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Peculiarities of ^{137}Cs translocation in higher plants under environmental and laboratory conditions

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Abstract. Accumulation of technogenic ^{137}Cs in higher plant roots and above-ground part and comparison of ^{137}Cs and ^{40}K transfer from roots to the above-ground part of plant as well as distribution within above-ground part of plant under environmental conditions were investigated. Parallely, the results of the investigations of ^{137}Cs accumulation in the roots and shoots of test-organism *Lepidium sativum* L. in the model hydroponic system aqueous solution–solid phase–plant were analyzed. Peculiarities of transfer of this radionuclide from roots to shoots during the entire plant growing period under experimental conditions were determined. ^{137}Cs activity in the tested plants of meadow ecotop was on an average 6-fold lower than in the plants of swamp and 10-fold lower than in the plants of forest ecotop.

Differences in ^{137}Cs and ^{40}K transfer from roots to the above-ground part of plant and their distribution in plants indicate particular biological metabolism of these radionuclides in plants. Increased levels of ^{137}Cs in soil practically did not affect the ^{40}K transfer from roots to the above-ground part of plants. The results of investigations under natural and laboratory conditions show that increasing contamination of growth medium with ^{137}Cs caused higher accumulation of this radionuclide in roots but its transfer from roots to the above-ground part of plant decreased or changed insignificantly. ^{137}Cs transfer from roots to above-ground part under natural (*Artemisia vulgaris*) and laboratory (*Lepidium sativum*) conditions was rather similar.

Key words: Ignalina NPP vicinity • ^{137}Cs • ^{40}K • plants • transfer factor • roots • above-ground part

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Introduction

The processes of radionuclide translocation (radionuclide transfer from one part of a plant to another, also from the root system to the plant above-ground part) are not well following radioecological issues [7, 23]. The basic factors having effect on this process are physiological peculiarities and growth stage of a plant. Dependence of translocation of various radionuclides in plant upon its growth stage is not yet accurately determined [8, 19]. The results of investigation of ^{137}Cs transfer from soil to plant roots and its translocation in the plant are scarce and often contradictory [8, 10].

Referring to the scientific literature, ^{137}Cs accumulation and translocation in plants depend on the plant species. In the *Panicum maxim* Jacq. and *Panicum miliaceum* L. ^{137}Cs accumulates more significantly in above-ground part whereas higher content of ^{137}Cs was determined for the root system of *Zea mays* L. [4]. The accumulation of ^{137}Cs is of rather similar level in both the roots and above-ground part of the rapes [5]. According to Gudkov *et al*. [9], differences in ^{137}Cs accumulation depending on plant species can be related to the phenological peculiarities of plant vegetative period as well as to the phases of plant growth. Investigations of radiocesium transfer to the grass plants have shown that translocation of this radionuclide in the studied plants does not depend on radionuclide accumulation in soil. Mechanisms of radiocesium transport in plants are more complex than simple ion-exchange because of mycorrhiza influence on the transfer of this radionuclide in plants [6, 20]. ^{137}Cs activity in *Calluna vulgaris* L. Hull with mycorrhiza was higher than that without mycorrhiza [22]. Tyson *et al*. [23] by investigating ^{137}Cs accumulation and translocation in cultured *Pteridium aquilinum* have determined that at the end of vegetation this radionuclide is sent back from leaves and stem to the tuber and then transferred to the leaves of the next generation and concentrated in the meristem.

^{137}Cs transfer to the above-ground part of the ligneous plants can depend on the growth conditions [21]. ^{137}Cs transfer to the above-ground part of plant decreases with an increase of richness of soil and, in contrast, increases with an increase of soil moisture. Furthermore, the influence of radiocesium and stable cesium on potassium uptake, transport and metabolism may be especially dangerous for plants as K is an essential macronutrient [2].

Investigations of radionuclide accumulation in the abiotic and biotic components of ecosystem and the processes of radionuclide transfer from one component to another as well as the effect of various factors on these processes are of great importance for the spreading of contaminants in the ecosystem and self-cleaning of contaminated territories. Translocation of radionuclides in plants, which are the basement of trophic pyramide, may enhance influence over radionuclide transfer via nutrition chains to the higher trophic levels.

Our study was aimed at investigating accumulation of technogenic ^{137}Cs in the higher plant roots and above-ground part, at evaluating and comparing ^{137}Cs and its chemical analogue ^{40}K transfer in the system plant roots–above-ground part as well as distribution of those radionuclides within above-ground part under environmental conditions. Evaluation of the distribution of ^{137}Cs in the roots and shoots of test-organism *Lepidium sativum* L. (garden-cress) during the growth period under laboratory conditions was carried out, as well.

Material

Environmental investigations

Plant sampling in the vicinity of Ignalina NPP (INPP) and Lake Drūkšiai (the cooler of INPP) was carried out in 1996, 2000, 2002 and 2004. Selected plant species were sampled in various ecotops of the terrestrial ecosystem, i.e. in a pine forest – *Vaccinium myrtillus* L. (European blueberry), *Calamagrostis arundinacea* L. (rough smallreed), *Caluna vulgaris* (L.) Huul (common heather), *Pteridium aquilinum* (L.) Kuhn (brake), in meadows – *Artemisia vulgaris* L. (common wormwood), *Lupinus polyphyllus* Lindl. (Washington lupin), *Dactylis glomerata* L. (common cock's-food) and meadow grassy plants, in swamp – *Calla palustris* L. (waterarum). The samples of *Phragmites australis* L. (common reed-grass) and *Typha latifolia* L. (great reed-mace) were collected in Lake Drūkšiai. The test-plant species were selected basing on the following criteria: high accumulation rate of radionuclides, wide spreading, occupation of large areas, large biomass and easy sampling. The roots and above-ground part of collected plants were investigated for ^{137}Cs activity concentration.

Pteridium aquilinum, Vaccinium myrtillus, Calamagrostis arundinacea, Calla palustris, Artemisia vulgaris, Poaceae (true grasses), *Dryopteris filix-mas* (L.) *Schott* (male fern) growing in the different ecotops of terrestrial ecosystem of the Ignalina NPP vicinity were tested for ^{137}Cs and ^{40}K transfer from plant roots to above-ground part and distribution of those radionuclides in the plants. The aquatic plants – *Phragmites australis* and *Typha latifolia* growing in the waste water (WW) channels of INPP and in the littoral zone of Lake Drūkšiai (the cooler of INPP) were applied to study ^{137}Cs and ^{40}K transfer and distribution in plants as well. Moreover, for the same purpose *Artemisia vulgaris* was collected from soils of the sites contaminated with technogenic radionuclides in a different way. Contamination types were as follows:

1) global fallout after nuclear weapon testing;
2) spills of waste water (WW) of Ignalina NPP and the Visaginas municipal waste water treatment plant (WWTP) (two and four years passed after the accident);
3) sludge from WWTP contaminated with radionuclides.

Model experiment under laboratory conditions

For experiments on ^{137}Cs accumulation from aqueous solution in the seeds, roots and shoots of *L. sativum* as well as radionuclide distribution among these components, *L. sativum* was grown in plastic boxes (110 × 160 × 6 mm) with covers to avoid evaporation. Each box contained 65 cm^3 of aqueous solution and 470 mg (~160 units) of seeds evenly spread on a filter paper covering the glass plate. The seeds germinated at 24 ± 1°C for 24 h in the darkness, and the roots and shoots were grown for 6 days at constant light at a temperature of 23 ± 1°C. Hydroponic system for model experiments was prepared from ^{137}CsCl (Vsesojuznoe objedinenie "Izotop" Leningradskoe otdelenie, FSU). ^{137}Cs activity concentration in the studied aqueous solution was 0.4 × 10^5 Bq/dm^3 at pH 7.5.

^{137}Cs and ^{40}K activity measurements

The sampled test-plants which grew under natural conditions were divided into roots and above-ground parts, dried and mineralized at 400°C. Gamma-spectrometric measurements were carried out using a high purity germanium (HPGe) detector coupled to MCA Inspector 2000 with Genie 2000 gamma-spectroscopy analysis software (Canberra Industries, USA). The detector is of GMX series by Ortec, USA, with a relative efficiency of 30% and energy resolution of 1.72 keV at 1333 keV [8, 11].

In model experiments ^{137}Cs activity in aqueous solution, solid phase and in dry biomass of plant roots

Table 1. ^{137}Cs activity in the roots and above-ground part of plants of terrestrial ecosystem

Plant species	^{137}Cs (Bq/kg)					
	Root system			Above-ground part		
	n	mean	min-max	*n*	mean	min-max
Forest						
Vaccinium myrtillus L.	2	50	48–52	13	43	9.2–75
Calamagrostis arundinacea L.	3	120	100–160	20	54	1.4–140
Pteridium aquilinum (L.) Kuhn	4	33	28–39	7	190	83–300
Swamp						
Calla palustris L.	10	41	7.7–67	10	60	5.7–110
Caluna vulgaris (L.) Huul	2	18	16–20	8	75	27–130
Meadow						
Artemisia vulgaris L.	7	13	2.1–56	7	1.6	0.5–2.8
Lupinus polyphyllus Lindl.	1	6.2		3	6.6	3.2–10
Dactylis glomerata L.	4	15	9.6–24	3	2.4	1.3–4.5
Grasses	3	14	8.0–26	3	7.0	4.1–9.2

n – number of values. min-max – limits of value variations.

and shoots were assessed by the method of gamma-spectrometric analysis. In order to assess ^{137}Cs activity in solution, 3 cm^3 of the solution were transferred into a vial of standard geometry. ^{137}Cs activity in the small volume samples was measured with a well-type (GWL-series) detector. The well-type detector has a sensitive volume of 170 cm^3, the well inside the germanium crystal is 16 mm in diameter and 40 mm in depth; it can accommodate small samples with an effective volume up to 4 cm^3. The resolution at FWHM is 2.05 keV at 1333 keV. As the relative efficiency of this detector is not specified by the manufacturer, it was determined experimentally placing a ^{60}Co point source at 25 cm from the endcap of the detector. The obtained value was 38%. The efficiency calibration for well-type and coaxial detectors has been carried out in the energy range 122–1461 keV by using single-photon emitting nuclides in standard reference solutions (Amersham) [8].

For the counting time of 100000 s when measuring in a full-container geometry with the well-type detector and the sample density of 1.0 g/cm^3, the estimated detection limit for ^{137}Cs is 12 mBq. Meanwhile, for the coaxial detector, the respective detection limit increases to 130 mBq.

^{137}Cs and ^{40}K internal transfer from one part (organ) of the plant to another was calculated according to the formula:

$$TF_{2,1} = C_{m,1}/C_{m,2} \quad (1)$$

where: TF is the transfer factor; $C_{m,1}$ and $C_{m,2}$ are the radionuclide activity concentrations in the above-ground part and roots of the plant, respectively (Bq/kg d.w.).

Statistical analysis

Statistical data analysis was computed using the computer software Statgraphics plus Version 2.1 program (Statistical Graphics Corp., Herndon, USA). The data presented below are the arithmetical mean of 2–3 experiments for which standard errors of estimation were calculated. Under laboratory conditions, the standard errors did not exceed 5% for all data.

Results and discussion

By investigating ^{137}Cs activity in the higher plants under environmental conditions we observed unequal distribution of this radionuclide in the plant roots–above-ground part system (Table 1). Data of investigations showed that the distribution of ^{137}Cs in plants was dissimilar and depended not only on plant species but also on their growth ecotop. ^{137}Cs distribution in plants could be stipulated by different ecological, biological, physiological and anatomical-morphological features as well as ecological conditions of plant habitat [9].

Calculated values of the ^{137}Cs and ^{40}K transfer factor (TF) from the plant roots to the above-ground part are presented in Fig. 1. TF values of both ^{137}Cs and ^{40}K depended on plant species and differed. Different TF values of the studied radionuclides for the same plant species were determined as well. ^{137}Cs and ^{40}K TF values from roots to stem, from roots to leaves and from stem

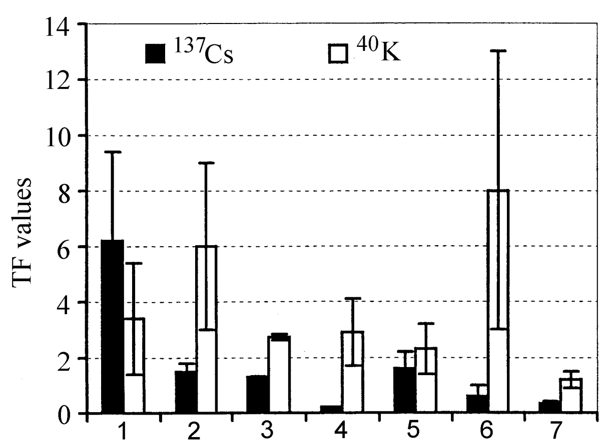

Fig. 1. ^{137}Cs and ^{40}K transfer factor (TF) from plant roots to above-ground part. 1 – *Pteridium aquilinum*; 2 – *Dryopteris filix-mas*; 3 – *Vaccinium myrtillus*; 4 – *Calamagrostis arundinacea*; 5 – *Calla polustris*; 6 – *Poaceae*; 7 – *Artemisia vulgaris*.

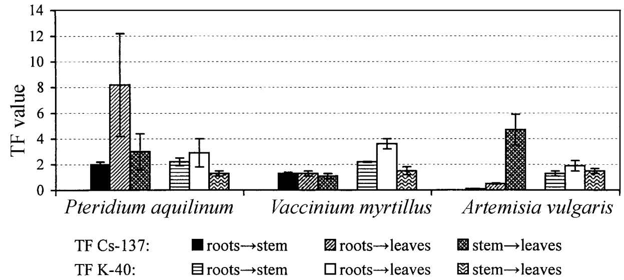

Fig. 2. Transfer factor (TF) of ^{137}Cs and ^{40}K between the different parts of plants.

to leaves also were dissimilar (Fig. 2). In the tested plants, the diverse percentage distribution of ^{137}Cs and ^{40}K from leaves to stems, depending on their biomass, was obtained (Fig. 3). Analysis of TF of ^{137}Cs and ^{40}K exhibited rather similar ^{40}K TF values between separate parts of the tested plant species, while ^{137}Cs TF values differed visibly (Fig. 2).

^{137}Cs and ^{40}K transfer from plant roots to the above-ground and distribution of these radionuclides in the plants were dissimilar. Differences in the ^{137}Cs and ^{40}K transfer between separate parts of plant and distribution of these elements confirm that biological metabolism of ^{137}Cs and ^{40}K in plants can be different. Transfer of ^{137}Cs and its chemical analogue ^{40}K may be related to plant ontogenesis that at different phases can condition inadequate transfer of substances between plant parts and organs. Metabolism of K in plants takes place together with Rb (K^+/Rb^+), but not with Cs. Accumulation of separate radionuclides in plants and their internal transport can depend on various factors: physicochemical features of radionuclides, biological features of the plant and its separate tissues, plant age, physiological structure as well as on environmental factors (humidity, temperature, pH of growing medium, composition and amount of salts) [1].

Presence of various chemical substances could have an influence on the ^{137}Cs transfer distribution in the plants growing in the medium contaminated with WW of INPP and municipal WWTP as well as in the plants growing in the WW channels of INPP. It is known [18] that chemical substances such as heavy metals, organic compounds (weak organic acids, dissolved organic materials, oil products), as well as various washing materials, containing chelating agents, from INPP are spread in the WW channels of INPP and WWTP. Complex effect of those chemicals could change physicochemical properties of radionuclides and functional state of plants and could influence ^{137}Cs accumulation. Laboratory investigations have shown that various chelating agents (EDTA, DTPA, OEDF), dissolved organic materials, the WW of the INPP channels and various municipal WW modify ^{137}Cs accumulation in the aquatic plants and its distribution in the cell compartments (wall, protoplasm, vacuole) [12]. The above-mentioned substances can manifest themselves in the magnification of ^{137}Cs accumulation in plants, but at the same time in diminution of transfer of this radionuclide to the compartments of the inner plant cell [12]. Therefore, it is to be supposed that upon the influence of the WW channels of INPP municipal WWTP due to the increasing ^{137}Cs accumulation in plants and diminished transfer of this radionuclide to the inner cell compartments, could occur accumulation of this radionuclide on the root surface. Owing to these processes, reduction of the ^{137}Cs transfer from roots to above-ground part could be available. Furthermore, ^{137}Cs accumulation in plants could be effected by the plant functional state that could be changed due to the presence of chemical substances [12, 13]. Sodium nitrate in the WW of INPP and Visaginas municipal WWTP also influences ^{137}Cs accumulation in the plant roots and plant growth [15].

Investigations of ^{137}Cs and ^{40}K TF from roots to above-ground part for the plants growing in the soil contaminated with WW of INPP and Visaginas municipal WWTP and for the plants growing in the INPP WW channels under natural conditions were carried out. The investigations were related to the knowledge about chemical substances which together with radionuclides get into the environment with WW of the Ignalina NPP. In the terrestrial ecosystem of the vicinity of INPP, we analyzed ^{137}Cs and ^{40}K activity distribution in the roots and above-ground part of *Artemisia vulgaris*. We studied if there are differences in distribution of these radionuclide activities depending on plant growing medium (soil). *A. vulgaris* growth in this soil was contaminated by technogenic radionuclides in different ways:

1) with global fallout;
2) with spills of WW from INPP and municipal waste water treatment plant (WWTP);
3) with sludge from WWTP contaminated with radionuclides.

Results of investigation show that increasing ^{137}Cs activity in soil caused an increase of its activity in plant roots. However, activity of this radionuclide in the above-ground part of plant changed slightly (Fig. 4). ^{137}Cs TF values in each studied case were lower than that

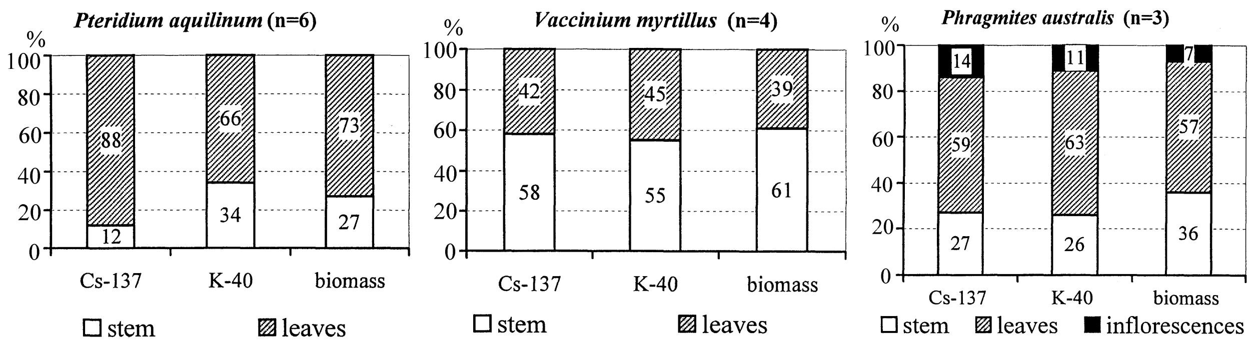

Fig. 3. Percentage share of ^{137}Cs and ^{40}K activity and biomass of the above-ground part of plants.

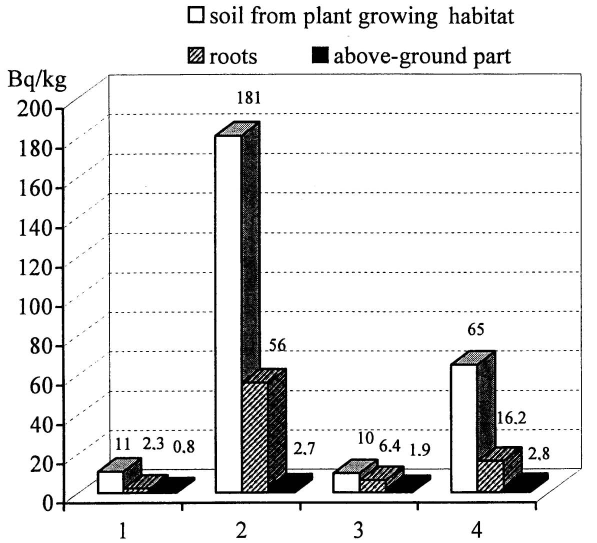

Fig. 4. ^{137}Cs activity concentration in *Artemisia vulgaris* (roots and above-ground part) growing in soil contaminated to a different degree. 1 – soil contaminated by global fallout; 2 – soil two years after contamination by WW of Ignalina NPP and WWTP; 3 – soil four years after contamination by WW of Ignalina NPP and WWTP; 4 – sludge of WWTP.

for ^{40}K. ^{137}Cs TF from roots to the above-ground part values were six-fold lower for *A. vulgaris* growing in the soil two years ago contaminated by WW from INPP and municipal WWTP compared to the ^{137}Cs TF values for *A. vulgaris* growing in the soil contaminated by global fallout and 3-fold lower comparing to the TF values for the plant growing in sludge of WWTP (Fig. 5). It should be taken into account that ^{137}Cs activity concentration in soil contaminated with radionuclides by global fallout was 16-fold and in sludge 3-fold lower than that in the soil contaminated by WW of INPP and municipal WWTP [16, 17]. Comparison of the ^{137}Cs and ^{40}K distribution in *A. vulgaris* growing in soil contaminated in different ways is indicative of different radionuclide behavior (Fig. 6). Distribution of ^{137}Cs in *A. vulgaris* depends on soil contamination level and contamination way. On the contrary, ^{40}K distribution in plant compared to that of ^{137}Cs is less dependent on soil contamination level and contamination way.

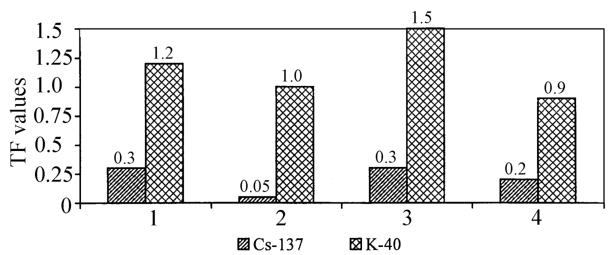

Fig. 5. ^{137}Cs and ^{40}K transfer factor (TF) from the roots to above-ground part of *Artemisia vulgaris* growing to different degree in soil contaminated by different ways. 1 – soil contaminated by global fallout; 2 – soil two years after contamination by WW of Ignalina NPP and WWTP; 3 – soil four years after contamination by WW of Ignalina NPP and WWTP; 4 – sludge of WWTP.

In a territory contaminated with radionuclides as a result of local accident, when four years have elapsed, ^{137}Cs activity in the soil due to the autorehabilitation processes distinctly decreased. This became similar to that in the soil contaminated by the global fallout (Fig. 4). The extinction of the more sensitive to the pollution plant species was observed after two years following an industrial accident in the territory contaminated with WW of INPP and WWTP. Only two the so-called anthropogenic plant species, *A. vulgaris* and *Carex sp*. survived. After four post-accidental years, the amount of plant species more sensitive to the pollution significantly increased in this territory. Based on the above-mentioned, a presumption on the autorehabilitation processes of polluted territory by WW of INPP and WWTP after four years can be made. That is why ^{137}Cs TF from roots to above-ground of *A. vulgaris* growing in the soil contaminated by global fallout and in the soil contaminated four years ago by WW of INPP and WWTP did not differ between themselves (Fig. 5).

It was determined that ^{137}Cs was accumulated much more (3.5 and 6.8 times, respectively) in the roots with stem-roots of helophytes *P. australis* and *T. latifolia* growing at the Lake Drūkšiai littoral zone than in their above-ground part. The difference in ^{137}Cs accumulation in roots with stem-roots was more significant (9 and 12 times, respectively) than in the above-ground part for the above-mentioned helophytes growing in the WW channels of INPP. TF of ^{137}Cs from the roots to above-

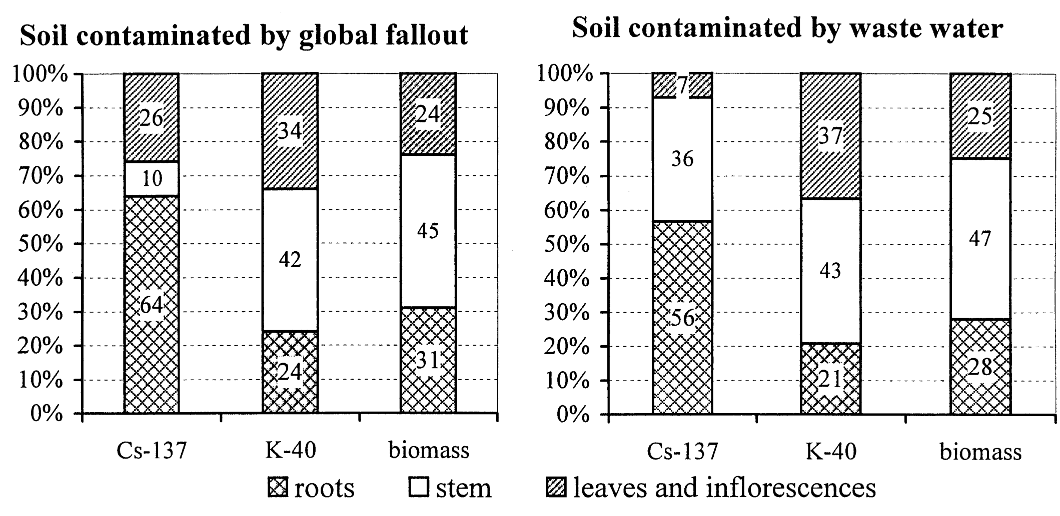

Fig. 6. Percentage share of ^{137}Cs, ^{40}K and biomass in *Artemisia vulgaris* growing in differently contaminated soils.

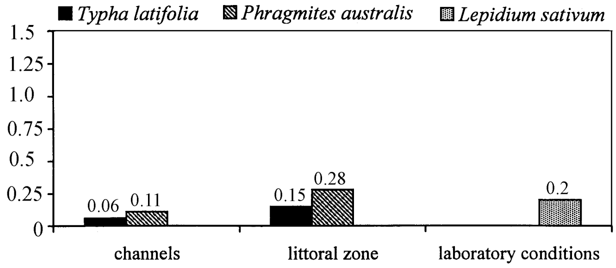

Fig. 7. ^{137}Cs transfer factor (TF) from the roots to above-ground part of *Typha latifolia* and *Phragmites australis* growing in the waste water channels of Ignalina NPP, the littoral zone of Lake Drūkšiai and *Lepidium sativum* growing in laboratory conditions.

ground part of *T. latifolia* and *P. australis* growing in the WW channels of INPP was approximately 3-fold lower than in the plants growing in the Lake Drūkšiai littoral zone (Fig. 7). Besides, contamination by ^{137}Cs of the lake sediments of organic origin was about 3 times lower than in the channels of WW of INPP [14]. The results presented in Figs. 5 and 7 demonstrate that ^{137}Cs TF values from roots to above-ground part for the plants growing in the soil contaminated by the WW of INPP and Visaginas municipal WWTP due to an accident two years ago and in the WW channels of INPP were lower than for the plants growing in the soil contaminated only by global fallout or for the plants growing in the Lake Drūkšiai littoral zone.

Investigations under laboratory conditions demonstrate that after 7-day growth period the ^{137}Cs activity in the roots of *L. sativum* was 4.3-fold higher than in the shoots (Fig. 8). The ^{137}Cs activity in seeds after one day growth amounted to 3.4×10^5 Bq/kg (Fig. 8). The value of ^{137}Cs TF from roots to shoots for *L. sativum* was 0.2 (Fig. 7). This TF value of ^{137}Cs under laboratory conditions was comparable to the TF value from the roots to above-ground part of *T. latifolia* and *P. australis* growing in the littoral zone of Lake Drūkšiai and *A. vulgaris* growing in terrestrial ecosystems (Figs. 5 and 7). According to the obtained results, the ^{137}Cs transfer from plant roots to above-ground part was slightly influenced by plant growth medium and its contamination level with ^{137}Cs.

By investigating ^{137}Cs distribution in the system aqueous solution–solid phase–plant at the stage of *L. sativum* shoot growth (7 days), it was ascertained that in aqueous solution that mass was the largest (96.7%)

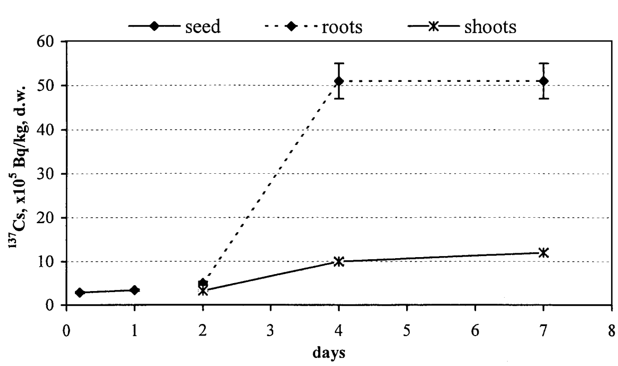

Fig. 8. Dynamics of ^{137}Cs accumulation in the roots and shoots of *Lepidium sativum* growing in a hydroponic system with activity concentration of 0.4×10^5 Bq/L.

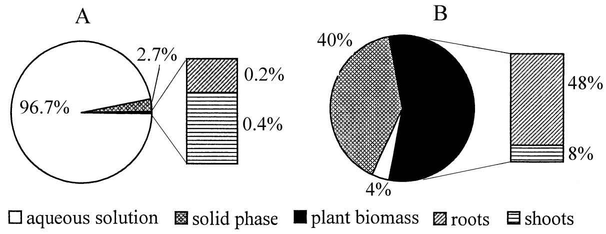

Fig. 9. Distribution of mass (A) and ^{137}Cs activity (B) between the components in the system aqueous solution–solid phase–plant (*Lepidium sativum*) after 7 days.

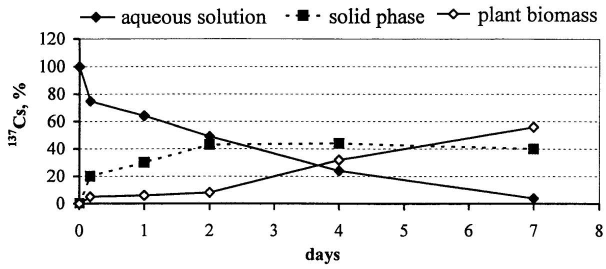

Fig. 10. Dynamics of distribution of ^{137}Cs activity in the system aqueous solution–solid phase–plant (*Lepidium sativum*).

and only 4% of ^{137}Cs remained (Fig. 9). 40% of ^{137}Cs was transferred from aqueous solution to the solid phase with a mass of 2.7%. The largest share of ^{137}Cs (56%) fell on plant biomass that occupied only 0.6%. ^{137}Cs accumulated in plant biomass was divided in the following manner: 48% in roots and 8% in shoots (Fig. 9).

Dynamics of ^{137}Cs distribution in the system aqueous solution–solid phase–biomass of *L. sativum* during plant growth process showed that within the first two days from the aqueous solution the ^{137}Cs activity decreased to 49% (Fig. 10) and the transfer of this radionuclide to the solid phase was 43%. Within the 2–7 day period, the ^{137}Cs transfer from aqueous solution to the solid phase changed insignificantly. At the plant root growth stage (until 2 days), the transfer of ^{137}Cs from aqueous solution to the plant roots increased from 5 to 8%. The ^{137}Cs transfer from aqueous solution to the plant *L. sativum* at the shoot growth period (within 2–7 days) increased from 8 to 56%. During *L. sativum* growth process (2–7 days), the ^{137}Cs distribution dynamics in the system roots–shoots showed that the above-ground part contained 4–8% of the ^{137}Cs amount accumulated in the plant (Fig. 11).

Referring to the results of investigations under natural and laboratory conditions, we can assert that in the

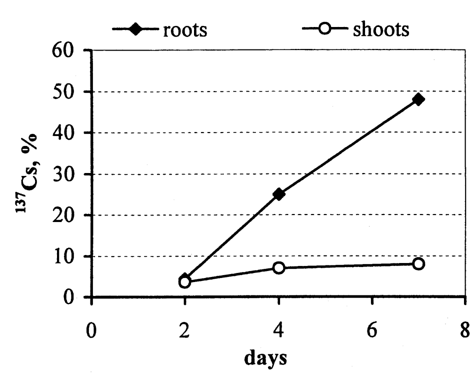

Fig. 11. Dynamics of ^{137}Cs activity distribution in the *Lepidium sativum* roots and shoots.

tested plant species ^{137}Cs activity in the roots was higher comparing to that in the above-ground part (Table 1, Fig. 8). This conclusion is in agreement with observation for croton plants (*Codiaecum variegatum*) [3].

Important finding is that the increasing ^{137}Cs contamination in plant growth medium has an effect on the increase of ^{137}Cs accumulation in roots, but the ^{137}Cs transfer from roots to above-ground part decreased or changed insignificantly.

Conclusions

^{137}Cs accumulation in the tested plant species as well as internal distribution of this radionuclide in the plant roots–above-ground part system under natural conditions depended not only on the plant species but on their growth ecotop as well. Obtained different results for the ^{137}Cs and its chemical analogue ^{40}K transfer from the plant roots to the above-ground part and for inner distribution of those radionuclides in the plants confirm the difference in ^{137}Cs and ^{40}K biological metabolism in plants.

^{137}Cs transfer to the plant *Lepidium sativum* from its growing medium under laboratory conditions depended on the plant growth stage. ^{137}Cs activity transferred to the plant was lower at the root growth stage (2 days) compared to that at the shoot growth stage (during the 5-day period). The largest part of ^{137}Cs activity fell to the plant roots (about 48%), whereas the ^{137}Cs transfer from roots to shoots amounted only to 8% of all radionuclide activity accumulated in the plant (56%).

The ^{137}Cs transfer from the roots to the above-ground part for both the plants of terrestrial or shoreline ecosystems of Lake Drūkšiai and for the plant *Lepidium sativum* under laboratory conditions were rather similar. TF values varied in the range of 0.15–0.3 and did not depend on the growth medium contamination with this radionuclide, however the dependence on plant species was observed. A considerable decrease (about one order of magnitude) in the transfer of ^{137}Cs from the roots to the above-ground part was determined for the plants growing in the soil contaminated by an industrial accident with WW of INPP and Visaginas municipal WWTP and for the plants growing in the WW channels of INPP irrespective of the plant growth medium contamination level with ^{137}Cs.

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