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ESTIMATION OF TIME OF SEMI-DECAYOF ^{137}Cs IN MUSHROOMS

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ABSTRACT
The mushrooms are particularly interesting type for examination because they absorb minerals, and with that they can not avoid contamination. Because of their specific content they are a trap for the contaminators. The purpose of this work is to determine the time of semi-decay of ^{137}Cs, that is, to conceive if there is difference between the measured and the calculated time of semi-decay of this radionuclide. Different species of mushrooms are takes as samples for analysis due to their great accumulation of this radionuclide. There were 5 types of mushrooms examined, and for each type 12 samples were analyzed.
After the performed analyses, the difference between the calculated and the measured activity of ^{137}Cs at all examined types of mushrooms is determined.
Key words: radioactivity, radionuclides, mushrooms, gamma spectrometry

INTRODUCTION

The radio nuclides, natural or artificial, with the process of migration come into the soil or the water, and through them in the products of animal or herbal origin and contribute foe overall radiation with humans. [2-3]

In order to protect the ecosystem i.e. the population of the environment of one area, it is necessary to make estimation of individualnoto nivo na kontaminacija. But, because the diversity of the organism is enormous even in small areas, this estimation is difficult and sometimes impossible.

The answer of the increase of contamination of the plants in the environment is modified with other factors of the environment and with the physiological status of the plants.

The adventage of the biomonitoring over the classical method of analysis is that it takes into consideration the integral effect of all tha factors and the contamination.

The content of the radionuclides in bioindicator types provides an insight into the level of radioactive contamination of the given ecosystem. For these needs, among the vegetation types the fungus and the lichens. [4]

After the Chernobile accident in 1986 the concentracion of ^{137}Cs and ^{90}Sr significantly was increased in a lot of European countries, and the need to research of these plants how they function as biologic indicators of radioactive pollution. [5]]

The contamination of the mushrooms depends on more factors: altitude above sea level, physical and chemical composition of the soil, meterorological conditions, the amount of rains etc.

The era of application of nuclear weapons began in 1945 (Hiroshima, Nagasaki), and the first trial of this weapon was performed by USA. The radionuclides, released in the environment with the process of translocation and elimination, come on the ground and the water, and through them, in the victuals with plant and animal origin. An accident which marks the 20th century is the one in the nuclear plant Lenin in Chernobyl when $12 \approx 10^{18}$ Bq radioactive material is thrown out in the environment, of which ^{137}Cs is most important [5-6] . As a fireproof radionuclide, it is especially important for the biological systems [6]. The fission yield of ^{137}Cs is 6,2% and has long time of semi-decay (30,7 years) so together with ^{90}Sr, these two are the most represented fission products in the nature.

Of ^{137}Cs which is found in the atmospheric rains, 75-99% gets in contact with the ground, and 1-25% is retained at the vegetation. The destiny of cesium which comes to the ground depends on the characteristics of the ground [7].

The accumulation of cesium on the ground depends on many factors (the type of soil), and numerous explorations have proved that it is mostly retained at the layer 5cm from the surface of the ground, since its speed of its penetration through the soil is 1-3 cm g^{-1}. Still, the speed depends on the type of soil and the quantity of athospheric rains [7].

Radioactive contamination from this radionuclide can happen at humans by:

1. Inhalation
2. Ingestion

The biological time of semi-elimination at humans is 10-110 days. This depens on the age limit, the size of the musle mass etc.

What is very important is that the specificity of ^{137}Cs is such that in the human organism is acts the same way as potassium and rubidium, which means that it is found in every cell of the organism i.e. it is distributed evenly in all organs [5].

However, the probability for break-down of this radioactive atom, in time interval D*t,* does not depend on the conditions in which the atom existed and on the condition it is found, but it depends only on the length of that time interval [8].

The number of radioactive atoms is decreasing over time exponentially (Fig.1):

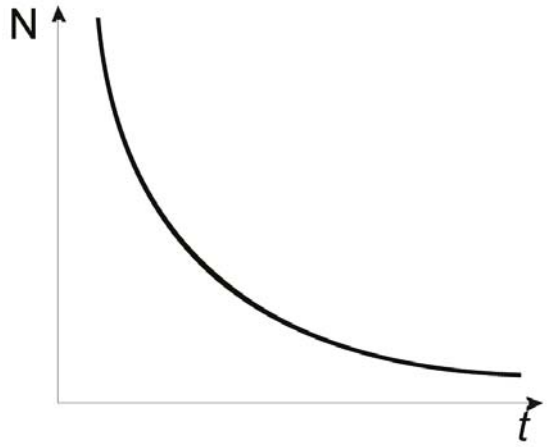


Figure 1. *The exponential law of radiactive decay*

If in a certain moment there are *N*-atoms of some radioactive element, and if from that number *dN* atoms are decayed in short time interval *dt*, the speed of the decay is: *-dN/dt.* Since the speed of decay is proportional to the total number of radiactive atoms *N*, what follows is that:

$$-\frac{dN}{dt} = \lambda N \qquad (1)$$

By integrating the equation (1) in interval of $t = 0$, when N_0 atoms were present, and the time *t*, for which the number of undecayed atoms has decreased from N_0 to *N*, the basic law for radioactive decay is formed*:*

$$\ln\left(\frac{N}{N_0}\right) = -\lambda t \quad (2)$$

$$N = N_0 e^{-\lambda t} \qquad (3)$$

Time of semi-decay ($t_{1/2}$) is the time for which half of the initially present radioactive atoms will decay, i.e. the time for which the activity of the radionuclide will be decreased for half of the initial value.

By replacing in (2) of $t = t_{1/2}$ and $N = N_0/2$:

$$N_0/2 = N_0 e^{-\lambda t_{1/2}} \qquad (4)$$

$$\log 2 = \lambda t_{1/2} \log e \qquad (5)$$

$$t_{1/2} = 0{,}693/\lambda \qquad (6)$$

The numerous values for the time of semi-decay are within millionth parts of second, up to billion years [6].

MATERIAL AND METHOD

The samples of mushrooms are taken from different localities in the Republic of Macedonia (Kicevo, Kocani, Veles, Bitola, Radovis). The activity of the mushrooms in 2011 is determined by semi-conductive 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.

Data for the activities of the same types of mushrooms are taken, together with analyses made in 2006 for the level of the radionuclide ^{137}Cs. In this paper the activity of the articfical CEZIUM is determined by gammaspectrometry.

As a standard for calibration of the efficency the calibration standard (mixture

241-Am, 203-Hg, 137-Cs, 60-Co, 113-Sn, 85-Sr, 109-Cd, 139-Ce, 57-Co, 88-Y) is used.

The testing was in accordance with the method IAEA Technical Report 295. The time for measurement of each speciment is 10800s, and the relative error is smaller than 10%.

After termination of the measurement, the software of the instrument gives a written report with already calculated values for activity of ^{137}Cs, which values will be compared to the ones from 2006.

The results are expressed in Bq/kg fresh mass.

RESULTS AND DISCUSSION

From the results one can conclude that the activities of ^{137}Cs in 2006 have bigger value than those activities of ^{137}Cs in the period of 2009, which is expected considering the fact that the activity of every isotope decreases over time (the law of radioactive decay presented in the equation) [8].

$$A = A_o e^{-\lambda t}$$

Using the measured activities in the period from 2006, as initial we will calculate, according to the above presented law of radioactive decay, the activities which the cesium ^{137}Cs should have (for its specific time of semi-decay) for the period from 2011

The days from 01.01.2006 and 01.01.2011 are used for calculations as average times for the above presented periods, thus for **t** are taken 1825 days, that is, exactly 5 years.

Table 1. *Measured and calculated results for the activities of ^{137}Cs for different types of mushrooms.*

Types of mushrooms	Measured average activity of ^{137}Cs in Bq/kg for period 2005 – 2006	Measured average activity of ^{137}Cs in Bq/kg for period 2010 – 2011 год	Calculated average activity of ^{137}Cs in Bq/kg for period 2010 – 2011 год
Boletus edulis	5,06	2,54	4,74
Amanita caesarea	1,73	1,61	1,61
Cantharellus cibarius	12,00	4,84	11,2
Lactarius deliciosus	6,23	1,06	5,18
Morchella conika	5,88	5,25	5,49

If we compare the measured values of the activities of ^{137}Cs separately for each type of mushrooms in the period from 2011 and the calculated values of the activities for ^{137}Cs for the same mushrooms respectively, we will notice that the activities measured for the period from 2011 have quite smaller values that the calculated.

If a reason for decreasing the activities of ^{137}Cs for the three years would only be the time for semi-decay of ^{137}Cs, then the calculated and the measured activities should match at least approximately.

But according to table 1 it is visible that the measured activities ^{137}Cs for all types of mushrooms, except of the Amanita caesarea, are quite lower than the expected calculations.

The reason for the different activities of ^{137}Cs from the expected ones is due to many factors:

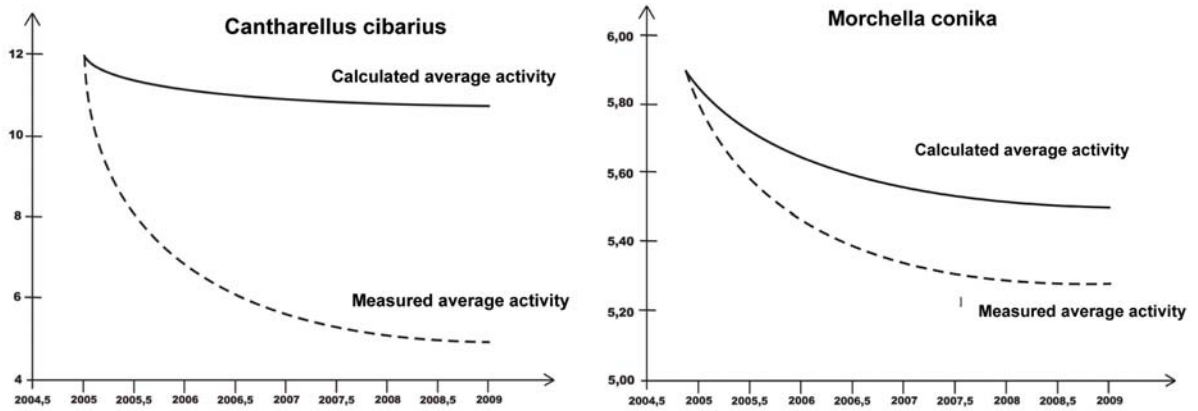
♦ Mechanical removal of ^{137}Cs, by rinsing the soil from rains;

♦ Different penetrative power of water in the soil wherewith the intensity of rinsing of ^{137}Cs is different;

♦ If at those places there was yield of mushrooms during these three years, with their picking, part of the quantity of ^{137}Cs is carried away.

The matching of the measured and the calculated activity at ^{137}Cs for the Amanita caesarea can be explained with the small penetration of the soil and the small quantities of rains. [8-9]

Graphic 1. *Comparisons between calculated and measured activity at different types of mushrooms for the time period 2006 and 2011*



From the tables, one can vividly see that there is a significant difference between the calculated and the measured values of ^{137}Cs, in both time periods.

CONCLUSION

The analyses made within this research point to the fact that the distribution of Cs ^{137} in the odserved types of mushrooms is not equal but it varies depending on the type of the mushrooms.Also,if we compare of Cs ^{137} in the same types id 2006 and 2011 we notice that ther is a decrease of the activity in the recent years which is to be expected. Also, that the real time of the activity of ^{137}Cs is shorter in relation to the physical time. These presented results at the mushrooms are a foundation for further analyses and measurements for the activity of ^{137}Cs, as well as other radionuclides in order to see whether there is a difference between the real and the physical time of activity in other samples being used in the nutrition.

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ПРОЦЕНКА НА ВРЕМЕ НА ПОЛУ-РАСПАД НА ^{137}Cs ВО ПЕЧУРКИ

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АПСТРАКТ

Печурките се посебно интересен тип за испитување поради нивната способноста да апсорбираат минерали и со ова тие не можат да ја избегнат контаминацијата. Поради нвниот состав тие се замка за контаминентите. Целта на овој труд е да се одреди времето на полу-распад на ^{137}Cs т.е. да се процени разликата помеѓу измерените и проценетото време на полу-распад на овој радионуклид. Како примероци за испитување се земени различни видови на печурки поради нивната способност за акумулација на овој радионуклид. Испитани се 5 типа на печурки и по 12 примероци од секој тип.

По завршените анализи разликата помеѓу пресметаните и измерените активности на ^{137}Cs кај сите типови на примероци е утврдена.

Клучни зборови: радиоактивност, радионуклиди, печурки, гама спектрометрија