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Radiocesium concentrations in mushrooms collected in the republic of North Macedonia

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Abstract. The bioenvironmental monitoring has shown that mushrooms have the ability to accumulate radionuclides and for this reason we can use them to assess and monitor the pollution of the ecosystem. The purpose of this study was to determine the level of radiocesium in wild mushrooms in the Republic of Macedonia, despite the fact that a long time has passed since the Chernobyl nuclear accident. For this purpose, several types of wild mushrooms from different locations in the Republic of Macedonia were analyzed. The samples were analyzedin terms of the radiocesium content by means of a standard spectroscopic system, with a high-resolution HPGe detector. Data acquisition and analysis were performed with 8192 channel digital analyzer; the duration of the acquisition interval for each sample was 108000s. The gamma line at 661.6 keV was used in order to determine the ^{137}Cs activity. The measured values of ^{137}Cs range from a minimum value of <1 Bq/kg to a maximum limit up to 3.60 Bq/kg. The highest specific activity of ^{137}Cs was detected in the morel and the lowest in the meadow mushroom.A difference was found between specific locations, due to the unequal rains throughout the year. There was also a difference between specific types of mushrooms from identical locations, which is the result of the different soil characteristics and the depths of the mycelium. Considering that the analyses show that the level of radiocesium is below 600 Bq/kg, a level which is allowed in mushrooms, the measured values are very low and there are no dangerous effects on the health of the population. These studies show that due to the long half-life of ^{137}Cs, continuous monitoring should be performed since mushrooms are often used in the human diet.

Keywords:bioindicators; mushrooms; radioactivity; Cs^{137} ; gamma spectrometry.

Introduction. The Chernobyl (CNPP) nuclear power plant accident happened in April 1986. This accident released huge amounts of radionuclides into the environment, including radioiodine and radiocesium, thereby polluting territories in the whole world (1). As a result of its long half-life of 30 years, its presence in the environment is monitored. Cesium is an element which behaves same as potassium and it is one of the most important elements for mushrooms (2,3,4).The bioecological monitoring has shown that mushrooms have the ability to accumulate radionuclides and for this reason we can use them as bioindicators to monitor the geographical and seasonal distribution of radioactive contamination.In addition, contaminated edible mushrooms may pose a certain radiological risk if they are consumed too intensively (5). In this study, we assessed the current concentration of radiocesium in wild mushrooms collected in the Republic of Macedonia, despite the fact that it has been a long time since the Chernobyl nuclear accident.Among the other examined edible mushrooms, special attention is paid to Boletus edulis and Cantharelluscibarius because these mushrooms are not only widespread and widely used in the human diet, but also have a high price.It is necessary to conduct comprehensive radiological protection and assessments of radiocesium concentrations in wild mushrooms in the long run.

Material and Methods. Six samples were collected, 0.5 kg for each different species of wild mushrooms (Boletus edulis, Cantharelluscibarius, Morchelaconica, Lactariusdeliciosus), in six sampling locations in the Republic of North Macedonia: All samples were homogenized, after removing the inedible parts, they were packed in plastic Marinelli beakers with a capacity of 0.5 L for gamma spectrometry analysis. The samples were measured on an instrument-gamma spectrometer (Canbera Packard) with a high purity germanium detector. The GENIE 2000 software was used for data acquisition and analysis (6).In particular, an appropriate library containing key information (energy, half-life, etc.) about the radionuclides present in the investigated samples was employed to identify them in the spectrum and then to perform correction and activity calculations.The activities of ^{137}Cs were determined by means of an estimation of the γ-line at 661.66 (keV).

Results and Discussion.

The concentration of radiocesium in each mushroom species is shown in Table 1.

Table 1. ^{137}Cs activity concentrations of mushroom samples

Samples	Specific activity ^{137}Cs (Bq/kg – 1)
S1	0.4 ± 0.1
S2	<0.5
S3	1.60± 0.1
S4	0.72 ± 0.1
S5	1.50 ± 0.1
S6	1.23 ± 0.3
D1	<0.1

D2	<0.1
D3	2.06 ± 0.1
D4	1.13 ± 0.1
D5	1.45± 0.3
D6	1.10 ± 0.3
L1	3.10 ± 0.1
L2	2.17 ± 0.2
L3	3.60 ± 0.1
L4	1.58 ± 0.1
L5	0.8 ± 0.2
L6	1.52 ± 0.1
H1	1.68 ± 0.5
H2	<1
H3	0.58 ± 0.5
H4	1.68 ± 0.8
H5	1.22 ± 0.5
H6	1.41 ± 0.3

S1-S6 (Boletus edulis): D1-D6 (Cantharelluscibarius): L1-L6 (Morchelaconica): H1-H6 (Lactariusdeliciosus)
The measured values of 137C range from a minimum value of <1 Bq/kg to a maximum limit of 3.60 Bq/kg. The highest specific activity of 137C was detected in MorchelaConica and the lowest specific activity was detected in the CantharellusCibariusspecies. A difference was found between certain locations, due to the uneven rainfall distribution throughout the year. There was also a difference between specific mushroom species from identical locations, which is a result of different soil characteristics and mycelial depths. Considering that the analyses show that the radiocesiumlevel is below 600 Bq/kg, a level which is allowed in mushrooms, the measured values are very low and have no dangerous effects on the population's health. These studies show that due to the long half-life of 137C, continuous monitoring should be performed because mushrooms are frequently used in human diet. The data reported in this article provide useful information regarding the environmental risk of the studied area and can be further used for radiological mapping.

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