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STUDIES ON ^{137}CS CONTENT OF LICHENS IN MOUNTAIN REGIONS OF ROMANIA

Untersuchungen zum ^{137}Caesium-Gehalt von Flechten aus den Gebirgsgegenden Rumäniens

by

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Key words: Lichens, ^{137}Cs, Chernobyl, environmental influence, monitoring.

Schlagwörter: Flechten, ^{137}Cs, Tschernobyl, Umwelteinflüsse, Monitoring.

Summary: A number of 193 lichen samples from 26 sample sites, all of which in forest ecosystems, at altitudes from 780 to 1500 m, were collected for ^{137}Cs activity concentration analyses, between May 1, 1993 and May 1, 1995 in the Carpathian Mountains of Romania. Same time, we have used the experience gathered in the previous years (1986-1992) from Retezat and Vlădeasa Mountains. The measured samples displayed a wide range of ^{137}Cs activities (1.46-14.19 Bq/g) in lichens; they were influenced by: microclimate features, forest type, stationary altitude, microhabitat and age of the thallus.

Zusammenfassung: In der Zeitspanne 1. Mai 1993 bis 1. Mai 1995 wurden 193 Flechtenproben von 26 Standorten aus Waldbeständen der Rumänischen Karpaten in 780 - 1500 m Höhe zur Bestimmung der ^{137}Caesium-Aktivität gesammelt. Verwendet wurden auch Ergebnisse früherer Jahre (1986 -1992) aus dem Retezat- und Vlădeasa-Gebirge. Die Untersuchungen berücksichtigten nur die mengenmässig vorherrschenden und häufigsten epiphytischen und erdbewohnenden Flechtenarten. Die Werte der ^{137}Cs-Aktivitäten variierten bei den untersuchten Flechtenproben zwischen 1,46-14,19 Bq/g; die ^{137}Cs-Aktivitäten wurden durch mikroklimatische Faktoren, Art des Waldbestandes, Höhenlage, Mikrohabitat und Alter der Thalli beeinflußt.

Ten years ago (27. April - 10. May 1986), an important part of Europe was contaminated by the Chernobyl reactor accident. Romania was one of the most radiopolluted countries, due to its geographical position, climatical and environmental conditions (1,2).

Increasing attention has been paid to the behaviour, deposition and cycling of radionuclides in forest ecosystems. The lichens have long been recognized as efficient accumulators of many elements (heavy metals and radionuclides) released into the atmosphere because of natural and human activities; the quantitative interpretation their radioactivity data is complicated by a lot of environmental, climatical conditions together with their morphological and physiological features (6,3,11).

The aim of our paper is to study the local deposition pattern of the ^{137}Cs in lichens, depending on the ecological elements in the different forest ecosystems of the Carpathian Mountains.

Material and methods

A number of 193 lichen samples were collected for ^{137}Cs activity concentration (AC) analyses, between May 1, 1993 and May 1, 1995, in five regions of the Carpathian Mountains of Romania:

a) Ceahlău Mt;

b) Obcinele Mt (East Carpathians);

c) Vrancea Mt (Carpathian curvature);

d) Retezat Mt (South Carpathians) and

e) Vlădeasa Mt (Romanian West Carpathians), including 26 sample sites, all of which in forest ecosystems (beech and spruce forests), at altitudes from 780 to 1500 m. Furthermore, we have used the experience gathered in the previous years (1986-1992) from Retezat and Vlădeasa Mts.

Our attention was limited to the most abundant and frequent lichen species *Pseudevernia furfuracea, Hypogymnia physodes* (epiphyte) and *Peltigera canina* (terricolous). The lichen samples were prepared using DAROCZY's et al. (4) original procedure, the ^{137}Cs counting were performed by gammaspectrometry.

All AC data obtained are corrected to the time of collection using $T_{1/2}$ - 30.14 y and $T_{1/2biol}$ - 2.46 y (10) and expressed in Bq/g dry weights.

Results and discussion

^{137}Cs concentration in lichens before and after the Chernobyl accident:

A comparison of AC data before and after the Chernobyl accident in Vlădeasa Mts (Fig. 1) shows significant differences. The low ^{137}Cs content detected in 1975 was due to the aboveground nuclear explosion in China (1960). After Chernobyl, the AC has greatly increased (aprox. 80-90 times) both in

epiphyta and terricolous lichen species. In the absence of any new radioactive fallouts, due to radiological and biological half life times, the decay of radioactivity was observed in 1993.

Depending on their morphology, significant differences are noticed among the studied lichen families. The lowest values have been reported in the case of *Usneaceae*, which could be due to the filamentous-cylindric aspect of the thallus and their position, which allow an easy leaching of rain polluted water.

These measurements suggest that lichens are suitable and unexpensive biological monitors of the fallout pattern.

Influence of forest type:

We have found, in accordance with HEINRICH's (8) and RAITIO's (11) statement, but without firm conclusions, that in the same studied mountains the radiocontamination of spruce forests' lichens is higher than that of mixed ones (Fig. 2).

Influence of altitude:

There are controversial opinions (5,9) concerning the relationship between cesium concentration activity in lichens and the altitude of ecosystems they were taken from. In the seven studied species by us from the Retezat Mts (Fig. 3) cesium content tends to increase with altitude. Considering their standard deviation values, these have not a statistical support (average values: 1.72 Bq/g ± 0.41 at 780 m altitude; 1.87 Bq/g ± 0.28 at 1100 m altitude; 2.43 Bq ± 0.46 at 1500 m altitude, respectively).

In the other studied mountains of Romania, these correlations are weaker.

Influence of age:

There are studies on lichen growth rates which provide a basis for generalization as well as reports on the accumulation of metals with the increasing thallus age (3, 7).

The epiphyta species searched by us: *Pseudevernia furfuracea* and *Hypogymnia physodes* grow apically, increasing in length. Their base fragment, which is the old one, has been found to be cir. twice as much contaminated as the younger part of the lichen (Table 1).

The terricolous lichens *Peltigera canina* and *Hypogymnia bitteriana* have a centrifugal growth pattern, the thallus grows outwardly with uniform margins. Our measurements show that the inner part of their thallus, which is the oldest, has the highest ^{137}Cs activity (Table 1).

Distribution of ^{137}Cs in lichens located on spruce fir:

Detailed information on the intrastational distribution of ^{137}Cs in lichens

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is rare and often controversial (3, 6, 8, 11).

Our results with *Hypogymnia physodes* show a fairly conventional contamination pattern, with the highest levels found at the top of the spruce, and large variation within the lower compartments, attributable to redistribution of the radionuclide deposit (Table 2). The amount and frequency of rain have played a fundamental role in the polluting uptake, particularly in retention and migration. In terms of the radioactive rain quantity (in the period 27 April - 10 May), we describe two types of deposition on spruce firs:

- in Vrancea Mts, because of reduced precipitation in that period (4.8 mm) we have measured significant differences (8.7 - 2.6 Bq/g) between the *Hypogymnia physodes* located at the top and at the bottom of the spruce.
- in Vlădeasa Mts, because of the important amount of precipitation (32.5 mm) the pollutants were gradually washed down, homogenizing the radiocontamination, so there are no significant vertical differences in the accumulation ability of lichens, located either on trunks (3.63 - 2.98 Bq/g) or on branches (5.55 - 4.82 Bq/g).

At the same time, we measured approx. 30% differences in ^{137}Cs activity of *Hypogymnia physodes* located on the external (2.5 Bq/g) or internal part (1.74 Bq/g) of the same branch. Other similar samples are in course of processing; the *Hypogymnia physodes* located on spruce branches are more contaminated than those on trunks.

The possible explanation are: the vertical position of the lichens growing on trunks, so the rain water lets out very fast; and their sheltering by the branches and leaves of the tree, which reduced the absorbtion and accumulation of radionuclides.

Conclusions

Radiocesium, resulted from the Chernobyl accident, is still detectable in 1995 in lichens from Romania, indicating great sensitivity to environmental radioactivity, that makes them suitable for obtaining reliable information on radionuclide distribution.

The ^{137}Cs contamination was influenced by microclimatic features, mainly the local rain folls and washing condition between April 26 and May 10, 1986; microhabitat: higher AC in spruce forest then in mixed one, on branches then on trunks in lichens localised undercanopy than in open places; altitude, which is not statistically supported; age, the old part of the thallus contains higher AC.

The most relevant result of our study is perhaps the conclusion, that the collecting methodology of lichens has an outstanding importance.

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Table 1: The influence of thallus age on radionuclides deposition (Bq/g).

Localization	Lichen sp.	Collection year	Lichen part / ^{137}Cs	
			Old	Young
Terricolous	*Hypogymnia bitteriana*	1993	3.52	0.82
	Peltigera canina I	1994	1.76	1.20
	Peltigera canina II	1994	0.63	0.39
	Peltigera canina III	1994	1.51	1.12
Epiphyta	*Pseudevernia furfuracea* I	1994	4.80	1.73
	Pseudevernia furfuracea II	1994	1.80	1.46
	Pseudevernia furfuracea III	1994	7.06	3.65
	Hypogymnia physodes I	1994	4.39	1.42
	Hypogymnia physodes I	1994	2.32	1.17
	Usnea florida	1994	1.47	0.44

Table 2: Vertical distribution of ^{137}Cs in *Hypogymnia physodes* located on spruce firs.

Mountains - spruce total high (m)	Collecting		^{137}Cs Bq/g
	Habitat	High (m)	
Vrancea - 26	trunk	9 - 13.5	2.62
		13.5 - 18	3.89
		18 - 22.5	7.09
	trunk+branch	18 - 26	8.70
	Mean		5.57 ± 2.80
Vládeasa - 19	trunk	0 - 4.5	2.98
		4.5 - 9	3.60
		9 - 13	2.07
		13.5 - 19	3.63
	branch	0 - 4.5	4.82
		4.5 - 9	3.90
		9 - 13.5	3.78
		13.5 - 19	5.55
	Mean		3.80 ± 1.04

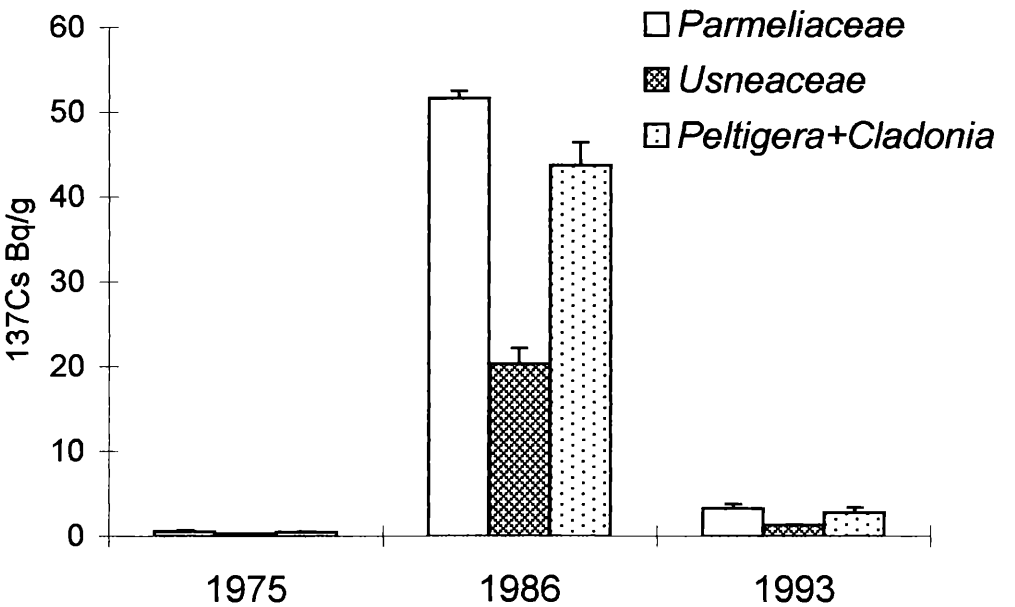


Fig. 1: ^{137}Cs activity concentration of lichens before and after the Chernobyl accident (Vladeasa Mt)

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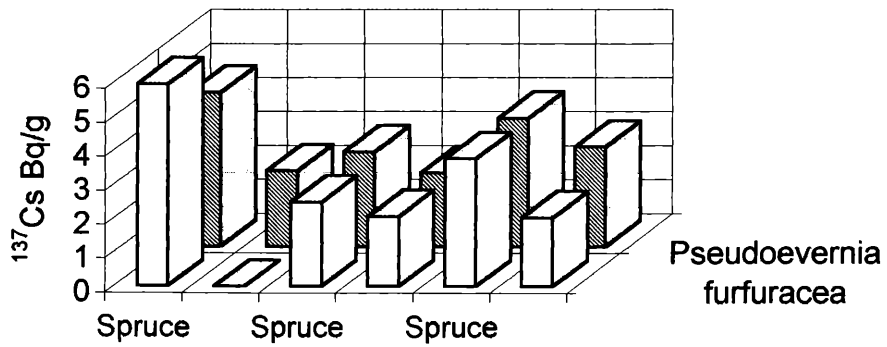


Fig. 2: ^{137}Cs activity concentration of lichens in different forest type.

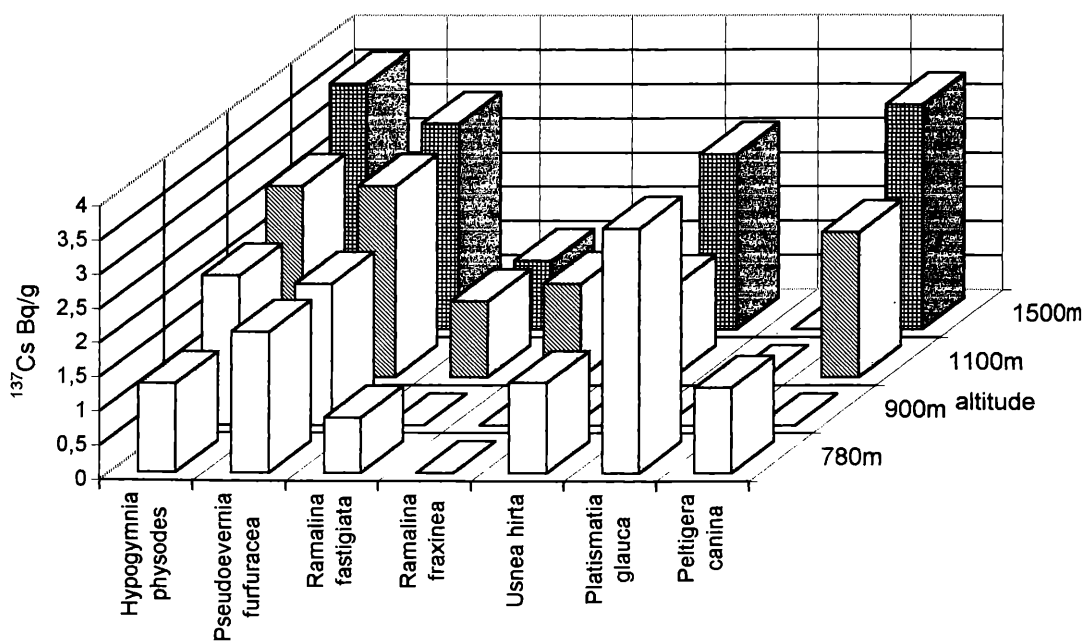


Fig. 3 Altitude dependance of radiocontamination in Retezat Mts.

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