufactured by ATOMTEKH, Republic of Belarus). The values were obtained in two stages: measurement of the working background spectrum and measurement of the activity of the sample weights. The working background spectrum was measured for 3 hours in advance and recorded in the memory of the MKS-AT1315 gamma-beta spectrometer. The control background spectrum was also measured and recorded in advance in a similar manner. The activity of radionuclides was measured by placing sample weights in a Marinelli vessel, which was transferred to the protection unit of the MKS-AT1315 gamma-beta spectrometer using the instructions and SPTR software.

The activity was measured on the MKS-AT1315 gamma-beta spectrometer by registering gamma and beta radiation with scintillation detection units. A detection unit with sodium iodide crystals 63 mm in diameter and 63 mm in height was used to register gamma radiation. A detection unit with polystyrene activated with para-terphenyl 128 mm in diameter and 9 mm in height was used to register beta radiation. The result of the registration was instrumental spectra, which were displayed in real time on a personal computer monitor. The exposure dose rate of gamma radiation was determined using a device from the measurement laboratory, a MKG-AT1321 spectrometer-dosimeter (manufactured by ATOMTEKH, Republic of Belarus). The device continuously counted gamma radiation pulses using a scintillation detector (sodium iodide crystals with a diameter of 25 mm and a height of 40 mm) and a built-in Geiger-Müller gas discharge counter. Statistical processing of the measurement results was performed by calculating the mean value and deviation from the mean value. All studies of cultivated and wild plants, including sample collection, were conducted in accordance with applicable institutional, national or international standards and met the requirements of the Convention on Biological Diversity (1992).

Results and Discussion

Radiological studies have established that the exposure dose of gamma radiation in the Bilokorovychi Village does not exceed 20 μR/hour (Table 1).

Table 1. Radiation safety indicators for atmospheric air in the Bilokorovychi Village

Measurement location	Gamma radiation exposure dose rate, μR/h
Forestry area	18.3 ± 1.6
Agricultural land	12.7 ± 0.7
Village area	14.7 ± 3.4

Source: provided by the authors

This indicator fully complies with Ukrainian radiation safety standards (State Hygienic Standards…, 1997). Determining the specific activity of soil is important in the soil-plant-animal-human chain. The activity of plant and animal products depends on the activity of the soil. Particular attention should be paid to radiological studies in areas of radioactive contamination. Studies by L. Romanchuk *et al.* (2019a) examined the specific activity of soil from such areas and determined high concentrations of radionuclides. Studies of agricultural land in the Bilokorovychi Village also indicate high specific activity in ^{137}Cs samples (Table 2). Long-term studies allow for the accumulation and analysis of material and the prediction of the distribution and accumulation of radionuclides, in particular ^{137}Cs. The more time has passed since the Chernobyl accident, the better the dynamics of its distribution have been studied. Landscapes are neutral in this respect, with positive and negative balances. ^{137}Cs accumulates more on slopes and at the edge of swamps, as well as in the layers of macromycetes, lichens and mosses. The soil retains almost 87% of the radionuclide ^{137}Cs (Orlov, 2021). The concentration of ^{137}Cs is an important indicator for studying the suitability of products for the population not only in the case of environmental contamination after the Chernobyl accident, but also after the Fukushima accident, since the half-life is 30 years, as noted by M. Hachinohe *et al.* (2021).

Table 2. Radiation safety indicators of samples of environmental components and food from Bilokorovychi village

Sample name	Specific activity for ^{137}Cs, Bq/kg	Permissible level for ^{137}Cs, Bq/kg	Specific activity for ^{90}Sr, Bq/kg	Permissible level for ^{90}Sr, Bq/kg
Soil	893.9 ± 91.3		0.1 ± 0.05	
Water	1.5 ± 0.09	2	0.1 ± 0.01	2
Moss	165.8 ± 10.3		0.1 ± 0.03	
Chaga	48.5 ± 3.6	200	89.9 ± 6.7	100
Acorns	372.1 ± 17.2		143.9 ± 10.4	
Viburnum (fruit)	13.7 ± 1.2	70	0.1 ± 0.01	10
Blueberry (stem with leaves)	347.5 ± 5.8	200	0.1 ± 0.02	100
Blueberry (fruit, dried)	2,798.4 ± 21.3	2,500	96.7 ± 9.3	250
Rosehip (fruit)	27.9 ± 1.7	70	0.1 ± 0.02	10
Honey mushrooms	146.8 ± 10.6	500	3.7 ± 0.2	50
Porcini mushrooms (dried)	5,292.4 ± 22.7	2,500	15.9 ± 0.7	250

Source: provided by the authors

Ionising radiation affects human health and life. The dose of internal exposure is formed by the consumption of food and drinking water containing radionuclides. Food can account for up to 95% of the internal exposure dose if such products are grown, consumed and consumed in a radioactively contaminated area. Chronic exposure is particularly common among residents of radioactively contaminated areas. Polissya ecosystems, in particular oligotrophic and mesotrophic bogs, were contaminated with radioactivity back in 1986. Research by scientists has established the intensive migration of the radionuclide ^{137}Cs. The specific activity of shoots and berries of the cranberry (*Vaccinium oxycoccus* L.) has significantly decreased (Krasnov *et al.*, 2022). The fruits of blueberries growing in Polissya are widespread and commonly consumed. Common blueberry (*Vaccinium myrtillus* L.) of the *Ericaceae* family is used in medicine in the form of dried fruits and leaves. It grows in the form of a small bush. Radiometry has established that the stems and leaves of blueberries exceed the established permissible levels (State Hygienic Standards..., 2006) by 1.7 times in terms of ^{137}Cs content, while the activity of ^{90}Sr is within the normal range (Table 2).

Dried blueberries do not meet the established permissible levels for ^{137}Cs activity, exceeding the limit by almost 300 Bq/kg, while ^{90}Sr activity meets the requirements of the State Hygienic Standards "Permissible Levels of Cs^{137} and Sr^{90} Radionuclides in Food and Drinking Water" (2006). The need to study porcini mushrooms (*Boletus edulis Bull. ex Fr.*; or *Boletus bulbosus Schaeff. ex Schroet.*) of the *Boletaceae* family for radionuclide content is due to the special demand for this product on the food market compared to other types of mushrooms. They were studied in dry form. The specific activity of porcini mushrooms for ^{137}Cs is 2.1 times higher than normal, although for ^{90}Sr it is 15.7 times lower than normal (Table 2).

Studies of dried blueberry samples conducted by scientists L. Romanchuk *et al.* (2019b) in the Ovruch and Narodychi districts of the Zhytomyr region, which are classified as areas of radioactive contamination, showed that permissible levels were exceeded by up to 5 times in some cases, making such products unfit for consumption. There were four settlements in the voluntary guaranteed resettlement zone where the specific activity of blueberries for ^{137}Cs was within the range of 565-665 kBq/kg. Similarly, in the Narodychi and Ovruch districts, significant radioactivity was observed in dry porcini mushrooms (2,058-12,870 kBq/kg). Scientists K. Beňová *et al.* (2021) also obtained results in their work that indicate that the activity of ^{137}Cs in the soil exceeds its content in blueberry leaves and stems. This confirmed the need for radioecological monitoring with the selection of various samples for further analysis.

The results of 10 years of observations in a large-scale analytical work by V. Kotelevych & O. Pinsky (2022) showed that exceedances of permissible levels in forest products, including mushrooms and berries, were recorded in almost 39% of samples. Exceedances of the radionuclide ^{137}Cs content in accordance with the State Hygienic Standards "Permissible Levels of Cs^{137} and Sr^{90} Radionuclides in Food and Drinking Water" (2006) were found in mushrooms and berries in the Narodychi, Olevsk, Korosten, Luhyn, and Yemilchyne districts. In particular, almost 14% of forest berry samples did not meet the requirements, especially those from the Narodychi and Ovruch districts. Mushrooms, especially porcini mushrooms, had the highest specific activity. These results only confirm the reliability of the current study. In 2017, the analysis of food samples registered the highest proportion of exceedances of permissible levels of radionuclides from the Narodychi and Ovruch districts, with mushrooms and forest berries accounting for a significant proportion. In 2019, approximately 0.1% of the samples selected were found to be non-compliant in terms of specific radioactivity, including mushrooms and medicinal plants. In 2020, high specific activity was again found in forest berries and mushrooms.

Chaga, or birch mushroom, of the *Hymenochaetaceae* family grows as growths on birch trees and is used in medicine. In terms of specific activity, this mushroom meets the established requirements. Attention should be paid to the peculiarity of the radionuclide content: the activity of ^{90}Sr is 1.9 times higher than that of ^{137}Cs (Table 2). *Viburnum* of the *Adoxaceae* family is a shrub 150 cm high. When raw, the fruits can be stored for a long time. They are used as a food product. In terms of specific activity, *Viburnum* fruits meet the established requirements, with the activity of ^{90}Sr being 10 times and the activity of ^{137}Cs being 5 times lower than the norm prescribed in the State Hygienic Standards "Permissible Levels of Cs^{137} and Sr^{90} Radionuclides in Food and Drinking Water" (2006) (Table 2).

Rosehip (*Rosa* L., 1753) of the *Rosaceae* family is known as a shrub, the most common species being *Rosa canina* L. It is used in medicine, most often in the form of dried fruits. In terms of specific activity, rosehip fruits meet the established requirements, with ^{90}Sr activity 10 times and ^{137}Cs activity 2.5 times lower than the norm specified in the regulatory document State Hygienic Standards "Permissible Levels of Cs^{137} and Sr^{90} Radionuclides in Food and Drinking Water" (2006) (Table 2).

Honey mushrooms are lamellar cap mushrooms that mainly grow on stumps and trees. They include various species: winter, spring, summer, meadow, autumn honey mushrooms and others. It is considered a food product in its raw form, which, after testing, can be used for culinary processing. The selected samples of honey mushrooms meet the established requirements (Table 2). V. Kotelevych *et al.* (2024) noted that, according to statistical data, in 2023, mushrooms were found in dry and fresh form with an excess of radionuclides according to the State Hygienic Standards "Permissible Levels of Cs^{137} and Sr^{90} Radionuclides in Food and Drinking Water" (2006). However, the type of mushrooms was not specified. It was assumed that this does not apply to honey mushrooms, as they grow above the forest litter level, which is what contributes to their relatively low radionuclide content.

There are many species of mosses (*Bryophyta*). The current study observed forest moss (*Sphagnum*). It attracted attention due to its prevalence and use as a decorative material in homes and as a basis for keeping some animals at home. Scientists use moss to measure the level of external radiation and air pollution, as noted by L. Barandovski *et al.* (2021). They proposed a model for calculating the radiation dose using the results obtained. Therefore, the study of the specific activity of moss is valuable from the point of view of radioecology. The specific activity of moss for ^{137}Cs is almost 5 times lower than the specific activity of soil (Table 2). Therefore, its use in small quantities in everyday life will not contribute significantly to the total radiation dose to humans. It should be noted that the specific activity of soil for ^{137}Cs is almost 9,000 times higher than for ^{90}Sr. This difference can be explained by the sorption capacity of radionuclides, which is obviously lower for ^{90}Sr than for ^{137}Cs, as noted by O.V. Nikitina (2021). The research is consistent with the data obtained by scientists Y. Guan *et al.* (2023) in the southern region of Guangdong, China. In particular, the specific activity of soil is five times higher than that of moss.

In the context of sustainable development, afforestation and reforestation in radiation-contaminated areas are important tasks. To this end, it is necessary to take into account the properties of radionuclide retention by forest ecosystem components and to implement certain measures. Shrubs, herbaceous plants and fungi accumulate almost 90% of radionuclides. Woody plants accumulate radionuclides in different ways, for example, conifers more than deciduous trees. Among the physiological properties of plants that need to be taken into account is the annual growth of wood. In oak and hornbeam, these indicators are low, so the accumulation of radionuclides is insignificant (up to 60 Bq/kg), while pine in the same conditions will have a specific activity of 70-500 Bq/kg (Trohymchuk, 2024). Acorns are the fruits of the common oak (*Quercus robur*) of the beech family (*Fagaceae*). During the study, acorns were considered as wild berries. Despite the fact that in the State Hygienic Standards "Permissible Levels of Cs^{137} and Sr^{90} Radionuclides in Food and Drinking Water" (2006), acorns are not listed, they were studied as a product from which coffee and flour can be made, as well as used as feed for farm animals. In this case, the regulatory content for ^{137}Cs is 500 Bq/kg, and for ^{90}Sr – 50 Bq/kg. Acorns accumulate a fairly large amount of Chernobyl radionuclides: 372.1 ± 17.2 Bq/kg and 143.9 ± 10.4 Bq/kg for ^{137}Cs and ^{90}Sr, respectively (Table 2), and it is precisely the activity of ^{90}Sr that will not meet the permissible levels. It can be assumed that acorns contribute to the radioactivity of forest litter. Therefore, acorns from this area of radioactive contamination are characterised by an increased level of radionuclide accumulation and are dangerous for use in the food industry and for burning as a source of heat.

Conclusions

Radiological studies have established that the exposure dose of gamma radiation in the Bilokorovychi Village, Korosten District, Zhytomyr Region, complies with Ukrainian radiation safety standards established for populated areas. The highest gamma radiation exposure dose was recorded in the forestry area (18.3 ± 1.6 μR/h), and the lowest in agricultural land (12.7 ± 0.7 μR/h). The specific activity of blueberry stems and leaves is 347.5 ± 5.8 Bq/kg for ^{137}Cs (1.7 times higher than the standard) and 0.1 ± 0.02 Bq/kg for ^{90}Sr (1,000 times lower than the standard). The specific activity of dry blueberry fruits is 2,798.4 ± 21.3 Bq/kg for ^{137}Cs (298.4 times higher than the norm) and 96.7 ± 9.3 Bq/kg for ^{90}Sr (153.3 times lower than the norm). That is, the stems, leaves and dry blueberries exceed the established state hygiene standards for ^{137}Cs content, while the activity of ^{90}Sr is within the norm and is unsuitable for consumption.

The specific activity of chaga, *Viburnum* berries and rosehips (dry) meets the established requirements for both ^{137}Cs and ^{90}Sr content. The samples of honey mushrooms are suitable for consumption (the specific activity for ^{137}Cs is 2.7 times lower than the norm and 13 times lower for ^{90}Sr). The specific activity of dry porcini mushrooms for ^{137}Cs (5,292.4 ± 22.7 Bq/kg) is 2.1 times higher than the norm (2,500 Bq/kg), for ^{90}Sr – 7 times lower than the norm, they are unfit for consumption. The specific activity of moss for ^{137}Cs is almost 5 times lower than the specific activity of soil, which was 893.9 ± 91.3 Bq/kg for ^{137}Cs. The specific activity of acorns is 372.1 ± 17.2 Bq/kg and 143.9 ± 10.4 Bq/kg for ^{137}Cs and ^{90}Sr, respectively, which does not allow them to be recommended as a food product. Authors consider it promising to expand the scope of research, in particular, to cover trees and shrubs of different ages, forest litter, and game. In the future, the authors intend to analyse the specific activity of oaks of different age categories and acorns from areas of enhanced radioecological control and from areas that are conditionally clean from radionuclide contamination.

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Conflict of Interest

None.

References

[1] Barandovski, L., Šajn, R., Andonovska, K.B., Frontasyeva, M.V., & Stafilov, T. (2021). Modeling of the ambient radiation dose level by using passive moss biomonitoring in Macedonia. *Journal of Radioanalytical Nuclear Chemistry*, 330, 267-278. doi: 10.1007/s10967-021-07943-1.

[2] Beňová, K., Gašpareková, I., Dvořák, P., & Havelková, A. (2021). Contamination of Slovak bilberry (*Vaccinium myrtillus* L.) with radiocaesium 137Cs in selected Slovak locations. *Folia Veterinaria*, 65(2), 48-57. doi: 10.2478/fv-2021-0017.

[3] Cannon, G., & Kiang, J.G. (2020). A review of the impact on the ecosystem after ionizing irradiation: Wildlife population. *International Journal of Radiation Biology*, 98(6), 1054-1062. doi: 10.1080/09553002.2020.1793021.

[4] Chobotko, G.M., Raichuk, L.A., Svydenko, I.K., & Umanskii, M.S. (2024). From crisis to recovery: Scientific endeavors of the Institute of Agroecology and Environmental Management of the NAAS of Ukraine in minimizing the consequences of the Chornobyl accident. *Agroecological Journal*, 2, 6-16. doi: 10.33730/2077-4893.2.2024.305647.

[5] Convention on Biological Diversity. (1992, June). Retrieved from https://zakon.rada.gov.ua/laws/show/995_030#Text.

[6] Drebot, O., & Zamula, C. (2020). Organizational aspects of forestry management in the conditions of radioactive pollution: The experience of Fukusima. *Balanced Nature Management*, 2, 42-50. doi: 10.33730/2310-4678.3.2020.212600.

[7] DSTU 4287:2004. (2004). *Soil quality. Sampling*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page?id_doc=54569.

[8] DSTU ISO 5667-11:2005. (2005). *Water quality. Sampling of samples. Part 11. Guidelines for sampling groundwater (ISO 5667-11:1993, IDT)*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page?id_doc=52474.

[9] Dunaievska, O., Sokulskyi, I., Melnyk, N., & Pitsil, A. (2024). Environmental problems of agriculture under martial law. *Ecological Sciences*, 1(52), 22-27. doi: 10.32846/2306-9716/2024.eco.1-52.1.3.

[10] Guan, Y., *et al.* (2023). Radioactivity research in mosses from typical Karst Regions in Leye Tiankeng, Southern China. *Journal of Environmental Radioactivity*, 261, article number 107145. doi: 10.1016/j.jenvrad.2023.107145.

[11] Hachinohe, M., Hamamatsu, S., & Kawamoto, S. (2021). A review of the radioactive cesium behavior in Japanese agricultural, livestock, fishery products and their foods in the decade following the Fukushima nuclear accident. *Food Science and Technology Research*, 27(1). doi: 10.3136/fstr.27.1.

[12] Kalda, G.S., Shevelya, V.V., Rybalka, K.A., & Żywiec, J. (2022). Analysis of radioactive contamination for the regions of Ukraine and Poland. *Ukrainian Journal of Civil Engineering and Architecture*, 6(012), 59-65. doi: 10.30838/j.bpsacea.2312.271222.59.911.

[13] Kotelevych, V., & Pinsky, O. (2022). The current state of food safety in terms of 137Cs content compared to 2010 in the context of food safety. *Bulletin of Poltava State Agrarian Academy*, 4, 246-258. doi: 10.31210/visnyk20222.04.29.

[14] Kotelevych, V., Pinsky, O., Honcharenko, V., & Budnik, T. (2024). Veterinary and sanitary assessment of food products and food raw materials according to quality and safety indicators in 2023 in the Zhytomyr Region. *Scientific Progress & Innovations*, 27(2), 66-72. doi: 10.31210/spi2024.27.02.11.

[15] Kovalskiy, V.P., Drukovanyy, M.F., & Oliynyk, Yu.G. (2021). Analysis of ways to increase radiation-protection of building materials. *Modern Technology, Materials and Design in Construction*, 30(1), 33-41. doi: 10.31649/2311-1429-2021-1-34-41.

[16] Kozubenko, Yu. (2022). Radiation pollution of the environment in the context of global social and environmental problems of the XXIst century. *Scientia et Societus*, 2, 118-125. doi: 10.31470/2786-6327/2022/2/118-125.

[17] Krasnov, V., Ivanyuk, I., Zhukovsky, O., Kurbet, T., & Orlov, O. (2022). Dynamics of 137Cs accumulation by cranberry on sphagnum bogs of Polissia of Ukraine. *Scientific Horizons*, 25(1), 68-75. doi: 10.48077/scihor.25(1).2022.68-75.
[18] Krushelnytska, K.O. (2022). Current issues of ensuring personal and public safety by police officer during the performance of duty in a zone of radioactive contamination. *Scientific Notes of Lviv University of Business and Law*, 33, 215-222. doi: 10.5281/zenodo.7545900.
[19] Law of Ukraine No. 15/98-BVR "On the Protection of a Person from the Influence of Ionizing Radiation". (1998, January). Retrieved from https://zakon.rada.gov.ua/laws/show/15/98-%D0%B2%D1%80.
[20] Law of Ukraine No. 2697-VIII "On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the Period up to 2030". (2019, February). Retrieved from https://zakon.rada.gov.ua/laws/show/2697-19#Text.
[21] Law of Ukraine No. 791a-XII-BVR "On the Legal Regime of the Territory that has Undergone Radioactive Contamination as a Result of the Chornobyl Disaster". (1991, February). Retrieved from https://zakon.rada.gov.ua/laws/show/791%D0%B0-12#Text.
[22] Nagornyi, Ye. (2024). Information technologies in the construction of the field of radiation pollution of the locality and forecasting. *Environmental Safety and Natural Resources*, 49(1), 155-160. doi: 10.32347/2411-4049.2024.1.155-160.
[23] Nikitina, O.V. (2021). Environmental evaluation of nuclide pollution rate of podzolized chernozem after long land use. *Agrobiology,* 1, 217-222. doi: 10.33245/2310-9270-2021-163-1-217-222.
[24] Oleshchenko, L.M., & Ilyin, M.O. (2023). Software analysis of radiation air pollution streaming data. *Visnyk of Kherson National Technical University*, 2(85), 187-195. doi: 10.35546/ kntu2078-4481.2023.2.26.
[25] Order of the Cabinet of Ministers of Ukraine No. 323-p "Strategy of Integrated Automated Radiation Monitoring System for the Period up to 2024". (2022, April). Retrieved from https://zakon.rada.gov.ua/laws/show/323-2022-%D1%80#Text.
[26] Orlov, O.O. (2021). Regularities of 137Cs migration on geochemical barriers of marginal zone of mezotrophic bog in Ukrainian Polissya. *Geochemistry of Technogenesis*, 6(34), 58-60. doi: 10.15407/10.15407/geotech2021.34.058.
[27] Resolution of the Cabinet of Ministers of Ukraine No. 391-98-p "On Approval of the Regulation on the State Environmental Monitoring System". (1998, March). Retrieved from https://zakon.rada.gov.ua/laws/show/391-98-%D0%BF#Text.
[28] Romanchuk, L., Lopatiuk, O., & Kovalova, S. (2019a). Evaluation of the content of 137Cs radionuclide in food products of residents of radioactively contaminated territories in the long-term period after the Chornobyl accident. *Scientific Horizons*, 22(8), 82-86. doi: 10.33249/2663-2144-2019-81-8-82-86.
[29] Romanchuk, L., Lopatiuk, O., Kovalchuk, Y., & Kovalova, S. (2019b). Evaluation of the content of 137Cs radionuclide in food products of forest origin of residents of radioactively contaminated territories in the long-term period after the Chornobyl accident. *Scientific Horizons*, 22(11), 108-112. doi: 10.33249/2663-2144-2019-84-11-108-112.
[30] Sitnikova, O., & Melnyk, A. (2022). Development of the algorithm to assess vulnerability of radiation sources. *Nuclear and Radiation Safety*, 1(93), 71-76. doi: 10.32918/nrs.2021.1(93).08.
[31] State Hygienic Standards "Permissible Levels of Cs 137 and Sr 90 Radionuclides in Food and Drinking Water". (2006, May). Retrieved from https://zakon.rada.gov.ua/laws/show/z0845-06#Text.
[32] State Hygienic Standards "Radiation Safety Standards of Ukraine (RSSU-97)". (1997, December). Retrieved from https://zakon.rada.gov.ua/rada/show/v0062282-97#Text.
[33] Tiutiunyk, V., Sobol, O., Kalugin, V., & Zakharchenko, J. (2020). Formation of the dynamic model for operative monitoring of the ecosystem's pollution level through emergencies at nuclear power plants. *Environmental Safety and Natural Resources*, 33(1), 95-114. doi: 10.32347/2411-4049.2020.1.95-114.
[34] Trohymchuk, I.M. (2024). Forest ecosystems and their radiation pollution. *Natural Sciences Education and Reasearch*, 4, 108-111. doi: 10.32782/nser/2024-4.17.

Радіоактивність за цезієм-137 та стронцієм-90 складових довкілля післячорнобильського періоду у 2024 році

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Анотація. Метою роботи було визначити питому активність складових довкілля та лісогосподарської продукції села Білокоровичі Коростенського району Житомирської області на вміст радіонуклідів ^{137}Cs та ^{90}Sr, що надійшли до них у результаті аварії на Чорнобильській атомній електростанції. Дослідження виконувалося згідно з темою науково-дослідної роботи «Моніторингові дослідження біосфери Українського Полісся» з вересня по листопад 2024 року з використанням дозиметричних та радіометричних методів. Встановлено, що потужність експозиційної дози гамма-випромінювання відповідає нормам радіаційної безпеки України для населених пунктів: 18,3 ± 1,6 18,3 ± 1,6 мкР/год зафіксовано в лісовому масиві, 12,7 ± 0,7 мкР/год на землі сільськогосподарського призначення, 14,7 ± 3,4 мкР/год у житловій частині села. Стебло, листя та сухі плоди чорниці перевищують вимоги ДР-2006 за вмістом ^{137}Cs у 1,7 разів та на 300 Бк/кг відповідно, тоді як за активністю ^{90}Sr знаходиться в межах норми. Питома активність чаги, плодів калини та шипшини відповідає вимогам ДР-2006 і становить за вмістом ^{137}Cs 48,5 ± 3,6 Бк/кг, 13,7 ± 1,2 Бк/кг, 27,9 ± 1,7 Бк/кг, та за активністю ^{90}Sr 89,9 ± 6,7 Бк/кг, 0,1 ± 0,01 Бк/кг, 0,1 ± 0,02 Бк/кг відповідно. Зразки опеньок придатні до споживання, оскільки питома активність за ^{137}Cs втричі нижча за норматив, а за ^{90}Sr – учетверо. Питома активність білих грибів за ^{137}Cs в 2,1 рази перевищує норму, а накопичення ^{90}Sr відбулося в 15,7 разів менше за норму. Питома активність моху за ^{137}Cs майже в 5 разів менша за питому активність ґрунту, яка становила 893,9 ± 91,3 Бк/кг за ^{137}Cs. Вода з артезіанських свердловин села за радіаційними показниками придатна до споживання. Жолуді помірно накопичують ^{137}Cs і ^{90}Sr (372,1 ± 17,2 Бк/кг та 143,9 ± 10,4 Бк/кг відповідно). Отже, дослідженнями встановлено, що непридатними до споживання є сухі плоди чорниці та сушені білі гриби

Ключові слова: питома активність; допустимі рівні вмісту радіонуклідів; аварія на атомній електростанції; потужність експозиційної дози гамма-випромінювання; радіаційна безпека; компоненти навколишнього середовища