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Cesium-137 in the soils in the territory of Tbilisi City (Georgia)

Eremia Tulashvili*, Bezhan Tutberidze, Mariam Akhalkatsishvili, Lela Mtsariashvili, Manana Chkhaidze, Irina Ambokadze

Ivane Javakhishvili Tbilisi State University, 13, Chavchavadze Ave., ., Tbilisi, 0179, Georgia

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A B S T R A C T

In the present work there are given results of research of the content of technogenic radionuclide Cs-137 in various types of the soil in the territory of some districts of Tbilisi City – the capital of Georgia. 56 soil samples have been selected and analyzed in the studied territory. Activity concentration of radionuclide Cs-137 in the investigated samples varied from 0.19 to 118 Bq/kg (on the average - 18.7 Bq/kg). Some features of distribution of cesium-137, in particular, from the type of soil and an arrangement of sampling location points are noted.

Keywords: Radioactive background, Activity concentration, Ecological problems, Technogenic radionuclides, Biological circulation, Cs-137.

*Corresponding author: Eremia Tulashvili; E-mail address: eremia.tulashvili@tsu.ge

Introduction

One of the main components of the radioactive background of the Earth is made by the radioactivity of the soils which is caused by the presence of radionuclides in them. There are the natural and technogenic radioactivity.

The natural radioactivity of soils is caused by the natural radioactive isotopes which are always presented in soils and soil-forming rocks.

The technogenic radioactivity of soils is caused by ingress in the soils the radioactive isotopes formed as a result of nuclear and thermonuclear explosions, in the form of the waste of the nuclear industry or as a result of failures at the nuclear enterprises. Formation of isotopes in soils can occur owing to an induced radiation. The most often the technogenic radioactive pollution of soils is caused by isotopes U-235, U-238, Pu-239, I-129, I-131, Ba-140, Ru-106, Sr-90, Cs-137, etc. Regarding the ecological problems the greatest danger is represented by the radionuclides Sr-90 and Cs-137. It is caused by the long half-life period (29.1 years for Sr-90, and 30.0 years for Cs-137), high radiation energy and the easy ability to enter into biological circulation, in a feed circuit. By chemical properties strontium is close to calcium and is a part of bone tissue, and cesium is close to potassium and joins in many reactions of live organisms. Cesium-137 strongly fixed in soils and can extend over the food chain "plant-cattle-human being". Therefore investigation of the content of technogenic radionuclides, first of all Cs-137, in this important environmental object represents an actual problem all over the world. Results of similar researches are given in many publications.

So, for example, in the work [1] there are given results of measurements of activity concentration of Cs-137 in the soil samples from the various areas of Punjab province, one of the most populated provinces of Pakistan. Activity concentration of Cs-137 was in the range from 1.1±1.0 to 5.3±2.5 Bq/kg. It is concluded that Cs-137 soil contamination does not pose radiation hazards to the population in the investigated areas.

The similar researches carried out spent for Gaziantep, an industrial and trade center in the south-eastern part of Turkey [2], have shown, that the activity concentration for the fission product Cs-137 in the surface soil samples was determined as

8.02 Bq/kg. The measurement results obtained in this study indicate that the region has a background radiation level that is within the natural limits and shows no significant departure from the other parts of the country.

Results of a systematic study of soil radioactivity in the metallurgical center of the Republic of Macedonia, the city of Veles and its environs, were given in the work [3]. It has been shown, that Cs-137 originated from the atmospheric deposition and present in soil in the activity concentration range of 2–358 Bq/kg is irregularly distributed over the sampled territory owing to the complicated orography of the land.

In another work [4] there are given the results of a wider monitoring project of the agricultural soils in Lombardy, Italy. It has been established, that activity Cs-137 varied from 1.1 to 241 Bq/kg. The lowest activity of Cs-137 is in the plain, whereas the highest is in the North on soils kept as lawn or pasture. The Cs-137 activity of some samples suggests the presence of accumulation processes that lead to Cs-137 enriched soils.

Natural and artificial gamma-emitting radionuclides, including Cs-137, were measured in the soils of a small catchment in the Central Pyrenees, Spain [5]. By results of researches it was revealed, that concentration of activity Cs-137 changed in the range 4.4-64.7 Bq/kg (average value 30.9 Bq/kg).

In Georgia regular researches of natural (and also technogenic) radioactivity were not actually carried out. Rather detailed researches of radioactivity in various environmental objects have been carried out in 1986, after failure on the Chernobyl atomic power station and, basically, concerned technogenic radionuclides [6, 7, 8]. In these works it has been shown, that during this period in the territory of the Western Georgia, basically in the strip adjoining to the sea the big concentrations of technogenic radionuclides were observed (in particular, Cs-137 concentration made from several hundreds to some thousands of Bq/kg). It is possible to note also works [9, 10] in which results of research of radiation condition of coast of water area of Black sea during later period are given, in particular, presence of 7 natural (Ac-228, Ra-226, Bi-214, Pb-214, Pb-212, Pb-210, K-40) and 1 technogenic radionuclide (Cs-137) has been fixed in soil in some areas of Adzharia (Batumi, Gonio, Sarpi, Chakvi, Kvariati). Some results of the last period are given in a study by Kekelidze et al [11]. Urushadze and Manakhov studied content of technogenic radionuclides Cs-137 and Sr-90 in different types of soil in the territory of Georgia [12].

In the present work there are given the results of research of activity concentration of technogenic radionuclide Cs-137 in the soil for the territory of some districts of Tbilisi – the largest city and capital of Georgia.

Materials and method

Study area

The territory of Tbilisi city represents the crossed mountain area within average watercourse of the River Mtkvari. Tbilisi occupies deep kettle-shaped valley which width changes from 3000-4000 m to 35-40 m. River Mtkvari crossing a city practically in meridional direction, divides the city on the two appreciably divergent parts: more raised right-bank and considerably lowered left-bank. Various types of the soil are extended in the territory of Tbilisi.

Sampling was carried out in the whole territory of the city. 56 soil samples were selected from 56 sample locations (see Table 1), in particular, of the following types:

- cinnamonic – 52 samples (including cinnamonic calcareous (Cn-Cr) – 40 samples, cinnamonic (Cn) – 11 samples, and gray cinnamonic – 1 sample);
- alluvial – 4 samples (including alluvial calcareous (Al-Cr) – 2 samples, and alluvial (Al) – 2 samples).

Table 1. *List of locations (L), field numbers (FN) of investigated samples and their types (ST)*

#	L	Lt(N); Ln(E)	FN	ST	#	L	Lt(N); Ln(E)	FN	ST
1	Tx-1	41.65475; 44.74512	253	Cn	29	Md-2	41.69876; 44.79234	286	Cn-Cr
2	Sx-2	41.67025; 44.76433	255	Cn-Cr	30	Bg-2	41.68781; 44.80784	277	-“-
3	Kx-3	41.66384; 44.80876	223	-“-	31	Bg-4	41.68812; 44.80587	279	-“-

4	Kx-11	41.67016; 44.81483	220	-“-	32	Bg-6	41.68726; 44.80043	281	-“-
5	Kx-12	41.67191; 44.80206	229	-“-	33	Nr-2	41.68791; 44.80956	272	-“-
6	Kx-14	41.67262; 44.80532	231	-“-	34	Ty-2	41.68606; 44.81288	268	-“-
7	Ot-2	41.67087; 44.83550	217	Al	35	Ty-4	41.68580; 44.81202	270	-“-
8	Ot-3	41.66283; 44.87747	215	-“-	36	Un-4	41.71729; 44.71539	310	-“-
9	Zp-1	41.64281; 44.89925	204	Gr-Cn	37	Un-7	41.71841; 44.70726	313	-“-
10	Pl-1	41.63803; 44.93040	203	Al-Cr	38	Dt-3	41.72591; 44.70825	318	-“-
11	Pl-2	41.64055; 44.93427	202	-“-	39	Nc-2	41.73422; 44.71744	322	-“-
12	Ky-2	41.64574; 44.64459	235	Cn	40	Nc-5	41.72997; 44.73037	345	-“-
13	Ky-4	41.66170; 44.65142	237	-“-	41	Tq-2	41.74955; 44.68550	324	-“-
14	Dr-2	41.67016; 44.64579	240	-“-	42	Ls-2	41.73931; 44.73998	327	-“-
15	Dr-3	41.66658; 44.65155	238	-“-	43	Ls-4	41.74110; 44.74720	329	-“-
16	Dr-5	41.66899; 44.66050	243	-“-	44	On-2	41.73565; 44.73711	331	-“-
17	Kj-7	41.65925; 44.69699	250	-“-	45	Vs-2	41.74922; 44.76422	337	-“-
18	Kj-10	41.65904; 44.70620	247	-“-	46	Vs-4	41.75508; 44.75447	348	-“-
19	Kj-12	41.65857; 44.73178	252	-“-	47	Gs-2	41.73913; 44.77042	340	-“-
20	Tj-2	41.70367; 44.70393	295	Cn-Cr	48	Vd-2	41.76638; 44.75136	352	-“-
21	Tj-5	41.67601; 44.67910	298	Cn	49	Vd-4	41.76638; 44.75185	355	-“-
22	Tj-6	41.67651; 44.67930	299	-“-	50	Vd-6	41.77999; 44.71153	357	-“-
23	Bb-2	41.71312; 44.71512	291	Cn-Cr	51	Tr-8	41.76956; 44.81288	387	-“-
24	Bb-4	41.71396; 44.69906	293	-“-	52	Dg-5	41.79669; 44.74310	365	-“-
25	Bb-6	41.70601; 44.74229	301	-“-	53	Dg-7	41.80437; 44.74184	367	-“-
26	Bb-8	41.70564; 44.73715	303	-“-	54	Dg-8	41.81081; 44.70615	368	-“-
27	Vk-2	41.70603; 44.75459	289	Cn-Cr	55	Ll-2	41.69071; 45.01003	371	-“-
28	Sl-7	41.69055; 44.79087	264	-“-	56	Ll-5	41.69164; 44.99147	374	-“-

Sampling and analysis

Sampling

Samples were selected used the special hand auger directly in plastic containers (volume up to 2.0 L). After drying in laboratory conditions samples were grinded and sieved for their homogenization. Then samples were dried at the temperature 105 - 110°C to constant weight and their bulk density and weight were determined. These values were used at the description of sample geometry. The samples were sealed in Marinelli beaker.

Measurement of gamma radiation activity

Measurements were carried out using a Canberra GC2020 gamma spectrometer with a semi-conductor germanium detector with a relative efficiency of 24%. The gamma spectra acquisition time was 72 h. For the analysis, the software Genie-2000 S500 was used. Cs-137 activity concentration was determined by the 661.65 keV line.

Results

Results of measurements of Cs-137 activity concentration in the investigated soil samples are given in Table 2. Generalized data of measurement results – average (*av*), minimal (*mn*) and maximal (*mx*) values – depending on the soil type are given in Table 3.

Table 2. *Activity concentration (A, Bq/kg) of technogenic radionuclide Cs-137 in the investigated soil samples*

#	L	FN	ST	A, Bq/kg	#	L	FN	ST	A, Bq/kg
1	Tx-1	253	Cn	19.5	29	Md-2	286	Cn-Cr	1.52
2	Sx-2	255	Cn-Cr	18.5	30	Bg-2	277	-“-	90.9
3	Kx-3	223	-“-	19.7	31	Bg-4	279	-“-	103
4	Kx-11	220	-“-	4.85	32	Bg-6	281	-“-	118
5	Kx-12	229	-“-	15.4	33	Nr-2	272	-“-	62.1
6	Kx-14	231	-“-	2.8	34	Ty-2	268	-“-	36.9
7	Ot-2	217	Al	21.0	35	Ty-4	270	-“-	0.19
8	Ot-3	215	-“-	18.2	36	Un-4	310	-“-	3.11
9	Zp-1	204	Gr-Cn	1.53	37	Un-7	313	-“-	3.08
10	Pl-1	203	Al-Cr	8.70	38	Dt-3	318	-“-	17.7
11	Pl-2	202	-“-	5.94	39	Nc-2	322	-“-	1.83
12	Ky-2	235	Cn	6.54	40	Nc-5	345	-“-	0.51
13	Ky-4	237	-“-	14.1	41	Tq-2	324	-“-	4.39
14	Dr-2	240	-“-	33.1	42	Ls-2	327	-“-	37.8
15	Dr-3	238	-“-	2.61	43	Ls-4	329	-“-	38.1
16	Dr-5	243	-“-	19.8	44	On-2	331	-“-	16.3
17	Kj-7	250	-“-	3.31	45	Vs-2	337	-“-	10.1
18	Kj-10	247	-“-	24.2	46	Vs-4	348	-“-	33.2
19	Kj-12	252	-“-	15.4	47	Gs-2	340	-“-	2.94
20	Tj-2	295	Cn-Cr	2.79	48	Vd-2	352	-“-	2.79
21	Tj-5	298	Cn	4.82	49	Vd-4	355	-“-	3.92
22	Tj-6	299	-“-	34.7	50	Vd-6	357	-“-	17.6
23	Bb-2	291	Cn-Cr	3.74	51	Tr-8	387	-“-	11.9
24	Bb-4	293	-“-	7.00	52	Dg-5	365	-“-	0.24
25	Bb-6	301	-“-	7.77	53	Dg-7	367	-“-	36.7
26	Bb-8	303	-“-	28.4	54	Dg-8	368	-“-	31.1
27	Vk-2	289	-“-	9.13	55	Ll-2	371	-“-	1.02
28	Sl-7	264	-“-	5.12	56	Ll-5	374	-“-	1.80
								av	18.7
								mn	0.19
								mx	118

Table 3. *Cs-137 activity concentration depending on the type of soil*

#	ST	A, Bq/kg		
		av	*mn*	*mx*
1	Cn	16.2	2.6	34.7
2	Cn-Cr	20.3	0.19	118
3	Al	19.6	18.2	21.0
4	Al-Cr	7.3	5.9	8.7
5	Gr-Cn	1.5	-	-

Apparently from measurement results, Cs-137 activity in the studied samples changes in sufficiently wide limits – from 0.19 to 118 Bq/kg (average value – 18.7 Bq/kg). Thus, the highest values of activity were observed for soil of the type Cn-Cr – the average value was 20.3 Bq/kg, and a little bit more low – for soils of the types Al and Cn – 19.6 and 16.2 Bq/kg, accordingly. Activity concentration in the soil samples of the type Al-Cr (7.3 Bq/kg) is much less, and the least value – 1.5 Bq/kg – was measured for the soil sample of Gr-Cn.

Discussion

As may be seen from the received results, technogenic radionuclide Cs-137 was observed in all samples in sufficiently appreciable amounts. Usually its presence in soil is connected with deposition of an atmospheric precipitation in which cesium was as a result of nuclear tests in atmosphere, and also as a result of failure of the Chernobyl atomic power station in 1986. By a number of data, in particular, according to systematic observations for the flat areas of East Georgia [13], values of Cs-137 activity are now, basically, in the range 1-10 Bq/kg. With certain degree of convention it is possible to consider this level as background value for the whole territory of Georgia. Average value (18.7 Bq/kg) is greater this quantity that can be due to non-uniform precipitations following the accident. However it is impossible to exclude completely that the pollution fact could have rather recent history, considering presence of nuclear objects in surrounding geographical region. Results received for locations Bg-2, Bg-4, Bg-6, and also Nr-2 (see Table 2) located in the southern part of Sololaki ridge are of the special interest. Values of Cs-137 activity in these locations several times exceed background values as well as average value of activity.

As a whole, cesium-137 distribution in the soils of territories with a complex relief and slopes of a various layouts similar to the investigated territory in many respects depends on the many factors, such as soil moisture and a type of soil mode, a slope steepness, soil type, humus content and granulometric structure of soil fractions. Additional researches are necessary for specification of the processes influencing on the radionuclides migration in a various territories.

Conclusion

As a result of the carried out researches it was established, that activity concentration of technogenic radionuclide Cs-137 in the soil samples selected in 56 control points in the territory of some districts of Tbilisi City, changes in the range 0.19-118 Bq/kg (average value – 18.7 Bq/kg). Locations with the raised concentration of cesium are noted.

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