

RADIOACTIVITY IN SOIL AND MOSSES FROM NP ĐERDAP IN 2019

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ABSTRACT

In June 2019, 18 soil samples and 20 moss samples were collected from 3 regions on the territory of National Park Đerdap. The radionuclide content (Bq/kg) in soil (moss) was: ¹³⁷Cs 3.5-496 (5.5-908), ⁴⁰K 36.4-918 (136-493), ²²⁶Ra 7.8-45.0 (4.2-34.1), and ²³²Th 8.2-59.5 (1.7-22.2). The external gamma dose rate (nGy/h) in 2019 on the territory of NP Đerdap is in the range from 22.4 to 93.6, average value 50.0. Values of the external gamma dose were in the range of the expected values and close to the average values in the world. The mean value of annual effective dose (10⁻⁵ Sv) in the NP Đerdap is 6.12×10⁻⁵ and is lower than the mean value on the world level of 7.00×10⁻⁵ Sv.

INTRODUCTION

There are five natural parks (NP) in Serbia, and the Đerdap is one of them since 1974, with an area of 63.350 ha. It is located in the Northeast of Serbia on the boundary with Romania.

All organisms of planet Earth are exposed to radiation that is classified by place of origin into earth and cosmic. Sources of ionization radiation by their genesis and occurrence in the environment are classified as: natural, anthropogenic and radioactive waste. Natural radionuclides (⁴⁰K, ²³²Th, ²²⁶Ra, ²³⁸U...) are formed during the nucleosynthesis process and have a long half-life and different physical, geochemical properties, half-life types, radiation intensities, isotropic prolific quantities, occurrence method and geochemical cycles [1]. Anthropogenic radionuclides are enhanced or created due to human activity. The ¹³⁷Cs anthropogenic radionuclide to the greatest extent entered the environment in Serbia after the accident in the Chernobyl nuclear power plant in the Ukraine in 1986. Mosses are widespread, long-lived, easy accessible and good bioindicators of pollution of the environment as they adopt nutrients from the atmosphere by dry and moist desorption through weakly or no developed cuticles.

EXPERIMENTAL

Investigations performed on the territory of NP Đerdap in the last few years have shown that the radionuclide content in moss and its substrate is not homogenous. In June 2019 18 soil samples and 20 moss samples were collected from 18 locations in NP Đerdap, from three regions: Tekija (Đerdap, 48; Crni vrh 1, 17, 59; Štrbačko korito 47, 59), Donji Milanovac (Pecka bara 25, 41; Boljetinka 58, 66, 81; Boljetinska reka 2, 9, 10) and Dobra (Leva reka 13c, 29a, 30, 52a). In the laboratory the samples were cleaned from visible impurities dried, homogenized and packed in Marinelli vessels with a volume of 0.5 and 1L. They were sealed with paraffin and left for at least four weeks to ensure equilibrium between ²²⁶Ra and its decay products prior to radioactivity measurements. A semiconducting germanium high purity detector of the n-type produced by ORTEC - AMETEK, USA, with 8192 channels, resolution 1.65 keV and relative efficiency of 34% at 1.33

MeV for ^{60}Co was used for detection. All samples were measured for 60000 s. Activity concentrations of ^{226}Ra and ^{232}Th were determined by their decay products ^{214}Bi , ^{214}Pb and ^{228}Ac , respectively. The ^{40}K activity was determined based on the gamma line at 1460 keV and ^{137}Cs at 661.6 keV. The total standard error of the method was estimated to be about 20%. Gamma-spectral analysis was performed with the Gamma Vision 32 software package. The external gamma dose rate and the annual effective dose the calculations were performed according to recommendations of UNSCEAR [2].

RESULTS AND DISCUSSION

The results obtained from measuring the content of radionuclides in investigated soil and moss samples collected in 2019 on the territory of NP, including values of the external gamma dose rate D (nGy/h) and annual effective dose D_E (10^{-5} Sv) are given in Table 1. The average value (Bq/kg) of the radionuclide content in soil collected on the territory of NP Đerdap (Tekija, Donji Milanovac, Dobra) was: ^{137}Cs 185 (156, 211, 174), ^{40}K 438 (460, 496, 289), ^{226}Ra 29.0 (35.8, 26.7, 23.1) and ^{232}Th 30.4 (35.4, 28.7, 26.2), and that is within the range of average values in soil in the world [2]. In moss it was: ^{137}Cs 142 (170, 171, 26.8), ^{40}K 224 (234, 234, 187), ^{226}Ra 13.7 (14.7, 15.9, 6.5) and ^{232}Th 8.2 (7.8, 9.6, 5.1), that is in the range determined in our previous research [3]. The external gamma dose rate (nGy/h) in 2019 on the territory of NP Đerdap (Tekija, D. Milanovac, Dobra) is in the range from 22.4 (28.3, 22.4, 24.5) to 93.6 (70.9, 93.6, 54.0), average value 50.0 (57.1, 50.3, 38.5). Values of the external gamma dose were in the range of the expected values and close to the average values in the world. The annual effective dose (10^{-5} Sv) in 2019 was from 2.75 to 11.48, and they are the same order of magnitude as values determined on other locations in our country [4]. The mean value of D_E in the NP Đerdap is 6.12×10^{-5} Sv.

Table 1. Radionuclide content (Bq/kg) in soil and moss samples and also values of the external gamma dose rate and annual effective dose
(MU-Management unit, S-Sample, M-Moss, Soil-Soil)

No	S	MU division	¹³⁷ Cs	⁴⁰ K	²²⁶ Ra	²³² Th	D (nGy/h)	D _E (10 ⁻⁵) (Sv)
1	Soil	Đerdap	23.6	575	42.8	45.0	70.9	8.7
1a	M	48	34.6	493	4.6	14.4	---	---
2	Soil	Crni vrh	348	184	19.1	19.6	28.3	3.5
2a	M	1	820	162	6.9	4.3	---	---
3	Soil	C. vrh	152	441	41.3	39.0	61.0	7.5
3a	M	17	35.2	174	14.0	15.1	---	---
4	Soil	C. vrh	3.5	471	24.5	26.5	47.0	5.8
4a	M	59	45.8	244	34.1	9.2	---	---
5	Soil	Štrbačko	207	499	45.0	39.3	65.3	8.0
5a	M	korito 47	53.6	160	20.6	1.7	---	---
6	Soil	Š. korito	201	588	42.2	43.0	70.0	8.6
6a	M	59	33.6	171	7.7	2.1	---	---
7	Soil	Pecka	39.7	602	39.4	40.5	67.8	8.3
7a	M	bara 25	59.0	237	19.3	15.3	---	---
8	Soil	P. bara	164	918	41.9	59.5	93.6	11.5
8a	M	41	16.8	189	6.5	9.7	---	---
9	Soil	Boljetinka	340	437	25.9	20.9	42.8	5.3
9a	M	58	115	225	12.0	6.1	---	---
9b	M		106	163	20.0	7.6	---	---
10	Soil	Boljetinka	130	634	29.4	29.4	57.8	7.1
10a	M	66	59.7	293	20.7	8.5	---	---
11	Soil	Boljetinka	438	80.6	19.1	18.0	23.1	2.8
11a	M	81	908	136	4.6	6.5	---	---
11b	M		112	160	24.5	8.9	---	---
12	Soil	Boljetinsk	22.5	624	35.8	43.0	68.5	8.4
12a	M	a reka 2	109	306	14.7	21.6	---	---
13	Soil	B. reka	58.8	333	7.8	8.2	22.4	2.8
13a	M	9	23.2	396	15.9	5.4	---	---
14	Soil	B. reka	496	341	14.1	9.8	26.7	3.3
14a	M	10	201	231	21.0	6.2	---	---
15	Soil	Leva reka	452	36.4	18.9	23.6	24.5	3.0
15a	M	13c	71.2	185	5.6	3.7	---	---
16	Soil	Leva reka	68.2	350	17.7	22.2	36.2	4.4
16a	M	29a	15.4	159	10.4	3.0	---	---
17	Soil	Leva reka	168	369	21.5	23.4	39.5	4.8
17a	M	30	15.0	175	4.2	4.1	---	---
18	Soil	Desna	9.3	400	34.1	35.7	54.0	6.6
18a	M	reka 52/a	5.5	229	5.8	9.7	---	---

CONCLUSION

Measured results show that all samples contained natural radionuclides (^{40}K , ^{226}Ra and ^{232}Th) and the produced radionuclide ^{137}Cs . High values of Pearson coefficients for radionuclides Ra-Th (0.925) in soil indicate their common origin and strong linear bond. The values of Pearson coefficients for K-Ra (0.690) and K-Th (0.765) indicate their medium connectivity. Values of the strength of the absorbed gamma radiation dose and the yearly effective dose from external exposure to gamma radiation based on the content of natural radionuclides in soil were in the range of the expected values and close to the average values in the world.

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