CONTAMINATION OF SLOVAK BILBERRY (*Vaccinium myrtillus* L.) WITH RADIOCAESIUM ^{137}Cs IN SELECTED SLOVAK LOCATIONS

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ABSTRACT

The aim of this study was to determine the activity of post-Chernobyl ^{137}Cs in Slovak bilberry (*Vaccinium myrtillus* L.) from selected locations of Slovakia depending upon: the season, location and the soil-plant transfer factor (TF). The ^{137}Cs activity was determined in samples of forest soil and bilberry bushes (stems, leaves and fruits) growing on the soil in three locations: Arboretum Mlyňany (1), Hodruša-Hámre (2) and Javorníky (3). Altogether we collected 35 samples; namely 15 samples from Arboretum Mlyňany, 10 samples from Hodruša-Hámre and 10 from Javorníky. The samples of soil were examined also for the activity of ^{40}K . The samples were collected in the spring, summer and autumn in the years 2019 and 2020 and were analysed by a gamma-ray spectrometry method. The highest levels of ^{137}Cs activity concentrations were determined in Hodruša-Hámre in September where they reached $161 \pm 13 \text{ Bq.kg}^{-1}$ in the soil, $3.95 \pm 1.07 \text{ Bq.kg}^{-1}$ in the stems and $14.7 \pm 4.26 \text{ Bq.kg}^{-1}$ in the leaves. The lowest levels were determined in the

Arboretum Mlyňany in October where the ^{137}Cs activity in the soil reached $13.1 \pm 1.15 \text{ Bq.kg}^{-1}$, while in the stems, leaves and fruits it was lower than the minimum detectable level. In the latter location, we also determined the highest activity of ^{40}K , the radioactive isotope physiologically and metabolically similar to ^{137}Cs . The mass activity of ^{137}Cs in all samples of bilberries were lower than the minimum detectable activity (MDA). The comparison of the results obtained in this study with the limit for total mass activity of radiocaesium ($^{134}\text{Cs} + ^{137}\text{Cs}$) in the food (600 Bq.kg^{-1}) allowed us to conclude that the fruits, stems and leaves of Slovak bilberries present neither health nor environmental risk.

Key words: gamma-ray spectrometry; radioactivity; radiocaesium; *Vaccinium myrtillus* L.; transfer factor

INTRODUCTION

Slovak bilberry (*Vaccinium myrtillus* L., Ericaceae) belongs among the boreal bushes with densely entwined

roots and individual plants occupying sometimes an area of several square metres.

Bilberry fruits have been an important part of local diets in many countries, including Slovakia. They are valued for their pleasant taste and aroma and are often processed into jams, preserves, juices, and alcoholic beverages. They are rich in anthocyanins which make for the intense dark purple coloration of the fruit, as well as all processed foods made from the berries [26]. Their high market value is caused by their relatively difficult availability—bilberry bushes only grow in the wild, montane areas. It is not possible to cultivate them due to very specific soil demands and the fruit harvesting is a tedious, tiring work, as it is done using either by hands or small harvesting rakes [18, 28].

European Medicines Agency considers bilberry fruits a traditional herbal medicinal product that is used either for treatment of mild diarrhoea and oral mucosa inflammation, or for the treatment of capillary fragility and heavy legs caused by venous circulatory disturbances [8]. Fruits are used in teas, juices, wine, tinctures, and capsules also against fever, cold and night blindness and stomach diseases. Tea from bilberry stems and leaves have been used as a supportive therapy in mild forms of *diabetes mellitus* [14].

Even decades after the Chernobyl nuclear accident, radiocaesium ^{137}Cs can under some conditions pass to plants and bushes growing on ^{137}Cs contaminated soil. Radiocaesium (mainly ^{134}Cs and ^{137}Cs) are the predominant contributors to radiation exposure after nuclear accidents because they have a relatively long half-life— ^{134}Cs has a half-life of 2.06 years and ^{137}Cs 30.2 years—highly transferable, and wide distribution in the environment [25]. Higher levels of ^{40}K in the growth media are known to reduce translocation of radiocaesium to plants [19].

The collection and consumption of bilberry plants and fruits are very popular in Slovakia which stimulated our interest in their health safety [2]. Bilberry bushes are capable of accumulating radiocaesium [5] and due to their spreading over large areas and easy identification and sampling they are considered as a bioindicator plant [24].

The uptake of radionuclides from soil by plants is expressed by means of a soil-plant transfer factor (TF), a tool in the form of a mathematical equation. TF is essential for environmental transfer models, which are useful for the prediction of radionuclide concentration in agricultural crop [7].

The aim of our study was to determine by means of

gamma-ray spectroscopy the mass activity concentration of radiocaesium ^{137}Cs in samples of bilberry plans and soil collected from selected locations in Slovakia with dependence on: the date of collection, character of collection sites and soil-plant transfer factor.

MATERIALS AND METHODS

Our investigations focused on the determination of mass activity level of ^{137}Cs ($\text{Bq}\cdot\text{kg}^{-1}$) by gamma-ray spectrometry in samples collected in selected mountain and sub-mountain locations in different seasons of the year—spring, summer, autumn. No samples were collected in winter due to the absence of plant parts and limited access. The selected locations differed in composition of soil and other factors that could affect the soil-plant transfer factor. The samples of soil collected in our study were analysed also for the activity of ^{40}K due to the similarity of this isotope with ^{137}Cs and its influence on plant uptake of Cs.

The samples of Slovak bilberry bushes and soil were collected from 3 locations in the Slovak territory: 1—Arboretum Mlyňany (land register Vieska nad Žitavou, close to the village of Zlaté Moravce); 2—Hodruša-Hámre (Protected landscape area Štiavnické vrchy); and 3—Javorníky (Fig. 1). These locations were selected on the basis of the presence of forest bilberries. Bilberry prefer soils with acidic pH [4]. Geophysical maps of soils in Slovakia was provided by the State Geological Institute of Dionýz Štúr which allowed us to identify the suitable areas. Within them, we subsequently identified areas with strong areal activity concentration of ^{137}Cs , i. e. the area of Štiavnické vrchy, the vicinity of the village of Zlaté Moravce and Javorníky.

Because one of the selected areas was situated in the Protected landscape area (site 2), according to the Act No. 543/2002 Coll. on Nature and Landscape Protection we had to obtain a permit to collect fruits and plant parts from this area. A similar situation applied to location 1 where sampling was conducted after obtaining permission from the Arboretum owner.

In the year 2019 we collected samples from the area in autumn (October, November) and in 2020 in the spring and summer (May, June, September) using the standard procedure – manual collection to glass or plastic sampling bottles (fruit and soil) or to cloth bags (shoots) in order to ensure the ventilation and breathing of the plants.

Fig. 1. Sites of collection of samples of soil and bilberry bushes: 1—Arboretum Mlyňany; 2—Hodruša-Hámre); 3—Javorníky. Elevation in metres above sea level (MASL): 1 = 165; 2 = 375—800; 3 = 905—1070

First we collected soil samples close to the growing bushes to the depth of 5—10 cm from the area of about 100 cm² (10 × 10 cm) by means of a garden spatula (total volume approx. 500 ml). Then we collected shoots of individual bushes to cloth bags by garden scissors or knife. We collected material from several places in order to sample the biggest possible area. Berries were collected in autumn in glass bottles. The volume of the samples were sufficient to fill up the measurement vessels. We collected all together 35 samples; i. e. 15 from Arboretum Mlyňany, 10 from Hodruša-Hámre and 10 from the sampling site Javorníky.

Dirt, stones, vegetation residues and other impurities were removed from the soil samples. Shoot samples were divided to stems and leaves and stem samples were subsequently cut to about 2 cm long pieces. Plant samples were frozen and transported together with soil samples to the Veterinary and Pharmaceutical University in Brno, the Czech Republic to the Central workplace for utilization of ionizing radiation where the relevant gamma-ray spectrometric determinations were carried out.

For examination, the samples were placed in Marinelli vessels of volume 450 ml or 200 ml vessels (samples from site 1). Two path gamma-ray spectrometry was used to determine the activity of gamma radiation emitting radionuclides ¹³⁷Cs and ⁴⁰K. The measurements were based on the

use of a germanium detector (HPGe) with relative effectiveness—HPGe GC2020 20 % and HPGe GC 4018 40 %, with resolution of both detectors equal to 1.8 keV. Software Genie (Canberra) and Gamwin (Nuwa Třebíč) were employed. Individual paths were checked by the Czech Metrological Institute.

In addition to mass activity concentration, also total combined standard uncertainty (u_a) was calculated according to the equation:

$$u_a = (u_E^2 + u_p^2 + u_y^2 + u_s^2 + u_{ss}^2 + u_r^2 + u_t^2 + u_A^2 + u_M^2)^{1/2}$$

where

- u_E relative uncertainty of effectiveness,
- u_p relative uncertainty of peak area,
- u_y relative uncertainty of yield,
- u_s relative uncertainty of sum of temporal coincidences,
- u_{ss} relative uncertainty of electronic stability,
- u_r relative uncertainty of decay,
- u_t relative uncertainty relative uncertainty of time,
- u_A relative uncertainty relative uncertainty of self-absorption,
- u_M relative uncertainty of reproducibility.

The transfer factor (TF) as a value determining the availability of ^{137}Cs from the soil for the root system of plants was determined. It was calculated as a proportion of the activity of the ^{137}Cs in the plant tissue and the activity of ^{137}Cs in the soil (expressed Bq.kg^{-1}) according to B u r g e r and L i c h t s c h e i d l [4].

$$\text{Transfer factor} = \frac{\text{Cs activity in plant (Bq.kg}^{-1}\text{)}}{\text{Cs activity in soil (Bq.kg}^{-1}\text{)}}$$

The statistical evaluation was carried out by means of MS Excel software comparing individual results that reached values exceeding MDA. The ^{137}Cs activity in samples collected in individual locations in different seasons was compared using ANOVA Single factor test. Differences in results of soil, stems and leaves from the sites Hodruša-Hámre and Javorníky were evaluated by the paired t-test. The level of $P < 0.05$ was considered significant.

The authors declare that there is no conflict of interest.

RESULTS

The results of the mass activity concentration of ^{137}Cs in individual samples collected from soil and Slovak bilberry bushes grown in the soil are presented in Tables 1—3. In addition to ^{137}Cs , the tables contain also results of the mass activity concentration of ^{40}K detected in the soil samples.

The comparison of the activity concentration of ^{137}Cs in bilberry plant parts and fruits detected in our study showed that this radionuclide level was much lower than the current Slovak limit for the total mass activity of radio-caesium ($^{134}\text{Cs} + ^{137}\text{Cs}$) in food (600 Bq.kg^{-1}) [23].

The statistical evaluation of our results showed that there were no significant differences in the activity of ^{137}Cs between the locations of Hodruša-Hámre and Javorníky.

Although no significant differences in the activity of ^{137}Cs in soils were observed between the seasons, decreases in the mass activity of ^{137}Cs in the soil in October – November was observed in all locations.

Table 1. Summary of the mass activity concentration of ^{137}Cs and ^{40}K in samples obtained from collection site 1—Arboretum Mlyňany

Date of sampling	Sample type	^{137}Cs [Bq.kg $^{-1}$]	Standard uncertainty [Bq.kg $^{-1}$]	^{40}K [Bq.kg $^{-1}$]	Standard uncertainty [Bq.kg $^{-1}$]
4th Oct., 2019	Soil	19.4	1.87	79	6.29
	Soil	13.1	1.15	291	23
	Stems A	< 3.80	0.291	–	–
	Stems	< 21.0	1.16	–	–
	Leaves	< 7.90	0.614	–	–
	Leaves	< 9.10	0.714	–	–
	Leaves A	< 16.0	1.28	–	–
	Fruit A	< 15.0	1.14	–	–
7th June, 2020	Soil	13.4	0.732	293	13
	Leaves A	< 22.0	1.68	–	–
	Stems	< 8.70	0.674	–	–
7th Sept., 2020	Soil	40.1	3.71	625	49.5
	Stems	< 16.0	1.27	–	–
	Leaves A	< 8.40	0.653	–	–
	Fruit A	< 5.00	0.788	–	–

A—longer detection time due to small sample; <—indicates value below minimum detectable activity (MDA)

Table 2. Summary of the mass activity concentration of ^{137}Cs and ^{40}K in samples obtained from collection site 2—Hodruša-Hámre

Date of sampling	Sample type	^{137}Cs [Bq.kg ⁻¹]	Standard uncertainty [Bq.kg ⁻¹]	^{40}K [Bq.kg ⁻¹]	Standard uncertainty [Bq.kg ⁻¹]
23rd Nov., 2019	Soil	95.2	4.98	54.6	2.49
	Stems	5.35	1.99	–	–
	Leaves	< 150	11.5	–	–
15th June, 2020	Soil	48.2	3.96	< 89	6.9
	Stems	< 19.0	1.48	–	–
	Leaves	< 25.0	1.98	–	–
7th Sept., 2020	Soil	161	13.0	< 230	18.4
	Stems	3.95	1.07	–	–
	Leaves	14.7	4.26	–	–
	Fruit	< 9.80	0.767	–	–

← indicates value below minimum detectable activity (MDA)

Table 3. Summary of the mass activity concentration of ^{137}Cs and ^{40}K in samples obtained from collection site 3—Javorníky

Date of sampling	Sample type	^{137}Cs [Bq.kg ⁻¹]	Standard uncertainty [Bq.kg ⁻¹]	^{40}K [Bq.kg ⁻¹]	Standard uncertainty [Bq.kg ⁻¹]
3rd Nov., 2019	Soil	54.1	2.54	89.2	4.25
	Stems	< 5.70	0.44	–	–
	Leaves	< 17.0	1.32	–	–
3rd May, 2020	Soil	112	5.18	184	8.71
	Stems	4.02	1.19	–	–
	Leaves	2.05	0.392	–	–
15th, Sept., 2020	Soil	80.5	3.73	234	11
	Stems	< 16.0	1.25	–	–
	Leaves	< 30.0	2.32	–	–
	Fruit	< 29.0	2.24	–	–

← indicates value below minimum detectable activity (MDA)

The results of the calculation of the transfer factor (TF), the parameter expressing the uptake of radionuclides from soil by the plants, are presented in Table 4. This factor was calculated from the results above the minimum detectable activity.

The transfer factor was determined only for samples with the activities of radiocaesium above MDA, i. e. from the sampling site 2—Hodruša-Hámre collected in Novem-

ber 2019 and September, 2020, and 3—Javorníky, collected in May, 2020, when the activities of radiocaesium were above the MDA. Because the activities in the leaves collected in site 2 in November 2020 were below MDA, the TF was calculated only for soil-stems transfer. For the same reason, the transfer factor was not determined for samples collected in the sampling site 1—Arboretum Mlyňany.

Table 4. Transfer factor calculated for collection sites 2—Hodruša-Hámre and 3—Javorníky

Collection site and date	Transfer factor	
2—Hodruša-Hámre 23rd Nov., 2019	soil—stems	0.056
	soil—leaves	–
2—Hodruša-Hámre 7th Sept., 2020	soil—stems	0.024
	soil—leaves	0.091
3—Javorníky 3rd May, 2020	soil—stems	0.036
	soil—leaves	0.018

DISCUSSION

The Chernobyl nuclear accident resulted in a massive release of large amounts of radioactive material into the atmosphere and its spreading by wind. This radioactive contamination reached also the Slovak territory. The number of deposited particles and the intensity of the settling radionuclide aerosol were affected by many factors including the explosion itself (force, height) and meteorological situation at the affected territory (particularly precipitations) [6]. The long half-life (30.2 years) of ^{137}Cs resulted in long persistence of this radionuclide, its low degradability and long-term biological availability [22].

Despite the fact that the Chernobyl accident occurred 35 years ago, traces of radioactive contamination are still detected in Slovakia as indicated by our investigation of soil and bilberry plants and fruit. The aim of this study was to point to the factors, either natural or anthropogenic, that can affect the process of migration of ^{137}Cs in soil or transfer from soil to plants and can result in potential differences in mass activity of this radionuclide between individual locations or yearly seasons. Thus, we tried to confirm or reject the hypothesis that there may exist significant differences in the mass activity concentration of ^{137}Cs , determined by gamma-ray spectrometry, in relation to location and the time of sample collection.

When analysing environmental samples, the measurement of radioactivity of samples depends on several factors, namely: type and energy of radiation, activity, size and shape of samples, etc. The total effectiveness of methods is affected not only by the effectiveness of the respective detector but also the so-called geometry of measurement. Geometry of measurement is a spatial relationship and configuration of the measured sample or radioactive beam in relation to the detector [27].

The < MDA designation used for some samples in enclosed tables indicates small amount, weight or size of the sample and geometry of measurement which may have affected the radionuclide activity determination.

According to our results there were no significant differences in the activity of ^{137}Cs between locations Hodruša-Hámre and Javorníky. In the location Arboretum Mlyňany the values were below MDA, i. e. the ^{137}Cs activity was low. The samples originated from a botanical institution with collection of woody species and all-year round care in the form of manuring, supplementation of nutrients or other maintenance interventions. According to Burger, Lichtscheidl [4], the key factors affecting the content of radiocaesium include not only soil composition but also its amendment and cultivation in the form of various anthropogenic activities such as turning, hoeing and others. Such activities are expected to support penetration of caesium to deeper layers of the soil and its migration. This may be important for shallow-rooted plants reaching to the depth of up to 10 cm, thus also bilberries [16], as the content of caesium in surface soil layers may be reduced by diffusion or mass flow. This could serve as an explanation why the activity of ^{137}Cs in soil in Arboretum Mlyňany was lower in comparison with locations 2 and 3. Another specific feature of this location was the highest level of ^{40}K . Guillén et al. [10], Almahayni et al. [1], Sait, Mays [20] reported that ^{137}Cs is physiologically and metabolically similar to potassium. Plants take up this nutrient by their root system. There exists a threshold for potassium concentration in soil above which the plants prefer potassium to caesium. Potassium fertilizers can thus be used as an effective mean for decreasing translocation of radiocaesium by saturation of soil with nutrient chemically similar to this radionuclide. Thus, it is possible that the above anthropogenic interventions and supplementation of soil with nutrients in the form of fertilizers could reduce the mass activity of ^{137}Cs and its soil-plant transfer. We observed variations in the activity of ^{40}K in location 1. The highest activity of this radionuclide in the soil was detected at the beginning of September and the lowest in October. According to Sait, Mays [20], the seasonal changes in concentration of potassium in plants with their growth are related to atmospheric conditions, supply of nutrients and developmental stage of the plant.

The highest activity of ^{137}Cs , either in the soil or in plants was detected in location 2. This result corresponds

to the final transfer factor which was insignificantly higher compared to location 3. Results for soil-stems transfer were higher in November than in September. The nutrient requirements in individual stages of the development of plants and fruits vary. The transfer factor is high in the initial stages, gradually decreases as fruits began to develop and is the lowest during their ripening [27]. The transfer factor between locations 2 and 3 may differ owing to different soil properties or atmospheric conditions that affect the growth and development of plants and their fruit [10]. According to these authors, the very low level of ^{40}K should be reflected in increased activity of ^{137}Cs in plants. The sampling sites in locations 2 and 3 were sites exposed to minimal human intervention so persistence of ^{137}Cs in upper soil layers was expected. It should be mentioned that samples originating from locations 2 and 3 were collected in a coniferous forest. According to Daniel et al. [6], higher levels of ^{137}Cs are expected in forests with presence of fallen leaves and fir-needles that increase the contamination of upper soil layers. The activity of ^{137}Cs in the bilberry plant and fruit are affected by: soil properties, content of minerals and pH, as mentioned by Matsukawa et al. [17]. These authors reported that low pH of soil can increase radiocaesium levels in bilberry plants and fruit. In the investigated locations silt soil with varying amounts of sand and clay prevailed. According to Sanchez et al. [21], low pH causes mineralisation of organic matter in the soil and NH_4^+ ions are produced. They accelerate mobility of ^{137}Cs in soil solution making it more available to plant roots.

In comparison with Hodruša-Hámre and Javorníky, less acidic soil prevails in Arboretum Mlyňany and this is reflected also in the activity of ^{137}Cs which was very low. According to Daniel et al. [6], the mobility of ^{137}Cs is the lowest at soil pH ranging from 4 to 7. The transfer and migration of this radionuclide gradually slows down with time in relation to texture and type of soil or mobility of soil microorganisms. Guillén et al. [10] also mentioned that the accumulation of radiocaesium in stems, leaves and fruits of berries may differ depending upon the atmospheric conditions, e.g. temperature and precipitations. During dry and hot periods the activity of ^{137}Cs decreases due to more rapid maturation of plants and fruit in comparison with more humid and colder seasons. It should be mentioned that the activity of ^{137}Cs is also affected by the altitude—the higher the elevation, the higher the activity of ^{137}Cs [6]. The height above sea level affects

indirectly radiocaesium transfer which is affected also by other direct factors such as soil properties. Forest soil at higher elevation generally contains more humus and its pH is lower. The mobility of radiocaesium and its availability to plants is thus higher in such soils [5]. The radiocaesium activity detected in our study was higher in locations 2 and 3 located at higher elevation than in location 1.

According to Daniel et al. [6], Guillén et al. [10], the content of clay in soil is another important factor with respect to radiocaesium activity in soil. This is in fact the key factor, as caesium can be irreversibly adsorbed to clay and its transfer to plants cannot occur. Clay serves as the main sorption site for radiocaesium.

The mass activity concentration in the investigated samples of stems, leaves and fruits was considerably lower than that determined in soil samples. Study by Grabovskiy et al. [9] showed a gradual decrease in contamination of vegetative and generative organs of plants with ^{137}Cs over time. A considerably higher reduction was recorded in plant parts and fruits of bilberries in comparison with soil samples. The authors explanation is that the availability of ^{137}Cs molecules present in soil for plant roots decreases. Should this tendency in contaminated areas persist in future, the activity of ^{137}Cs in free nature will be rapidly decreased. Reduced mobility and transfer of ^{137}Cs to plants is indicated by the study of Krut's, Delvaux [15] due to the mixing of organic matter with minerals owing to intensive biological activity, for example by movement of soil fauna.

The analysis of samples collected in locations Hodruša-Hámre and Javorníky showed no significant differences. The insignificance of differences could be ascribed to different atmospheric conditions, soil moisture and type or pH in these locations [9, 10, 13, 21].

Although no significant differences in the activity of ^{137}Cs in soils were observed between the seasons, a decrease in mass activity of ^{137}Cs in soil in autumn was observed at all locations. According to Guillén et al. [10], de Baulois et al. [3], the transfer of radionuclides is affected by the presence of mycorrhizae fungi living in symbiosis with the roots of the host plants. Their function involves transfer of carbon from plant to fungi and of mineral nutrients (particularly phosphorus and nitrogen) from fungi to the plant. Thus the mycorrhizae fungi serve as a “filter” for the host plant as they accumulate non-essential elements, such as for example caesium, and thus

limit toxicity and biological availability of the contaminant and its transfer from soil to plant. It is possible that this was one of the reasons why in autumn, the season favourable for fungi, a decrease in the mass activity of ^{137}Cs in soil was detected. The highest levels of radiocaesium were recorded in September (location Hodruša-Hámre and Arboretum Mlyňany) and in May (Javorníky). According to Grabovský et al. [9], Kenzo et al. [11], seasonal deviations may be caused by the age of plants. The increase in the activity of ^{137}Cs immediately after the growth of shoots indicates strong accumulation of ^{137}Cs in young tissues. Young plants thus exhibit higher concentration of ^{137}Cs in leaves than the old ones collected from the same site. This could explain the lower concentrations of ^{137}Cs in the older parts of plants collected in autumn compared to younger plants sampled in spring and summer. According to Saltaýes [20], soil moisture is an important factor affecting the activity of ^{137}Cs . The high activity recorded in September may be attributed to the increasing soil moisture at the end of August which could stimulate the plant growth in comparison with summer and resulted in increased concentrations of ^{137}Cs in September. This could explain the sudden increase of radiocaesium in Hodruša-Hámre and Arboretum Mlyňany in September in comparison with the levels at the other sampling dates. According to Kenzo et al. [12], a decrease in the activity of ^{137}Cs from spring to summer may be attributed to several processes, e.g., to dilute this radionuclide as a result of biomass increase over the growing season, leaching due to precipitation or translocation to other organs together with potassium.

A comparison of results of mass activity concentration of radiocaesium in Slovak bilberry plants and soil obtained in this study with the limit for total mass activity of radiocaesium ($^{134}\text{Cs} + ^{137}\text{Cs}$) in food (600 Bq.kg^{-1}) [23] allowed us to conclude that the consumption of investigated fruits, or use of plant parts presents no health risk. Also the level of this radionuclide in soil raises no environmental concern.

CONCLUSIONS

Our research demonstrated that samples of Slovak bilberry and the relevant soil collected from 3 selected locations in Slovakia contained radionuclide ^{137}Cs even 35 years after the Chernobyl nuclear accident. According

to expectations, the highest activity concentrations of ^{137}Cs were detected in location 2—Hodruša-Hámre (elevation 375—800 m), that was least affected by anthropogenic activities and movement of people. The lowest ^{137}Cs activity was determined in Arboretum Mlyňany, situated at lower elevation with higher content of ^{40}K in the soil. The temperatures in this location are higher and anthropogenic activities more intensive. No significant seasonal influence or dependence of mass activity concentration of ^{137}Cs on location was detected. The results obtained indicate that the mass activity concentrations of ^{137}Cs in the investigated fruits, stems and leaves of Slovak bilberries present neither health nor environmental risk.

ACKNOWLEDGEMENTS

The study was supported by the Project FVHE-Široký-2021ITA26.

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Received March 18, 2021

Accepted May 11, 2021