Investigation of the effect of specific activity of $^{137}\text{Cs}$ in the production of cheese from mountain Golija

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Abstract

The components of the field of gamma radiation are variables in function of time and location, and it is necessary to disclose them and permanent monitoring at specific locations.

The importance of this work is that we had found the load of ionizing radiation on the mountain Golija, which is expressed with intensity of gamma radiation dose exposure (SI units of pC / kg.s). In addition, ionizing radiation implied emission of $^{137}\text{Cs}$ and obtained values were measured in the environment, i.e. air at the appropriate locations. The results represent the average of the total of one hundred measurements for each location.

Within a certain number of households is also made detection of biologically significant radionuclide $^{137}\text{Cs}$ in the food chain, including water, soil, hay and silage, as well as transfer to milk and cheese. The $^{137}\text{Cs}$ activity concentration was expressed in Bq/kg.

Due to the strong specificity of obtained results statistical analysis was done by calculating average values within the variation within each group ($\bar{X}_v$).

Key words: radioactivity, $^{137}\text{Cs}$, food chain, milk, cheese from mountain Golija

Introduction

The radiation load of the living world in a certain part of the territory, which is caused by the effects of all forms of ionizing radiation in the environment, can be estimated using radiation phon of biosphere [1]. It is therefore necessary to monitor and measure radio ecological parameters of biosphere [2], for determination of so called Zero state at a defined location on one or more measurement points.

In the last four decades occurred several nuclear disasters of which the breakdown of peaceful nuclear plant in Chernobyl, 1986, represented a real radioactive disaster. On that occasion almost all European countries were affected, more or less with the radioactive contamination of the environment [3].

The occurrence of fallout, as well as various types of atmospheric residue especially endangered grazing animals - milking cows (cows, sheep, goats) or animals in whose nutrition is necessary green mass. It is well known that the biologically significant radio nuclides ($^{89,90}\text{Sr}$, $^{134,137}\text{Cs}$, $^{131}\text{I}$, $^{103,106}\text{Ru}$, etc.) after ingestion were very quickly eluted from the body of animals [4]. For example, $^{131}\text{I}$ occurs in milk in 3 to 6 hours after ingestion and...
similar situation is with the other radionuclide from a mixture of fission products [5]. In this way, in milk and dairy products occur the residues of radioactive substances.

Radioactive isotope $^{137}\text{Cs}$ was reached into environment by precipitation, after the nuclear tests in the 60’s and after the nuclear disaster at Chernobyl 1986. Chemical similarity to potassium explains its high mobility in biological systems. Because of its long half-life ($^{137}\text{Cs}, T_{1/2}$ of 30 years) it must be monitored in all samples of the environment [6]. Thus, transfer of Chernobyl cesium in the milk of cows in the various Nordic countries was compared. Data were collected from agricultural and individual farms. 1986. and 1987. greatest amounts of $^{137}\text{Cs}$ were found in Finland and Norway, the average value in Sweden, the Faroe Islands and Iceland, and the lowest values detected in Denmark. It is believed that the Faroe Islands, Iceland and Norway were the most affected by the new disaster [7].

Resorption of radioactive cesium, from the digestive tract of animals, is significantly reduced in animals that eat dry bulky feed. Also, the grazing nutrition causes a higher radioactive contamination with radioactive cesium of dairy cows compared with the stable nutrition, this is highly expressed in ruminants, particularly in sheep, because they are taking parts that are close to the ground, resulting in entry of smaller amounts of land into body. Cows which are grazing in highland area are much more contaminated with radioactive cesium, compared with cattle that grazed in the plains: in the lowland area by 7 times, and highland area for 30 times. Here, we should not lose out of sight the fact that is of the crucial importance for the level of activity of radionuclide $^{137}\text{Cs}$: the amount of precipitation in the highland area is 1.1 to 1.5 times higher than in lowland areas.

Distribution of radioactive cesium after a one-time entry into the body of cattle, sheep and pigs is similar in all species approximate to distribution of potassium. However, the biological elimination is highly different in the individual animal species and is significantly greater in ruminants than in non ruminants. Biological elimination of the radionuclide $^{137}\text{Cs}$ is done with excretions (feces, urine) and secretions (milk) and during the first 7 days is 30 % in feces and urine and 10 % in milk. Although the elimination of the radionuclide $^{137}\text{Cs}$ over milk is less studied than the elimination of radioactive strontium, it was known that the 10 times more cesium is excreted through the milk than strontium, which appears to be higher, depending on the absorption of cesium from the digestive tract.

In daily ingestion of radionuclide $^{137}\text{Cs}$, during the long period, daily extracted milk of dairy cows are containing about 10 % of the daily entered activities of this radionuclide, which is an average of 1.4 % per liter of milk. In the daily ingestion of dairy cows with fresh forages (clover) which had been radioactively contaminated with radioactive cesium - $^{134}\text{Cs}$ and $^{137}\text{Cs}$ - at the time of acute radiation situations related to the Chernobyl in 1986, the examination has shown that the level of activity of this radionuclide in the milk increases during the first 5-7 days, after which it declined slightly and remained at the saturation level. Almost identical results were obtained during the winter feeding of dairy cows with silage contaminated by radioactive nuclides of cesium - $^{134}\text{Cs}$ and $^{137}\text{Cs}$ [8, 9, 10].

Control of fallout on a global scale, studies on the training grounds for the testing of nuclear weapons and laboratory studies have suggested, and it is absolutely accepted, the radioactive iodine ($^{131}\text{I}$), radioactive strontium ($^{85}\text{Sr}$ and $^{90}\text{Sr}$) and radioactive cesium ($^{137}\text{Cs}$) released the highest doses. Over the last decade, there has been significant progress in developing countermeasures for prevention or reduction of contamination of animal products from radioisotopes of iodine, cesium and strontium [11].
Materials and methods

In the standardization of production process for traditional production of cheese from Golija mountain, the impact of radioactivity in production represents an important part of research. Examinations were planned to include all parameters that contribute to obtaining the final product- cheese from this mountain. It is presumed that the examinations are carried out in the Golija mountain, in the selected area and selected households in spring 2009.

Measuring of gamma radiation exposure dose in the air

Visiting the mountain Golija, it was determined that the examinations will be perform in the village Katići and at four location for measuring the intensity of gamma radiation dose exposure in the air. For measuring we used the alarm monitor of radiation MZ-100, and the obtained results, i.e. the values of exposure doses are expressed in pC/kg.s.

The alarm monitor recorded hundreds of different results at every selected location, which were presented in the form of average values. We got the mean value ($X_{sr}$) of intensity of gamma radiation exposure dose in the air by comparing these values with all four locations.

Elevation of selected location is about 1,000 feet, and the names we have undertaken locally are known as (Figure 1, 2, 3, 4):


Figure 1: Kurčubić elevation  
Figure 2: Bogdanović well  
Figure 3: - Stanišić hill  
Figure 4: Obradović boarding house
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$^{137}$Cs activity concentration in food chain

<table>
<thead>
<tr>
<th>o.</th>
<th>Sites</th>
<th>The average values of intensity of gamma exposure dose rate in the air (pC/kg.s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Kurčubić elevation</td>
<td>1,65</td>
</tr>
<tr>
<td>2.</td>
<td>Bogdanović well</td>
<td>1,62</td>
</tr>
<tr>
<td>3.</td>
<td>Stanišić hill</td>
<td>1,59</td>
</tr>
<tr>
<td>4.</td>
<td>Obradović boarding house</td>
<td>1,68</td>
</tr>
</tbody>
</table>

In the village of Katići experiments have been set up to examine the $^{137}$Cs activity concentration (Bq/kg) in the food chain of dairy cows and its transfer through the milk in the finished product – cheese from Golija mountain.

The study involved six selected households, where the samples were collected from the food chain: water, soil, hay, silage, milk, cheese. Households covered by examining are known to the authors and in the paper are marked with numbers: 1, 2, 3, 4, 5, 6.

Water samples, which are used to supply the dairy cows were taken in plastic bottles in quantities of 1 liter. Soil samples from which are prepare hay and silage for feeding dairy cows and feeding animals are taken from three layers of different depths (0-5 cm, 5-10 cm and 10-15 cm) and a metal blade in plastic bags in quantities of 1 kg. Also samples of hay and silage, used for feeding milking animals, were taken from storage-place in plastic bags in quantities of 1 kg.

Milk samples were collected as a bulk sample of milk obtained from dairy cows over a particular host, the same goes for cheese samples. In addition, milk samples collected in special plastic bottles volume of 1 liter, and samples of cheese in plastic bags in quantities of 1 kg. The above samples transferred to the hand fridge in the lab for testing.

Gamma spectrometry analysis and measuring the $^{137}$Cs activity concentration in the food chain was performed on the detector of high purity germanium (HP Ge) with a multichannel analyzer ("ORTEC"). Examinations were performed in laboratory conditions.

### Results and discussion

Intensity of gamma radiation exposure dose in the air were measured at four different locations is shown only as an average value of one hundred consecutive measurements (device MZ-100). These values ranged from 1.59 to 1.68 pC/kg.s or mean value for all locations was 1.64 pC/kg.s (Table 1).

Table 1. The average values of intensity of gamma exposure dose rate in the air

$X_{av}=1.64$ (1.59-1.68)

The obtained results are in accordance with findings of [12] amounts 1.63 to 1.81 pC/kg.s and they are obtained as a result of the constant monitoring of radiation background on a permanent location in Belgrade.

Similar results are obtained in radioactivity monitoring of the environment [13] in Serbia. Radiation-hygienic supervision over the HACCP system in the region of Golija guarantees the radiation safety, by the resource status of the radio ecological aspects in the production of healthy food. Our results are required to contribute to the further optimization of the monitoring system to produced natural radioactivity, which is of special significance for other forms of agricultural production (crop to livestock) [14].
137Cs activity concentration in water samples which is using for supply livestock shows detection of all six samples and values ranged from 0.02 to 0.12 Bq/kg or Xsr = 0.05 Bq/kg (Table 2). In paper [15] 137Cs activity concentration in all samples in the river and drinking waters in the territory of Serbia was on the limit of detection, which is in accordance with our results. Similar results were shown [16] for a total of 22 analyzed samples of drinking water. In some samples of tap water, especially those during the summer months, detected traces of 137Cs, but the measured values are about 1,000 times less than the legislation limits.

Furthermore, observing gamma spectrophotometric analysis and the value of 137Cs activity concentration (Bq/kg) (Table 2), shows that in samples taken from all three depths of the ground (0-5 cm, 5-10 cm to 10-15 cm), in all six households were detected 137Cs.

Thereby, in the shallowest layer of soil (0 to 5 cm) interval of variations of 137Cs activity concentration ranged from 34.62 to 157.55 Bq/kg i.e. an average of 101.25 Bq/kg. These values for medium deep layer of soil (5 to 10 cm) ranged from 13.57 to 185.40 Bq/kg i.e. the mean value were lower than in the shallow layer amounted to 92.44 Bq/kg. The mean value of 137Cs to the deepest layer (10-15 cm) was 84.18 (18.10 to 144.48 Bq/kg). It can be seen that the obtained mean values decrease with increasing depth layer of soil from which the sample was taken.

In the study area for monitoring the environment in Serbia they got the approximate data [17].

Rinsing process and the relocation of 137Cs can lead to very unequal distribution of radionuclide’s in one area so that on the basis of the results of numerous studies suggests that migration of radionuclide’s in soil depends on many environmental factors, especially soil properties such as physical and chemical properties (content of organic matter, adsorption complex characteristics, pH, mineral compositions, etc.), the structure (mechanical composition), water regime (water content, groundwater level), cultural practices (tillage, fertilization), etc [18]. Also, at the mountain Stara Planina in the Bulgarian part of the mountain, according to measurements from 2005, 137Cs activity concentration ranged in the interval between 11 and 2543 Bq/kg. It was concluded that the adoption to migration of 137Cs in soil is largely dependent on physicochemical characteristics of the land and the type of vegetation. The wide variations of the measured specific activity are a consequence of the variability of these parameters in the soils of the investigated area. [19].

Table 2. Specific activity of 137Cs in the food chain

<table>
<thead>
<tr>
<th>Sample type</th>
<th>Values of 137Cs activity concentration (Bq/kg)</th>
<th>Xsr (Bq/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Households</td>
<td>1</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td>&lt;0,10</td>
</tr>
<tr>
<td>Ground 0-5cm</td>
<td></td>
<td>98,73</td>
</tr>
<tr>
<td>Ground 5-10cm</td>
<td></td>
<td>93,85</td>
</tr>
<tr>
<td>Ground 10-15cm</td>
<td></td>
<td>99,29</td>
</tr>
<tr>
<td>Hay</td>
<td></td>
<td>0,30</td>
</tr>
<tr>
<td>Silage</td>
<td></td>
<td>0,71</td>
</tr>
<tr>
<td>Milk</td>
<td></td>
<td>0,36</td>
</tr>
<tr>
<td>Cheese</td>
<td></td>
<td>0,61</td>
</tr>
</tbody>
</table>

Xsr: Mean
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$^{137}$Cs activity concentration have been studied on hay and silage which were used to feed dairy cows at all six households, which are the final part of the food chain in the production of milk and the final product – cheese from mountain Golija.

It was found that $^{137}$Cs was detected in the hay silage at all six samples and values were an average of 0.74 (0.19 to 1.87) Bq/kg for hay, respectively, and 0.36 (0.14 to 0.71) Bq/kg for silage (Table 2). It can be seen that both the mean do not exceed the limit of 1.0 Bq/kg.

Similar results have shown in [20] because the values of $^{137}$Cs activity concentration obtained for feed does not exceed the prescribed level.

The degree of the presence of $^{137}$Cs is not the same in all regions of Serbia, which is, among other things, caused by unequal $^{137}$Cs activity in the precipitation in 1986. Thus, a high $^{137}$Cs activity concentration in the soil reflected in the activity of radionuclide’s in the hay. $^{137}$Cs activity in the hay from mountain Maljen were 32.4 Bq/kg, while in Toplica district the value was 8.1 Bq/kg. In the region of Uzice $^{137}$Cs activity concentration in the precipitation was the highest, which led to its greater activity in the soil, human and animal feed [21].

Table 2 shows the values of $^{137}$Cs activity concentration in the milk obtained from cows used in the experiment. $^{137}$Cs was detected in all samples and these values for individual households are ranged from 0.06 to 0.68 Bq/kg with a mean value of 0.27 Bq/kg.

Similar results were obtained in [23, 23] where $^{137}$Cs activity concentration were in the range of measured phon. In [24] measured milk samples also have values higher than 1.0 Bq/kg. The results of veterinary-sanitary control [25] confirmed that the milk as a strategic food were radiation-hygienic safe when importing.

The predictions model of $^{137}$Cs concentration in the cow’s milk, based on soil properties and quantities of radioactive rains, was made in the England [26]. Transfer of biologically significant radionuclide’s from plant foods, i.e. grass crops to milk, compared to other foods of animal origin, is of particular interest, since the radionuclides of used plant foods quickly pass in the milk [27]. The radiation load of milk by radioactive residues was almost exclusively a result of transfer of radionuclide’s in the food chain, i.e. its segment soil - plant - milk [28].

Similar results [29] were obtained in samples of cheese obtained from milk which values of $^{137}$Cs activity concentration (Bq/kg) ranged from 0.03 to 0.71 Bq/kg or with a mean of 0.38 Bq/kg (Table 2). In terms of the established level of $^{137}$Cs cheese represent safe food, in terms of radiation-hygienic control, because the radioactivity in the cheese, as well as milk, was within acceptable limits that are specific to these areas.

Conclusions

Based on the results obtained, we can conclude that the activities of natural and artificial radionuclides in milk and dairy products varied in acceptable limits that are specific to these areas, and in these core samples from the food chain of dairy cows, in order to provide quality nutrition in terms of radiation-hygienic monitoring. Also, quantitatively determined resource status Golija with radio ecological aspects.

Acknowledgments

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Literature


10. IAEA, Derived intervention levels for application in controlling radiation doses to the public in the event of a nuclear accidentor radiological emergency, Principles, Procedures and Data. Safety Series No. 81, IAEA, Vienna (1986).


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