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OF THE
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BIOACCUMULATION OF ^{40}K AND ^{137}Cs IN MUSHROOMS COLLECTED IN DIFFERENT LOCATIONS IN MACEDONIA

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INTRODUCTION

Radionuclides, regardless if they are natural or produced, with the process of migration enter the soil and water and through these, in the products of plant and animal origin and contribute for the total radiation strain in people.

The content of radionuclides in the bio-indicator connections provides an insight in the extent of radioactive contamination of the given ecosystem. For these needs, most commonly used plant types are moss, fungi and lichens [1,2].

After the Chernobyl accident in 1986, there was a significant increase of the concentration of ^{137}Cs and ^{90}Sr in many European countries, thus a need arose for research of these plants and their functioning as biological indicators of the radioactive pollution [3].

Mushrooms are particularly interesting type for examination because they absorb mineral substances, thus they cannot avoid contamination. Due to the specific construction, they represent a trap for the contaminants [4]. The contamination of mushrooms depends on many factors: elevation, physical-chemical composition of the soil, weather conditions, quantity of rains, etc. [5]. In areas rich with rains, the main part of the radioactive substances, which from the atmosphere fall on the surface of the soil sphere, it takes place by wet falling (washing), this means that the level of radioactive contamination, primarily, determines the quantity and frequency of rains [6-7].

The mushrooms were represented as a quite important asset for the circulation of substances, as well as the radioactive caesium in the upper layers of forest soils [8-10]. Further on, it was proven that mushrooms as one of the most important components in the ecosystem of the forest soil, are quite involved in the immobilization and translocation of ^{137}Cs [11-13].

Hence, ^{137}Cs can be accumulated and redistributed also in and through the mushrooms, whereupon it will become temporary unavailable for the remaining plants in the ecosystem. Some studies indicate that more than 40 % of the ^{137}Cs intake is retained in the mushroom roots [8]. Many studies have shown that the mycelium of mushrooms can effectively, at least temporarily, importantly keep the levels of radiocaesium [8].

Hence, the mycelium represents in a way, a type of suction of radiocaesium [14]. The concentration of ^{40}K in mushrooms varies within a small span while the concentration of ^{137}Cs has broad range of variation. Hence, it is considered that the mechanism of intake of ^{137}Cs is different the one of ^{40}K [14-15].

MATERIALS AND METHODS

The mushrooms were collected as random samples from the source companies in the period from autumn 2011 to spring 2012 from different regions in Macedonia (Demir Hisar, Kicevo, Kocani, Bitola, Radovis, Strumica, Gostivar, Krusevo, Kavadarci, Veles), and 1 kg at each place.

The samples were not washed, only the surface of the mushroom was mechanically cleaned. Radioactivity measurement was performed with no previous preparation of the samples. The fresh samples were measured in 0.5 liter dishes for measuring gamma activity. Measuring of radioactivity was performed with clean semi conductive gamma spectrometer (Canberra Packard) which provides identification of radionuclides and assessment of their activity. The efficiency of the detector was 30 % measured at ^{60}Co .

After termination of the measurement, the software of the instrument provided a written report with previously calculated values of activities of radionuclides that we check in the program EXCEL. The results are presented in Bq/kg fresh mushrooms.

RESULTS AND DISCUSSION

Systematic monitoring of the level of radioactivity in samples of mushrooms has been performed at the Faculty of Veterinary Medicine in Skopje within the Food Institute.

Table 1 presents results of measurement of the specific activities of ^{40}K and ^{137}Cs in samples of mushrooms for the period 2011 – 2012. From the table, one can conclude that the highest values of caesium had *Hyundum repandum*, *Morchela conika* and *Cantharellus cibarius*, and the lowest values had *Marasmius oreads* and *Amanita caesarea*.

Table 1. Results regarding specific activity of ^{40}K and ^{137}Cs in mushrooms

Type of mushroom	Sample	^{40}K average Bq/kg	^{137}Cs average Bq/kg
<i>Boletus edulis</i>	54	120.0	4.8
<i>Amanita caesarea</i>	16	130.0	1.5
<i>Cantharellus cibarius</i>	34	150.0	12.4
<i>Lactarius deliciosus</i>	11	85.0	6.3
<i>Marasmius oreads</i>	5	110.4	0.4
<i>Morchela conika</i>	4	135.1	5.9
<i>Hyundum repandum</i>	7	153.4	108.6

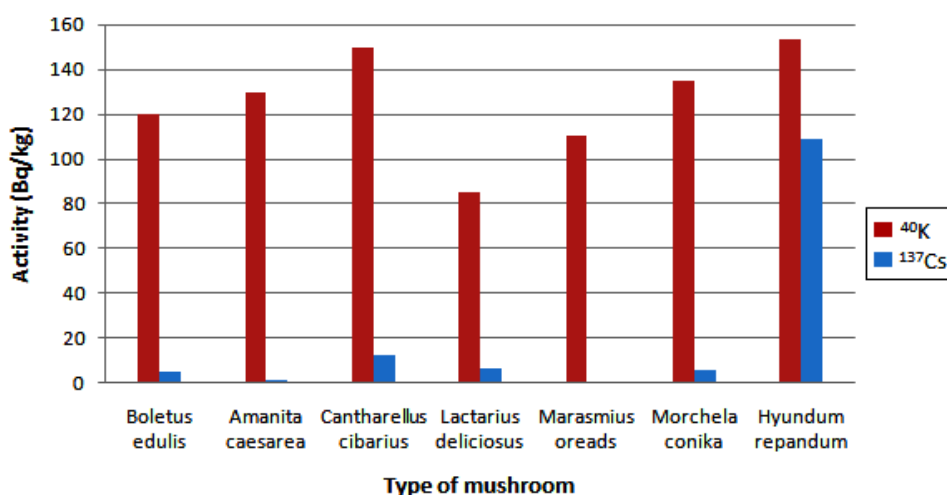


Figure 1. Results about specific activities of ^{40}K and ^{137}Cs in mushrooms

From the obtained results of the gamma spectrometry analysis, one can conclude the following:

Radionuclides come in the fruiting body of mushrooms mostly from the substrate through the expanded network of the hyphae, which is why the accumulation is conditioned on the chemical constitution and the physical characteristics of the substrate. The distribution of ^{40}K and ^{137}Cs in the observed types of mushrooms is not equal, but it varies depending on the mushroom (Figure 1). For example: *Mocharela conika* where the average activity of ^{137}Cs is 5.90 Bq/kg in fresh mass. *Mocharela conika* and

Hyundum repandum in comparison to *Marasmius oreads* where the average activity of ^{137}Cs is 0.40 Bq/kg in fresh mass. *Mocharela conika* and *Hyundum repandum* have the highest value of ^{137}Cs which is in accordance with the literature data about mushrooms that decompose the wood. *Mocharela conika* grows at higher elevation, most frequently in evergreen forests where it supply could radionuclides from the fallen needles from the evergreen woods and from the tree bark. *Marasmius oreads* is a saprobe type of mushroom that grows in meadows. It has small dimension of mycelium which is why it has small absorption power [16].

Mushroom collected from evergreen forests have higher levels of radioactivity that the one in the deciduous forest, which is a case with the types *Cantharellus cibarius* and *Mocharela conika* that are collected in this type of forests [16].

However, these levels of ^{137}Cs in mushrooms are within the normal limits so if a human consumes them in extreme quantities, that contamination have very small part in the permitted annual dose of 1 mSv. On the basis of the obtained results, from the analyses of the mushrooms we can say that they are normal and appropriate according to the Ordinances for maximally permitted limits of radioactive contamination (Off. J. 29).

These preliminary examinations indicate that further examination needs to be conducted due to the long half-life of ^{137}Cs which will be reallocated, washed and redistributed, however, for a long time present in the ecosystem.

The discrimination of caesium and potassium in mushrooms is not yet entirely clarified and requires further examinations and studies that would include a large number of mushroom species.

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BIOACCUMULATION OF ^{40}K AND ^{137}Cs IN MUSHROOMS COLLECTED IN DIFFERENT LOCATIONS IN MACEDONIA

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Wild mushrooms have become popular delicacy in many countries including Macedonia. Some of these mushrooms are especially interesting for analysis because they absorb mineral materials, and with this they can avoid contamination. Because they have specific content they are trap for contaminations.

There is a shortage of investigations in Macedonia referring to radioactive contamination of mushrooms. For that reason the aim of this investigation was to determine the degree of radioactive contamination of certain varieties of mushrooms.

During the investigation, 131 samples of mushrooms were taken from different locations in Macedonia.

Radioactive measurement was done without previous preparation of samples. The fresh samples are measured in 0.5 l containers for analysis. The radioactive measurement is done with clean semi-conducting gamma spectrometer (CANBERRA PACKARD) which provides identification of radionuclides and estimation of their activity. The efficiency of the detector is 30 % measured of ^{60}Co .

On the basic of results we can see that activity of radionuclides in the tested mushrooms is not equal, but varies depending on the type of the mushrooms.

From the analysis, we see that the results are normal and are in range of Regulations for maximum allowed limits for radioactive contamination.

The level of specific activities of radionuclide concentrations for the given types of mushrooms are level of regional values.