

Determination ^{226}Ra , ^{232}Th , ^{40}K , ^{238}U , ^{235}U and ^{137}Cs in Agricultural Land in the Villages Pcinja District

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ABSTRACT

This paper presents the results of research of natural and artificial radioactivity of agricultural land in the Pcinja district in the south of Serbia. This region was chosen for analysis because of its significant share in agricultural production, on the one hand and due to the relative proximity of the location of the Chernobyl accident and izloženoti series 1999. on the other hand. The paper analyzes the characteristic values of activity concentration (^{226}Ra , ^{40}K , ^{232}Th , ^{238}U and ^{235}U), as a representative of natural radioactivity and ^{137}Cs , as a representative of artificial, human-induced radioactivity. The results show that the content of each of these radionuclides have different concentrations, but what is important is that the results do show a small value. Further research should continue in the direction of continuous monitoring and the development of new improved technologies removal, even small concentrations such as are found in Pcinja district and minimizing the impact on human health and the environment.

Keywords: radionuclides ^{226}Ra , ^{232}Th , ^{238}U i ^{235}U , ^{40}K , ^{137}Cs , land, methods, Pcinja district.

I INTRODUCTION

Natural radioactivity comes primarily from 3 natural radioactive sequences, which are ^{226}Ra , ^{232}Th , ^{238}U , and ^{235}U as well as ^{40}K , while the radionuclide ^{137}Cs is artificial. In the soil it can be found in a quantity that is above the detection threshold of low-voltage detector systems. This isotope has a half-life of 30 years and has mostly reached the environment during a disaster in the nuclear power plant in Chernobyl. The land is a complex material consisting of mineral (inorganic), as well as an organic component that is mainly caused by the breakdown of plant material. An inorganic, or mineral component of the soil consists of particles formed by the erosive action of various natural factors on the walls. As the rocks that are part of the earth's crust possess a certain concentration of natural radionuclides, it is expected that they can be found in the soil caused by the decomposition of the rock. [4] The results of the study are characteristic values of activity concentrations of ^{226}Ra , ^{40}K , ^{232}Th , ^{238}U , ^{235}U and ^{137}Cs in soil samples of the inhabitants of the Pcinja region. The content of each of these radionuclides has different concentrations, but what is important is that the results show low values. The concentration of natural radionuclides varies depending on various factors such as relief, soil type, climatic conditions and agricultural practice [11]. Natural radionuclides of uranium and thorium are widespread in the Earth's crust.

II MATERIALS AND METHODS

During 2014, about 20 samples of agricultural arable and non-cultivated land from the surrounding villages (villages) in the Region of Vranje were sampled. Land sampling was done with the aim of examining the soil and determining whether it possesses a high or low concentration of radioisotopes. The isotope concentration of radionuclides ^{226}Ra , ^{232}Th , ^{238}U , and ^{235}U , ^{40}K , ^{137}Cs is of great importance, especially if it is considered that plant crops are used on this soil to be used as food for humans and animals. The risk that occurs with the introduction of

radionuclides from the soil through the product in the human organism is large and depends on the concentration of radionuclides and their effective amount that they can manifest. The concentration of radioactive clues ^{226}Ra , ^{232}Th , ^{238}U and ^{235}U , ^{40}K , ^{137}Cs will be found in the soil and later in the plant itself will depend on the geographical area [12]

Table 1. List of samples and coordinates of the guiding position

s.n.	Location	Sample Earth	Depth of taking (cm)	Coordinates		Elevation	Date of sampling
				X (SGS)	Y (IGD)		
1	Bujkovac	Arable	0-5	42°33'26"	22°00'35"	718	09.11.2014.
		Arable	0-10	42°33'26"	22°00'35"	718	09.11.2014
		Arable	0-20	42°33'26"	22°00'35"	718	09.11.2014
2	Korbevac	Arable	0-5	42°23'06"	21°44'24"	441	05.11.2014
		Arable	0-10	42°23'06"	21°44'24"	441	05.11.2014
		Arable	0-20	42°23'06"	21°44'24"	441	05.11.2014
3	Suvi Dol	Untrained	0-5	42°33'07"	21°56'05"	359	11.11.2014
		Livada	0-10	42°33'07"	21°56'05"	359	11.11.2014
		Livada	0-20	42°33'07"	21°56'05"	359	11.11.2014
4	Toplac	Livada	0-20	42°32'18"	21°58'02"	528	17.11.2014.
		Livada	0-40	42°32'18"	21°58'02"	528	17.11.2014.
5	Ranutovac	Livada	0-10	42°34'06"	21°56'58"	359	18.11.2014
		Livada	0-20	42°34'06"	21°56'58"	359	18.11.2014

At each site, soil samples were taken from the surface layer of 0-5 cm, 0-10 cm and 0-20 cm depth, and from some locations samples were taken from the soil and at a depth of 0-40 cm (village Toplac).

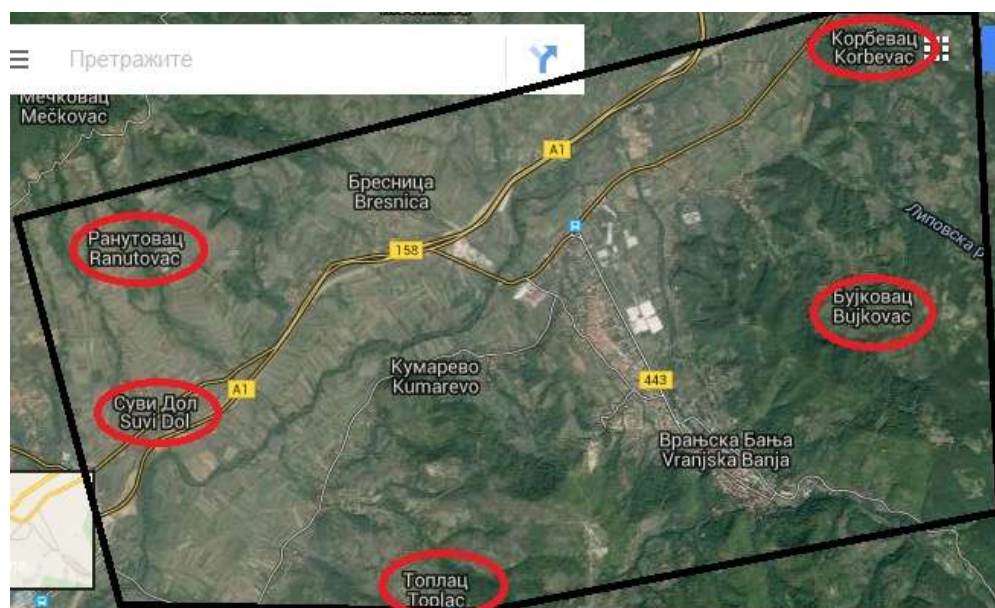


Figure 1. Geographical representation of the village in the Region of Vranje, from which samples of soil and cereals were taken for radioactivity testing

The testing of radioactivity of soil samples was performed by gamma spectrometric method, as well as the determination of total beta and alpha activity. Radioactivities of environmental parameters were examined at the Institute of Nuclear Sciences "Vinca", Belgrade.

Gamma emission spectrometry was performed on HPGe relative efficacy detectors of 18%, 20% and 50% of CANBERRA. The resolution of all detectors is 1.8 keV on the energy of 1332 KeV. Calibration of sample sampling detector countries was done with reference radioactive material, silicon resin matrix, Czech Metrological Institute, Praha, 9031-OL-420/12, total activity 41.48 kBq as of 31.08.2012. (^{241}Am , ^{109}Cd , ^{139}Ce , ^{57}Co , ^{60}Co , ^{203}Hg , ^{88}Y , ^{113}Sn , ^{85}Sr ^{137}Cs).

The timing of the samples is 60 hp. The measurement results are given with a measurement uncertainty expressed as an expanded measurement uncertainty for the factor $k = 2$ which for a normal distribution corresponds to a confidence level of 95%.

Determination of the concentration of natural radionuclides ^{226}Ra , ^{232}Th , requires analysis of the spectrum over descendants, in samples in which the radioactive balance has been established. The concentration of ^{226}Ra is determined by the descendants ^{214}Pb , ^{214}Bi , that is, through the energies of 295 keV, 352 keV, 609 keV, 1120 keV, 1764 keV (using energies with high probability of passage) by determining activity on each energy and calculating the mean value. [5]

The second natural radionuclide ^{232}Th is determined by descendants ^{228}Ac , at energies of 338 keV, 328 keV, 911 keV. The activity of ^{226}Ra and ^{232}Th is determined by calculating the mean value of the activity of the offspring. Activity ^{40}K is determined based on its energy of 1460 keV. In the case of ^{238}U , the activity is determined by the descendant ^{234}Th , at a energy of 63 keV and 1000 keV, since these two radionuclides are in balance. The ^{235}U is determined over the energy of 185 keV after correction to the contribution of ^{226}Ra to the given energy. The activity of the produced radionuclide ^{137}Cs was determined based on its energy of 661.6 keV. [12]

Gasaspectrometric testing of samples can be done in original fresh or dry samples after necessary homogenization in samples requiring special preparation, ie in concentrated samples [7]. Preparation of samples in fresh state includes, homogenization and measurement in certain measurement geometry, in particular in plastic containers of 125 cm^3 . In order to determine the content of natural radionuclides in the samples, a radioactive balance is established, by beating with beeswax.

III RESULTS AND DISCUSSION

The results of the gamma emitter spectrometry are shown in the table. Table 2 shows the results of land measurement.

Table 2. Concentration of detected radionuclides in soil [Bq / kg]

Land, depth of taking (cm)	(Bq/kg)						\dot{D} (nGy/h)	D_E (mSv)
	^{226}Ra	^{232}Th	^{40}K	^{238}U	^{235}U	^{137}Cs		
Korbevac								
0-5	43 ± 3	55 ± 4	730 ± 50	47 ± 8	2.7 ± 0.2	16 ± 1	83.53	0.102
0-10	45 ± 3	54 ± 4	730 ± 50	51 ± 9	2.4 ± 0.2	16 ± 1	85.85	0.105

0-20	38 ± 3	51 ± 4	690 ± 40	40 ± 8	2.4 ± 0,2	15 ± 1	73.89	0.091
Suvi Dol								
0-5	38 ± 3	52 ± 4	490 ± 30	35 ± 8	1.7 ± 0.1	10.1 ± 0.7	69.39	0.085
5-10	33 ± 2	48 ± 3	470 ± 30	34 ± 9	1.7 ± 0.2	7.9 ± 0.6	63.84	0.078
10-15	37 ± 3	50 ± 3	460 ± 30	34 ± 8	1.9 ± 0.2	7.2 ± 0.5	66.48	0.081
Ranutovac								
0-10	33 ± 2	39 ± 3	560 ± 30	32 ± 8	1.7 ± 0.2	12.6 ± 0.8	62.15	0.076
0-20	32 ± 2	38 ± 3	550 ± 30	30 ± 7	1.6 ± 0.1	12.3 ± 0.8	60.67	0.074
Toplac								
0-40	42 ± 3	54 ± 4	690 ± 40	50 ± 10	2.0 ± 0.2	7.6 ± 0.6	80.79	0.099
0- 20	39 ± 3	52 ± 4	660 ± 40	35 ± 7	1.9 ± 0.3	7.6 ± 0.6	76.95	0.094
Bujkovac								
0-5	22 ± 2	30 ± 2	500 ± 30	25 ± 8	1.6 ± 0.2	17 ± 1	49.13	0.061
0-20	25 ± 2	29 ± 2	520 ± 30	22 ± 8	1.1 ± 0.1	17 ± 1	50.75	0.062
0-10	23 ± 2	30 ± 2	510 ± 30	25 ± 7	1.5 ± 0.1	18 ± 1	50.01	0.061

In the samples of the tested soil the obtained values of the concentration of detected radionuclides are characteristic for the soil. ^{226}Ra concentrations are from 22 to 45 Bq / kg, for ^{232}Th from 29 to 55 Bq / kg, for ^{40}K from 460 to 730 Bq / kg, for ^{238}U from 22 to 51 Bq / kg, for ^{235}U from 1.1 to 2.7 Bq / kg and ^{137}Cs from 7.2 to 17 Bq / kg.

In addition to natural radionuclides in the soil samples, ^{137}Cs radionuclide, which is a result of a nuclear accident in Chernobyl, was also detected. Prolongation and relocation processes of cesium can lead to very uneven distribution of this radionuclide in one area. However, in these examined samples, fear of this is negligible because the values of radionuclides ^{137}Cs are very low. The obtained ^{137}Cs concentrations were in the range of 7.6 to 17 Bq / kg [2].

The concentration of natural ^{238}U activity ranges from 15-55 Bq / kg for non-agricultural and 14-82 Bq / kg for agricultural land. The tested agricultural land samples showed that the value obtained for this radionuclide ^{238}U is in the range of 22-51 Bq / kg. This means that the concentration values of the ^{238}U activity are in the range of values characteristic for the land. No activity was observed in any sample as ^{238}U , ^{235}U , nor depleted uranium.

Only at the Bujkovac site were the lower values of concentrations of detected natural radionuclides compared to other sites in the soil, because the soil is more sandy, dominated by sandbags.

In the samples of the tested soil, the concentration of radionuclide was low. This means that the land is of good quality and that there are no consequences of contamination of harmful radionuclides such as ^{226}Ra , ^{232}Th , ^{40}K , ^{238}U , ^{235}U and ^{210}Pb . ^{137}Cs are distinguished here because it is artificial, a radionuclide created, well that it is also in small quantities. It can be said that the South Serbia Region and the places located on the left and right shores of the South Sea are good and suitable for the development of agricultural products, because the concentration of harmfulness of these radionuclides is low.

Table 3. Mean soil samples for different detected radionuclides from different locations

Mean value of soil sample	²²⁶ Ra (Bq/kg)	²³² Th (Bq/kg)	⁴⁰ K (Bq/kg)	²³⁸ U (Bq/kg)	²³⁵ U (Bq/kg)	¹³⁷ Cs (Bq/kg)
Korbevac	44	54	730	49	2,55	16
Suvi Dol	36	50	473	34	1,77	8,4
Ranutovac	32	39	555	31	1,65	12,2
Toplac	40	54	675	42	1,95	7,6
Bujkovac	24	29	510	23	1,35	17

Table 3 shows the mean values of radionuclide concentrations in the tested soil samples in the territory of the Pcinja region. From Table 3 it can be seen that radionuclide value ²²⁶Ra ranges from 24-44 Bq / kg, value ²³²T of 29-54 Bq / kg, value ⁴⁰K from 473-730 Bq / kg, value ²³⁸U from 23-49 Bq / kg, value ²³⁵U of 1.35-2.55 Bq / kg and a value of ¹³⁷Cs of 7.6-17 Bq / kg. The obtained values of the tested radionuclides are in accordance with the results of the samples tested in regional studies [11], although mean values were taken [3].

On the basis of the obtained results, it can be said that the concentration of radionuclides ¹³⁷Cs in relation to the concentrations of other radionuclides in the soil at the same depths is significantly lower than the radionuclides ²²⁶Ra, ²³²Th, ⁴⁰K and ²³⁸U [8]. It should be said that the concentration of ¹³⁷Cs radionuclides is lower at higher depths in the results obtained in the tested soil samples in the Pcinja region.

These values can be compared with the values measured in other countries in the region and beyond (Table 4). It can be observed that the soil's radioactivity is moving in approximately the same range, while the deviation is affected by the type and type of soil. The concentration of the activity of the thorium ²³²Th is slightly higher for the Indian soil, while the concentration of uranium activity of ²³⁸U in Sicily (Stromboli) [1] is elevated relative to the Vojvodina soil (a possible explanation is the existence of a wall of volcanic origin on Stromboli). The ratio of uranium / thorium ²³⁸U / ²³²Th is approximately the same for other land (Turkey, Ireland and Japan) [9], as is the case with the land in the Pcinj region, which indicates the absence of uranium contamination. However, if the use of phosphate fertilizers with increased uranium content is intensified, this balance may be disturbed.

Table 4. The content of radionuclides in the soil of other countries

The value of radionuclides	India (Selvasekarapandian et al., 2000)	Egypt (Sroor et al., 2001)	Istanbul (Karahana and Bayulken, 2000)	Irska McAuley and Maran, 1983)	Japan (Chen et al., 1991)
²³² Th	104±77	6±3	35±7	26	54
²³⁸ U	34±11	13±9	27±11	37	32.4
⁴⁰ K	217±145	433±130	322±87	350	794
²³⁵ U	2.89±0.1	3.2±1,1	2.1±0,3	1.78±0.1	1.97±0.2

IV CONCLUSION

In all soil samples, the presence of ¹³⁷Cs originating from the Chernobyl accident was detected, but its concentration was low. This is good because the processes of washing and relocation of cesium can lead to very uneven distribution of this radionuclide in one area and this can be harmful to the environment and human health.

The permissible concentration of the natural ^{238}U activity ranges from 15-55 Bq / kg for non-agricultural and 14-82 Bq/kg for agricultural land, so if the obtained values of this radionuclide are compared with this then the concentration is within normal limits. The ^{238}U concentration concentration values are in the range of values characteristic for the land. No activity was observed in any sample as ^{238}U , ^{235}U , nor ^{40}K nor ^{232}Th .

Monitoring and minimizing the effects of heavy metals, organic pollutants, radionuclides and fields of radiation in the living environment are based on various chromatographic and spectrometric detection techniques, statistical and mathematical models for optimizing experimental settings and procedures, predicting behavior and processing of results, and procedures for concentrating And extraction. The presence of these substances and radiation fields, even at very low concentrations and levels, such as in the Pcinja region, requires research in the direction of developing new and improving existing methods for their detection, predicting their distribution, and new improved technologies for their removal and Minimizing the impact on human health and the environment.

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