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Spatial ^{137}Cs distribution in forest soil

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Abstract This work presents the distribution of radioactive caesium in several types of forest soil originating from the Lesisko reserve (Opole Province, Poland). Vertical distribution of ^{137}Cs isotope was determined in the profiles related to physicochemical properties of different types of soils and their location. Thickness of emerging genetic horizons, structure and morphology of soil profiles were determined. The highest ^{137}Cs activities were found in Of and A horizons. At the same time, there was a sudden drop of ^{137}Cs activity in mineral horizons of soil profiles. By analysis of caesium radioisotope content and its distribution in soil profiles significant correlations were observed between certain physico-chemical properties (e.g. pH value, hydrolytic acidity, granulometric composition) of soils in selected forest habitats.

Key words forest • radioactive caesium • radioecology

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Introduction

The beginnings of radioecology date back to the 1950s and 1960s, when radioactive fallout originating from nuclear weapons tested in the atmosphere became the reason for the interest in occurrence of radioisotopes in the environment. Then, mainly the radioactive dose permissible for people and its effects on health were concerned; most of the research was focused on agro-ecosystems [15].

On April 26, 1986, because of the Chernobyl disaster, large quantities of radioactive substances were emitted to the atmosphere. Radionuclides released within 10 days in the form of gas, aerosols and dust spread according to weather conditions. As a result of the Chernobyl fallout, not only substantial areas of Europe were polluted, but also to a much smaller extent other continents [8, 10, 16].

During the first year after the Chernobyl fallout, high radioactivity level was also detected in the Western Europe in such products as vegetables and milk, and in products originating from natural or semi-natural ecosystems such as: game, mushrooms and berries. Then, the scope of radioecological research was significantly expanded, including natural ecosystems [22].

Almost 20 years after the Chernobyl fallout, elevated activity of ^{137}Cs is still detected in forests and wastelands. Forest soils are characterised by an unchanged system of genetic horizons in soil profile, where each horizon is distinguished by relatively monochrome colour, consistency, granulation, chemical constitution, quantity and quality of organic matter and other properties. This fact causes that soil of forest complexes is a very good material for study of migration, change in chemical composition and vertical distribution of radioisotopes.

This work discusses the content of ^{137}Cs isotope in each genetic level of soils in relation to physicochemical properties of soil types and to location of the soils.

Methods

The measurement of radiocaesium activity in samples of woodland soil was carried out by means of a gamma-spectrometer with a germanium detector HPGe (Canberra) of high resolution: 1.29 keV (FWHM) at 662 keV and 1.70 keV (FWHM) at 1332 keV. Relative

Table 1. Comparison of the examined types of soils

No. of exposure	Type of soil	Location above sea level [m]	Genetic horizons	Thickness [cm]
1	Typical fallow soil located on clayey sand	268	Ol	2–1
			Of	1–0
			A	0–5
			ABbr	5–20
			Bbr_1	20–55
			Bbr_2	55–75
			Cca	75–100
			Rca	>100
2	Typical fallow soil located on clayey sand	275	Ol	3–2
			Of	2–0
			A	0–6
			E1et	6–35
			E2et	35–60
			Bt	60–70
			C/Bt	70–85
			Cca	>85
3	Brown limestone soil formed from shell limestone	283	Ol	3–2
			Of	2–0
			A	0–7
			B1br	7–20
			B2br	20–30
			Bbr/Cca	30–37
			Cca	>37
4	Brown limestone soil formed from Jurassic limestone	290	Ol	3–2
			Of	2–0
			A	0–5
			B1br	5–25
			B2br	25–45
			Bbr/Cca	45–65
			Rca	>65
5	Typical fallow soil located on clayey sand	280	Ol	3–2
			Of	2–0
			Ah	0–6
			Eet	6–32
			Bt	32–60
			BtC	60–105
			C	>105
6	Typical fallow soil located on clayey sand	310	Ol	2–1
			Of	1–0
			Ah	0–5
			B1br	5–32
			B2br	32–55
			B3br	55–78
			C1	78–120
			C2	>120
7	Typical fallow soil located on clayey sand	281	Ol	2–1
			Of	1–0
			Ah	0–7
			B1br	7–38
			B2br	38–73
			C	73–110
			Cca	>100

efficiency: 21.7%. Energy and efficiency calibration of the gamma spectrometer was performed with standard solutions, type MBSS 2 (Czech Metrological Institute, Praha), which covers an energy range from 59.54 keV (^{241}Am) to 1836.06 keV (^{88}Y). Geometry of calibration source and samples: Marinelli 450 cm^3. Measuring process and analysis of spectra were computer controlled with the use of software GENIE 2000.

The following physicochemical properties of soils were determined, using methods generally applied in soil science:

- granulometric composition – by the aerometric method according to the modified Prószyński method,
- soil acidity (pH) – by the potentiometric method in 1 M KCl (at soil/solution ratio 1:10 (mineral soil) or 1:1.25 (organic soil) and in distilled water (1:10 or 1:2, respectively),
- hydrolytic acidity (Hh) – by the Kappen method in 1 M CH_3COONa,
- total basic positive ions (S) – by the Kappen method in 0.1 M HCl,
- percentage of $CaCO_3$ – by the Scheibler method.

The sampling area was the Lesisko nature reserve (Poland), covered by the partial protection, located within the National Scenic Park of St. Anna Mountain in Zdzieszowice commune, near the Żyrowa village. It belongs to the Strzelce Opolskie forest inspectorate. There are fallow, limestone soils in the Lesisko reserve. Seven soil profile exposures were carried out during field works.

The Lesisko reserve is almost completely overgrown with beech stand (of estimated age 130–165 years). Alder dominates only in some places on land depressions. There are larches, oaks, maples and sycamores as admixture species.

Results and discussion

Description of soil profiles is presented in Table 1. In this table denotations of each genetic (sub-)horizons was introduced in compliance with [11]: Ol – fresh litter sub-horizon; Of – fermentative sub-horizon; A – humus horizon; Ah – humus sub-horizon, contracting the humicated organic matter; Eet – eluvial sub-horizon; Bbr – enrichment sub-horizon; Cca – bedrock sub-horizon; Rca – rocky basis.

Results of the measurements of ^{137}Cs activity and physicochemical properties of examined soils are presented in Tables 2–15. The data of radiometric measurements (Table 16) were calculated for May 1, 2004.

Table 2. Physicochemical properites – profile 1

No.	Genetic horizons	Thickness [cm]	^{137}Cs [Bq/kg d.m.]	pH KCl	pH H_2O	Hh	S	T	V_S [%]	$CaCO_3$ [%]
							Cmol(+)/kg			
1	Ol	2–1	7.8 ± 0.4	5.25	6.15	41.60	51.20	92.80	55.2	–
2	Of	1–0	79 ± 1	5.19	6.07	34.80	61.20	96.00	63.8	–
3	A	0–5	34.7 ± 0.3	4.96	6.05	4.50	4.20	8.70	48.3	–
4	ABbr	5–20	0.2 ± 0.01	6.51	7.40	0.80	10.95	11.75	93.2	–
5	Bbr_1	20–55	–	7.02	7.81	0.21	15.55	15.76	98.7	–
6	Bbr_2	55–75	–	7.12	7.82	0.41	–	–		0.8
7	Cca	75–100	–	7.19	7.99	0.37	–	–		0.8
8	Rca	>100	–				Rubble			79.8

pH_{KCl} and pH_{H_2O} – the reaction values determined for KCl and aqueous solutions, respectively.
Hh – hydrolytic acidity. S – sum of basic exchangeable cations. T – sorption complex capacity; $T = S + Hh$.
V_S – degree of sorption complex saturation by basic cations; $V_S = S/T$.

Table 3. Physicochemical properties – profile 2

No.	Genetic horizons	Thickness [cm]	^{137}Cs [Bq/kg d.m.]	pH KCl	pH H_2O	Hh	S	T	V_S [%]	$CaCO_3$ [%]
							Cmol(+)/kg			
1	Ol	3–2	6.2 ± 0.4	5.25	6.15	44.00	45.60	89.60	50.9	–
2	Of	2–0	90 ± 1	4.87	6.02	57.60	44.00	101.60	43.3	–
3	A	0–6	31.89 ± 0.4	4.28	3.52	8.18	2.30	10.48	21.9	–
4	E1et	6–35	0.16 ± 0.04	4.45	4.08	3.17	1.85	5.02	36.9	–
5	E2et	35–60	–	4.58	4.14	2.96	1.75	4.71	37.2	–
6	Bt	60–70	–	5.42	4.41	2.33	7.90	10.23	77.2	–
7	C/Bt	70–85	–	5.54	4.35	2.10	8.15	10.25	79.5	–
8	Cca	>85	–	7.76	7.18	0.41	–	–		6.50

Meanings of denotations are the same as in Table 2.

Table 4. Physicochemical properties – profile 3

No.	Genetic horizons	Thickness [cm]	^{137}Cs [Bq/kg d.m.]	pH		Hh	S	T	V_S [%]	$CaCO_3$ [%]
				KCl	H_2O		Cmol (+)/kg			
1	Ol	3–2	6.4 ± 0.3	5.33	6.40	35.60	55.60	91.20	61.0	–
2	Of	2–0	79.9 ± 0.8	5.22	6.38	34.40	37.60	72.00	52.2	–
3	A	0–7	91 ± 1	3.57	4.12	31.00	4.55	35.55	12.8	–
4	B1br	7–20	0.2 ± 0.03	3.95	4.51	4.89	1.60	6.49	24.7	–
5	B2br	20–30	–	4.06	4.69	5.80	1.75	7.55	23.2	–
6	Bbr/Cca	30–37	–	4.68	5.66	6.40	–	–		7.5
7	Cca	>37	–				Rubble			78.5

Meanings of denotations are the same as in Table 2.

Table 5. Physicochemical properties – profile 4

No.	Genetic horizons	Thickness [cm]	^{137}Cs [Bq/kg d.m.]	pH		Hh	S	T	V_S [%]	$CaCO_3$ [%]
				KCl	H_2O		Cmol(+)/kg			
1	Ol	3–2	7.0 ± 0.4	5.33	6.26	34.00	48.80	82.80	58.9	–
2	Of	2–0	99 ± 1	5.34	6.13	38.00	47.80	85.80	55.7	–
3	A	0–5	99 ± 1	3.43	3.95	14.40	6.05	20.45	29.6	–
4	B1br	5–25	0.36 ± 0.04	3.63	4.88	7.65	1.95	9.60	20.3	–
5	B2br	25–45	–	3.78	4.92	6.42	3.50	9.92	35.3	–
6	Bbr/Cca	45–65	–	6.03	6.83	1.80	–	–	–	4.5
7	Rca	>65	–				Rubble			59.8

Meanings of denotations are the same as in Table 2.

The soil samples studied differ significantly in physicochemical properties (Tables 2–15).

On the basis of the field and laboratory research, two sub-types of soils were determined in the examined area: brown limestone soils and typical fallow soils. The morphology and physicochemical properties of the examined profiles are mainly dependent on the properties of their bedrock.

The pH value of examined soils is in a wide range that results chiefly from the property of bedrocks and the influence of other soil-forming factors, principally flora and climate.

Aerosols and dust fractions with predomination of clayey dust are most abundant in the examined soil profiles.

Brown limestone soils in deeper layers are mainly formed from light or medium clays. Humus and sub-humus horizons of such soils are characterised by the grain-size composition of clayey sands or sandy dusts. The framework (skeletal parts) is formed by pieces of limestone on the deepest horizon.

On the basis of the research carried out, considerable differences of ^{137}Cs activity (especially for Of) in between the soil horizons were identified. The highest activity was found in the organic horizons Of and A. In the deeper, mineral soil horizons (B, C), practically no presence of ^{137}Cs was detected. Low ^{137}Cs activity was identified in Ol sub-horizon. The range of measured ^{137}Cs activities for Ol sub-horizon was within 0.8–11.9 Bq/kg d.m. This means that the low humificated plant

Table 6. Physicochemical properties – profile 5

No.	Genetic horizons	Thickness [cm]	^{137}Cs [Bq/kg d.m.]	pH		Hh	S	T	V_S [%]	$CaCO_3$ [%]
				KCl	H_2O		Cmol(+)/kg			
1	Ol	3–2	5.6 ± 0.3	5.05	5.89	48.35	34.85	83.20	41.9	–
2	Of	2–0	33 ± 5	4.27	4.91	61.20	25.80	87.00	29.7	–
3	Ah	0–6	136 ± 1	3.83	4.65	30.40	4.65	35.05	13.3	–
4	Eet	6–32	8.0 ± 0.5	4.40	4.96	5.65	0.05	5.70	0.9	–
5	Bt	32–60	–	4.23	5.05	9.90	2.45	12.35	19.8	–
6	BtC	60–105	–	4.49	5.27	3.10	5.50	8.60	64.0	–
7	C	>105	–	4.48	5.35	2.20	5.00	7.20	69.4	–

Meanings of denotations are the same as in Table 2.

Table 7. Physicochemical properties – profile 6

No.	Genetic horizons	Thickness [cm]	^{137}Cs [Bq/kg d.m.]	pH KCl	pH H_2O	Hh	S	T	V_S [%]	$CaCO_3$ [%]
							Cmol(+)/kg			
1	Ol	2–1	0.80 ± 0.04	5.03	5.89	52.30	34.20	86.50	39.5	–
2	Of	1–0	128 ± 1	4.15	5.12	68.40	42.20	110.60	38.2	–
3	Ah	0–5	134 ± 1	3.84	4.62	30.30	6.50	36.80	17.7	–
4	B1br	5–32	0.01 ± 0.01	4.33	5.27	7.05	2.85	9.90	28.8	–
5	B2br	32–55	–	4.16	5.19	10.65	3.45	14.10	24.5	–
6	B3br	55–78	–	4.53	5.54	5.40	6.60	12.00	55.0	–
7	C1	78–120	–	4.64	5.46	2.20	7.75	9.95	77.9	–
8	C2	>120	–	4.75	5.92	1.85	8.60	10.45	82.3	–

Meanings of denotations are the same as in Table 2.

Table 8. Physicochemical properties – profile 7

No.	Genetic horizons	Thickness [cm]	^{137}Cs [Bq/kg d.m.]	pH KCl	pH H_2O	Hh	S	T	V_S [%]	$CaCO_3$ [%]
							Cmol(+)/kg			
1	Ol	2–1	11 ± 6	4.88	5.48	32.40	57.80	90.20	64.1	–
2	Of	1–0	38.5 ± 0.6	4.03	5.05	64.00	40.80	104.80	38.9	–
3	Ah	0–7	118 ± 1	3.91	4.29	23.70	7.35	31.05	23.7	–
4	B1br	7–38	0.8 ± 0.2	4.22	4.74	5.10	5.59	10.69	52.3	–
5	B2br	38–73	–	4.32	4.85	3.10	1.35	4.45	30.3	–
6	C	73–110	–	4.69	5.78	1.85	5.30	7.15	74.1	–
7	Cca	>110	–	6.78	7.68	0.20	–	–		34.8

Meanings of denotations are the same as in Table 2.

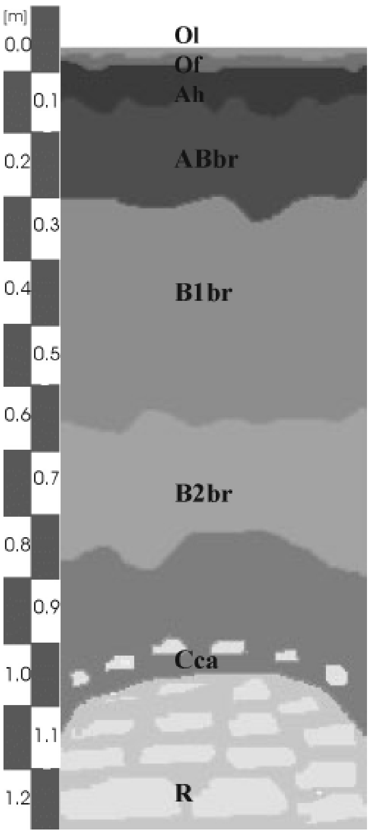

Fig. 1. Horizon denotations in soil profiles.

materials have a small sorption capacity. However, the presence of ^{137}Cs in the sub-horizon Ol reflects continuous circulation of the isotope in the soil–plants–soil system [7, 14, 21].

Caesium circulation between the elements of woodland ecosystem lead to almost complete preservation of caesium in a ten-centimetre thick surface soil layer. The explanation is supported by the literature data [1–3, 9, 12, 17–19] and our earlier research [7, 21].

The horizon denotation in soil profile was presented in Fig. 1, while the ^{137}Cs activities in all 7 soil profiles were shown in Fig. 2.

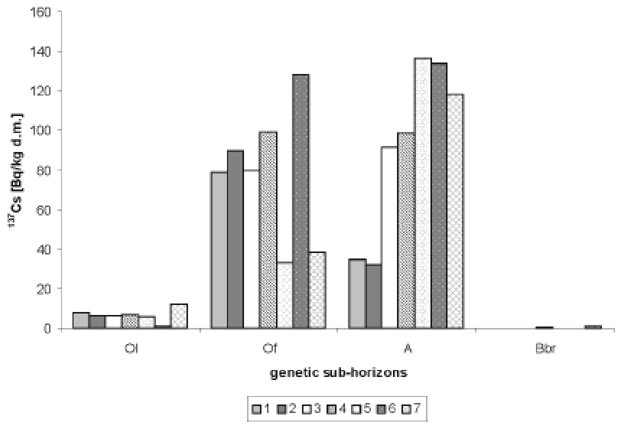

Fig. 2. ^{137}Cs activity in all 7 soil profiles studied.

Table 9. Granulometric composition – profile 1

No.	Genetic horizons	Thickness [cm]	Skeletal parts [%]	Fine earth Ø 1.0–0.5 mm [%]	Ø 0.5–0.25 mm [%]	Ø 0.25–0.1 mm [%]	Ø 0.1–0.05 mm [%]	Ø 0.05–0.02 mm [%]	Ø 0.02–0.005 mm [%]	Ø 0.005–0.002 mm [%]	Ø <0.002 mm [%]
1	Ol	2–1		Organic matter							
2	Of	1–0									
3	A	0–5	1.6	15	23	22	23	16	1	0	0
4	ABbr	5–20	3.4	15	28	21	16	4	5	1	6
5	B1br	20–55	1.8	17	30	23	10	8	5	1	6
6	B2br	55–75	1.6	16	30	23	19	8	5	1	6
7	Cca	75–100	3.2	12	22	12	18	7	5	3	21
8	R	>100	48.8	Rubble							

Ø – granulometric fraction diameters.

Table 10. Granulometric composition – profile 2

No.	Genetic horizons	Thickness [cm]	Skeletal parts [%]	Fine earth Ø 1.0– 0.5 mm [%]	Ø 0.5–0.25 mm [%]	Ø 0.25–0.1 mm [%]	Ø 0.1–0.05 mm [%]	Ø 0.05–0.02 mm [%]	Ø 0.02–0.005 mm [%]	Ø 0.005–0.002 mm [%]	Ø <0.002 mm [%]
1	Ol	3–2		Organic matter							
2	Of	2–0									
3	A	0–6	0.9	5	20	15	29	24	4	2	1
4	E1et	6–35	1.4	13	25	15	21	11	9	1	5
5	E2et	35–60	1.3	11	28	18	27	7	4	0	5
6	Bt	60–70	1.2	11	23	17	21	6	4	0	18
7	C/Bt	70–85	2.1	11	22	17	23	7	3	0	17
8	Cca	>85	4.6	8	14	18	30	14	11	0	5

Ø – granulometric fraction diameters.

Table 11. Granulometric composition – profile 3

No.	Genetic horizons	Thickness [cm]	Skeletal parts [%]	Fine earth Ø 1.0–0.5 mm [%]	Ø 0.5–0.25 mm [%]	Ø 0.25–0.1 mm [%]	Ø 0.1–0.05 mm [%]	Ø 0.05–0.02 mm [%]	Ø 0.02–0.005 mm [%]	Ø 0.005–0.002 mm [%]	Ø <0.002 mm [%]
1	Ol	3–2		Organic matter							
2	Of	2–0									
3	Ah	0–7	0.3	12	20	19	10	31	8	0	0
4	B1br	7–20	2.7	13	24	22	11	11	13	2	4
5	B2br	20–30	2.1	15	23	20	9	12	12	2	8
6	Bbr/Cca	30–37	3.2	10	13	14	8	11	12	3	29
7	Rca	>37	78.0	Rubble							

Ø – granulometric fraction diameters.

Table 12. Granulometric composition – profile 4

No.	Genetic horizons	Thickness [cm]	Skeletal parts [%]	Fine earth Ø 1.0–0.5 mm [%]	Ø 0.5–0.25 mm [%]	Ø 0.25–0.1 mm [%]	Ø 0.1–0.05 mm [%]	Ø 0.05–0.02 mm [%]	Ø 0.02–0.005 mm [%]	Ø 0.005–0.002 mm [%]	Ø <0.002 mm [%]
1	Ol	3–2		Organic matter							
2	Of	2–0									
3	Ah	0–5	1.1	10	16	19	17	28	9	1	0
4	B1br	5–25	0.1	10	18	17	13	13	14	5	10
5	B2br	25–45	0.7	9	18	17	11	14	11	4	16
6	BbrC	45–65	1.5	8	12	11	8	8	9	3	41
7	Rca	>65	52.6	Rubble							

Ø – granulometric fraction diameters.

Table 13. Granulometric composition – profile 5

No.	Genetic horizons	Thickness [cm]	Skeletal parts [%]	Fine earth Ø 1.0–0.5 mm [%]	Ø 0.5–0.25 mm [%]	Ø 0.25–0.1 mm [%]	Ø 0.1–0.05 mm [%]	Ø 0.05–0.02 mm [%]	Ø 0.02–0.005 mm [%]	Ø 0.005–0.002 mm [%]	Ø <0.002 mm [%]
1	Ol	3–2	Organic matter								
2	Of	2–0									
3	Ah	0–7	0.0	5	7	11	26	36	13	2	0
4	Eet	7–32	0.0	3	6	8	17	36	20	2	8
5	Bt	32–60	0.0	2	3	6	18	34	14	3	20
6	BtC	60–105	0.0	3	6	8	18	32	13	2	18
7	C	>105	0.0	4	6	11	21	33	11	2	12

Ø – granulometric fraction diameters.

Table 14. Granulometric composition – profile 6

No.	Genetic horizons	Thickness [cm]	Skeletal parts [%]	Fine earth Ø 1.0–0.5 mm [%]	Ø 0.5–0.25 mm [%]	Ø 0.25–0.1 mm [%]	Ø 0.1–0.05 mm [%]	Ø 0.05–0.02 mm [%]	Ø 0.02–0.005 mm [%]	Ø 0.005–0.002 mm [%]	Ø <0.002 mm [%]
1	Ol	2–1	Organic matter								
2	Of	1–0									
3	Ah	0–8	0.0	4	5	6	36	34	9	2	4
4	B1br	8–32	0.0	4	5	7	21	32	17	2	12
5	B2br	32–55	0.0	4	5	6	18	36	12	3	16
6	B3br	55–78	0.0	3	4	8	25	33	9	2	16
7	C1	78–120	0.0	2	5	11	30	32	8	0	12
8	C2	>120	0.0	2	3	5	22	43	12	1	12

Ø – granulometric fraction diameters.

Table 15. Granulometric composition – profile 7

No.	Genetic horizons	Thickness [cm]	Skeletal parts [%]	Fine earth Ø 1.0–0.5 mm [%]	Ø 0.5–0.25 mm [%]	Ø 0.25–0.1 mm [%]	Ø 0.1–0.05 mm [%]	Ø 0.05–0.02 mm [%]	Ø 0.02–0.005 mm [%]	Ø 0.005–0.002 mm [%]	Ø <0.002 mm [%]
1	Ol	2–1	Organic matter								
2	Of	1–0									
3	Ah	0–7	0.0	4	8	9	30	37	9	1	2
4	B1br	7–38	0.0	8	13	13	17	27	14	1	7
5	B2br	38–73	0.0	9	19	17	12	22	13	3	5
6	C	73–110	0.0	6	16	20	17	14	8	3	16
7	Cca	>110	41.8	9	12	13	10	12	13	9	22

Ø – granulometric fraction diameters.

Table 16. Average activities of ^{137}Cs on the genetic horizons [Bq/kg d.m.]

	Minimum	Maximum	Average
Ol	0.8	11.9	6.53
Of	33.3	128.0	78.03
A	31.9	136.3	89.6

Table 17. Correlation coefficient values for the dependence between the ^{137}Cs activity and some physico-chemical properties on Ol, Of and A horizons ($p = 0.05$)

	pH_{KCl}	pH_{H_2O}	H^+	Hh	S	T	V_S
Ol	–0.151	–0.308	0.512	–0.811*	0.805*	0.355	0.820*
Of	0.313	0.378	–0.506	–0.115	0.436	0.222	0.347
A	–0.788*	–0.499	0.350	0.895*	–0.273	0.880*	–0.756*

* Significant correlations.

Table. 18. Correlation coefficient values for the relation between ^{137}Cs "activity in the humus horizon and the soil granulometric composition $p = 0.05$)

	1.0–0.1 mm	0.1–0.02 mm	<0.02 mm
^{137}Cs	–0.796*	0.693*	0.955*

* Significant correlations.

Table 16 presents the average ^{137}Cs activities on the same genetic horizons of profiles.

A diverse soil ^{137}Cs activity was found depending on the height above of the sea level of the place of sampling. The lowest activity was detected in the upper part of the slope (except for site no. 7), whereas the highest – in the lower part. It seems that the reason for caesium accumulation in the lower part of the slope might be the deposition of the soil material carried off from the slope. Similar observations were made in [4].

The determined caesium isotope content and its distribution in profiles, correlated significantly with certain physicochemical properties of the soils studied (Tables 17 and 18).

The statistical analysis of the data obtained showed linear dependencies between some of the studied parameters.

The determined ^{137}Cs content and its distribution in profiles was correlated significantly and marked with asterix (*) with certain physicochemical properties of the soils studied (Tables 17 and 18). But the mutual correlations between soil properties were also observed. There were found statistically significant correlations between pH_{KCl}, pH_{H_2O} and Hh parameters in Of and Ol horizons. Additionally, for the Ol horizon a significant correlation between Hh and *S* parameters was observed.

In humus A horizon, only a pH_{H_2O} and Hh correlation was found, but exclusion of the point representing the lowest pH of soil (Table 2, horizon ABbr) was needed. The statistically significant correlations were found between granulometric parameters of soil in this horizon. Taking only one of the granulometric parameters, the remaining two ones could be computed.

Statistical analysis has shown that the ^{137}Cs content in Ol horizon depended significantly on Hh, *S* and V_S parameters (Table 17). For the Of horizon, no significant correlations between the ^{137}Cs activity and the soil physicochemical properties have been noticed. In humus horizon (A), significant dependences between the ^{137}Cs activity and Hh, *T* parameters were found but negative correlations among ^{137}Cs activity and pH_{KCl} and V_S parameters were also determined. In the humus horizon with greater sorption capacity, the considerably greater ^{137}Cs activity was observed. In humus horizon (A), significant dependences between the ^{137}Cs activity and soil granulometric composition was also found (Table 18). With the increase in percentage of dust fraction the activity of ^{137}Cs was increased too.

Conclusions

- The ^{137}Cs content in soil profiles from the Lesisko reserve is highly diversified. Relatively high content of ^{137}Cs was determined for Of and A horizons. A significant decrease of ^{137}Cs activity in successive levels of the profile was found.
- The ^{137}Cs activities measured in the Lesisko reserve are relatively low as compared with high activities detected in the nearby area of Opole Anomaly [5, 6, 13, 20].

  The statistical analysis showed that there were significant correlations between certain physicochemical properties (e.g. Hh, *S*, *T*, granulometric composition) of soils of selected forest habitats.
- Forest soils are a valuable source of information regarding distribution of anthropogenic isotopes in the soil profile.

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