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Prof. Dr Snežana Šerbula

18-21 June 2019, Hotel Jezero, Bor Lake, Serbia

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ACTIVITY LEVELS OF ^{137}Cs AND ^{40}K IN MOSS COLLECTED IN 2018 FROM THE NP ĐERDAP

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Abstract

Moss samples (33 samples, 10 species) were collected in June 2018 on the territory of NP Đerdap from 14 management units and two regions: Dobra (17 samples, 7 species) and Đerdap (16 samples, 8 species). ^{137}Cs and ^{40}K were present in all samples. Activity levels of ^{137}Cs and ^{40}K in investigated samples were from 14.9 to 251 Bq/kg and from 127 to 721 Bq/kg, respectively. The average activity level of ^{137}Cs in moss samples was 82.7 Bq/kg and for ^{40}K it was 297 Bq/kg. Research in 2018 shows that activity levels of ^{137}Cs and ^{40}K in moss from the Đerdap region were higher compared to the levels in moss from the Dobra region. Activity levels of ^{137}Cs in moss collected in 2018: Hypnum cupressiforme Hedw. (Dobra, Đerdap), Polytrichum formosum Hedw. (Dobra, Đerdap) and Isothecium alopecuroides (Dubois) Isov. (Dobra) were lower when compared to values obtained in previous years. The ratio between average values of ^{137}Cs and ^{40}K is from 0.049 to 0.786. The Pearson correlation coefficient between ^{137}Cs and ^{40}K is positive (0.265) leading to the conclusion that there is no linear correlation between these two radionuclides.

Keywords: National Park Đerdap, mosses, radioactivity, ^{137}Cs, ^{40}K

INTRODUCTION

The National park (NP) Đerdap, is one of the parks in Serbia. It is situated in the Carpathian mountain region in Northeastern Serbia close to the boundary with Romania. Its area is 63608 ha, about 100 km long along the left bank of the Danube. It encompasses a narrow woodland mountain area about 3-9 km wide along the Danube, with a height of about 50-900 m altitude. It was founded in 1974 [1].

Development of ecology as a science and better understanding of the food chain and biochemical cycles indicated the necessity of viewing short and long-term consequences of the influence of radionuclides on individuals, populations, communities and ecosystems. The behavior of radionuclides in the environment has been the subject of scientific research based on radiation biology and ecology. Radionuclides enter the soil and water through migration and accumulation processes. This way they can enter into a plant and by its consumption into an animal or human body [2].

In nature, radionuclides are found in the air, water and soil and are part of rocks, seas and oceans. Over 1500 radionuclides are known and they can be grouped into two categories: natural and anthropogenic (produced). The origin of natural radionuclides can be primordial (initial - before the formation of Earth) and cosmogenic (formed as the result of interaction between cosmic rays). ^{40}K is a primordial radionuclide that is present in 0.0117% in natural potassium [3]. ^{40}K is one of the main radionuclides in magma, an unavoidable component in the food chain (soil-plant-human). Humans ingest about 44000 Bq yearly of this radionuclide with food. The physical half-life of ^{40}K is $T_{1/2}=1.28\cdot10^{9}$ years. Since the sixties of the last century produced (artificial) sources of ionization radiation represent a significant problem besides natural sources of ionization radiation. According to the UNSCEAR data large amounts of ^{137}Cs entered into the environment after nuclear tests (1945-1980) [4] that is most dangerous and significant for the living world. The physical half-life of ^{137}Cs is 30.2 years and it is a chemical analogue of potassium and follows its metabolitic paths in an organism. In April 1986, the accident in the Chernobyl (present Ukraine) nuclear power plant took place. $3.8\cdot10^{16}$ Bq ^{137}Cs was emitted into the environment. Different parts of Europe were contaminated differently. It was estimated that during 1986 about 10% of the total emitted ^{137}Cs was deposited on the territory of Yugoslavia [5]. Research by our scientists have shown that the accident in the Fukushima nuclear power plant (2011, Japan) did not have an influence on ^{137}Cs deposition in Serbia [6].

Mosses are suitable bioindicators for research and tracking of the deposition of radionuclides in from the air. They do not have a developed root system, body, leaf and cuticle. The absence or strong reduction of cell membrane and their thin leaves enable easy adoption of water and nutrients from the atmosphere. They can absorb radionuclides, heavy metals, pesticides and other pollutants in measurable concentrations. About 661 species of moss grow in Serbia and 229 moss species grow on the territory of the NP Đerdap [7]. Mosses as indicators of environment pollution were first used in Sweden.

MATERIALS AND METHODS

Research that has been conducted on the territory of the NP Đerdap in the last few years has shown that the content of ^{137}Cs and ^{40}K in moss samples is not homogeneous. Moss samples (33, 10 species) were collected in June 2018 on the territory of NP Đerdap from 14 management units (MU), from two regions (number of samples): Dobra (17) and Đerdap (16). The following mosses were collected (number of samples): **1.** *Hypnum cupressiforme* Hedw. (13), **2.** *Brachythecium salebrosum* (F. Weber and D. Mohr Schimp) (4), **3.** *Atrichum undulatum* (Hedw.) P. Beauv (3), **4.** *Polytrichum formosum* Hedw. (4), **5.** *Brachythecium rutabulum* (Hedw.) Schimp (3), **6.** *Dicranum scoparium* Hedw. (2), **7.** *Isothecium*

alopecuroides (Dubois) Isov. (1), **8.** *Anomodon viticulosus* (Hedw.) Hook and Tayl. (1), **9.** *Anomodon attenuatus* (Hedw.) Hueb (1), **10.** *Plagiothecium denticulatum* (Hedw.) Schimp (1). After sample transport to the laboratory, they were cleaned from noticeable dirt (earth, grass, pine needles), dried and homogenized and packed into Marinelli vessels with a volume of 1.0 L. The sample mass was up to 150 g.

An ORTEC - AMETEK, USA semiconducting germanium high purity detector with 8192 channels, resolution of 1.65 keV and relative efficiency of 34% at 1.33 MeV for ^{60}Co was used to determine the radionuclide content. Calibration of the detector efficiency and energy was performed by the Department of Physics, Faculty of Natural Science University of Novi Sad. All samples were measured for 60000 s. Spectra analyses was performed using the Gamma Vision 32 software [8]. The ^{40}K content was determined using the gamma line at 1460 keV, while the ^{137}Cs content was determined using the line at 661.6 keV.

In order to secure checking of the measuring device for potential pollution periodic measurements of the detector system background was performed. Background measurement was performed prior to sample measurements. The relative measurement instability of all results was up to 10% of activity levels in analyzed samples. Quality control of gamma spectrometric measurements was performed using a calibration standard and reference materials and by regular yearly participation in comparisons between laboratories organized by the International Agency for Atomic Energy.

RESULTS AND DISCUSSION

Table 1 shows the moss species (number of samples), management unit, activity level (Bq/kg) of ^{137}Cs and ^{40}K, their ratio in moss collected in 2018 from the Dobra region. Activity levels of ^{137}Cs in investigated moss samples were from 14.9 Bq/kg (moss 7, MU Čezava) to 128 Bq/kg (moss 1, MU Leva reka). Activity levels of ^{40}K in investigated moss samples were from 127 Bq/kg (moss 4, MU Boljetinska reka) to 470 Bq/kg (moss 5, MU Kožica). Research shows that the average activity levels and standard deviation for ^{137}Cs and ^{40}K in moss from the Dobra region were 60.1±43.0 Bq/kg and 278±116 Bq/kg, respectively.

Table 2 shows the moss species (number of samples), management unit, activity level (Bq/kg) of ^{137}Cs and ^{40}K, their ratio in moss collected in 2018 from the Đerdap region. Activity levels of ^{137}Cs in investigated moss samples were from 36.5 Bq/kg (moss 1, MU Tekija) to 251 Bq/kg (moss 3, MU Crni vrh). Activity levels of ^{40}K in investigated moss samples were from 145 Bq/kg (moss 9, MU Tekija, Kosovica) to 721 Bq/kg (moss 2, MU Brzujka). Research shows that the average activity levels and standard deviation for ^{137}Cs and ^{40}K in moss from the Đerdap region were 107±62.7 Bq/kg and 318±133 Bq/kg, respectively.

From Tables 1 and 2 follows that ^{137}Cs and ^{40}K are present in all investigated samples, mosses are radionuclide bioaccumulators, and activity levels of ^{137}Cs and ^{40}K in moss from the Đerdap region are higher in relation to the values in moss from the Dobra region.

The average activity levels and the standard deviation for ^{137}Cs and ^{40}K in moss collected in 2018 on the territory of NP Đerdap, in the Dobra and Đerdap regions, were 82.7±57.7 Bq/kg (min 14.9 Bq/kg (moss 7, MU Čezava), max 251 Bq/kg (moss 3, MU Crni vrh)) and 297±124 Bq/kg (min 127 Bq/kg (moss 4, MU Boljetinska reka), max 721 Bq/kg (moss 2, MU

Brzujka)), respectively. The average activity levels for ^{137}Cs are lower compared to the values obtained in samples collected in the previous years that leads to the conclusion that there were no new pollutions with this radionuclide on the territory of the NP Đerdap [9–11].

Table 1 *Moss species (number of samples), management unit, activity levels (Bq/kg) of ^{137}Cs and ^{40}K, their ratio in moss collected in June 2018 in the Dobra region*

Moss (number of samples)	Management unit	^{137}Cs (Bq/Kg)	^{40}K (Bq/Kg)	$^{137}Cs/^{40}K$
1 (7)	Čezava	25.2	203	0.124
		17.4	221	0.079
	Leva reka	128	360	0.356
	Desna reka	32	157	0.204
	Boljetinka	116	435	0.267
	Pecka bara	126	335	0.376
		114	419	0.272
2 (3)	Desna reka	15.5	319	0.049
	Kožica	70.4	408	0.173
		101	157	0.643
3 (1)	Leva reka	35.2	348	0.101
4 (2)	Boljetinska reka	67.9	127	0.535
	Boljetinka	81	131	0.618
5 (1)	Kožica	36.7	470	0.078
6 (2)	Čezava	19.1	224	0.085
		20.6	257	0.080
7 (1)	Čezava	14.9	157	0.095

Table 2 *Moss species (number of samples), management unit, activity levels (Bq/kg) of ^{137}Cs and ^{40}K, their ratio in moss collected in June 2018 in the Đerdap region*

Moss (number of samples)	Management unit	^{137}Cs (Bq/Kg)	^{40}K (Bq/Kg)	$^{137}Cs/^{40}K$
1 (6)	Crni vrh	138	263	0.525
		102	269	0.379
	Tekija, Dafin	120	334	0.359
	Tekija	36.5	269	0.136
		48	296	0.162
	Manastirički gaj	79	192	0.411
2 (1)	Brzujka	72.6	721	0.101
3 (1)	Crni vrh	251	417	0.602
		141	246	0.573
4 (2)	Crni vrh	53.9	413	0.131
	Faca Tekija	93.7	250	0.375
5 (2)	Crni vrh	65	276	0.236
	Tekija, Kosovica	111	356	0.312
8 (1)	Crni vrh	45.3	226	0.175
9 (1)	Tekija, Kosovica	114	145	0.786
10 (1)	Prapezešće	237	407	0.582

The ratio between average activity levels of ^{137}Cs and ^{40}K was from 0.049 (moss 2, Dobra region, MU Desna reka) to 0.786 (moss 9, Đerdap region, MU Tekija, Kosovica). The

Pearson correlation coefficient between ^{137}Cs and ^{40}K is positive (0.265) and its value leads to the conclusion that there is no linear correlation between these two radionuclides.

CONCLUSION

Radionuclides ^{137}Cs and ^{40}K were present in all investigated moss samples collected in 2018 from the NP Đerdap. Mosses are good bioindicators of radionuclide pollution. Activity levels of ^{137}Cs in investigated moss samples from the Dobra region were 14.9-128 Bq/kg and for ^{40}K they were 127-470 Bq/kg. The average activity level in moss from the Dobra region for ^{137}Cs was 60.1 Bq/kg and for ^{40}K it was 278 Bq/kg. Activity levels of ^{137}Cs in investigated samples from the Đerdap region were 36.5-251 Bq/kg and for ^{40}K they were 145-721 Bq/kg. The average activity level in moss from the Đerdap region for ^{137}Cs was 107 Bq/kg and for ^{40}K it was 318 Bq/kg. The activity levels of ^{137}Cs and ^{40}K in moss from the Đerdap region were higher compared to the levels obtained in moss from the Dobra region.

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REFERENCES

[1] R. Lazarević, B. Kirbus, T. Rakičević, *et al.*, NP Đerdap: Pamtivek prirode i čoveka, Ecolibri, Beograd (1996), p.38 (in Serbian).

[2] WHO (World Health Organization), Guidelines for Drinking-water Quality, 4th ed., Geneva, Switzerland (2011), *Available on the following link*: http://apps.who.int/iris/bitstream/10665/44584/1/9789241548151_eng.pdf, *Accessed on*: 1 March 2019.

[3] A. Dangić, Biohemijski procesi u prirodi i radionuklidi, Monografija Jonizujuća zračenja iz prirode, Beograd (1993) (in Serbian).

[4] United Nations Scientific Committee on the Effects of Atomic Radiation 1982, Report to the General Assembly, with Annexes, Ionizing Radiation: Sources and Biological effects, United Nations, New York (1982).

[5] Savezni komitet za rad, zdravstvo i socijalnu zaštitu, Nivo radioaktivne kontaminacije čovekove sredine i ozračenost stanovništva Jugoslavije 1986. godine usled havarije nuklearne elektrane u Černobilu, Beograd (1987) (in Serbian).

[6] I. Bikit, D. Mrđa, N. Todorović, *et al.*, J. Environ. Radioact; 114 (2012) 89–93.

[7] Master plan Turističke destinacije Donje Podunavlje, Vlada Republike Srbije, Ministarstvo ekonomije i regionalnog razvoja, Beograd (2007) (in Serbian).

[8] ORTEC, Gamma Vision 32, Gamma – Ray Spectrum Analysis and MCA Emulation, ORTEC, Oak Ridge, Version 5.3 (2001).

[9] A. Čučulović, R. Čučulović, S. Nestorović, *et al.*, Ecologica; (2019) *in press*.

[10] A. Čučulović, R. Čučulović, S. Nestorović, *et al.*, 14th International Conference on Fundamental and Applied Aspects of Physical Chemistry, Proceedings, September 24-28, Belgrade, Serbia (2018) 821–824.

[11] A. Čučulović, R. Čučulović, S. Nestorović, *et al.*, XXIX Simpozijum DZZ SCG, Zbornik radova, 27-29 September 2017, Srebrno jezero, Srbija (2017) 99–107.

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