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INVESTIGATION INTO ^{137}Cs FOUND IN THE SOIL PROFILE WITHIN VILNIUS REGION AND ESTIMATION OF INHABITANTS EXPOSED TO ^{137}Cs TRANSFERED THROUGH THE FOOD CHAIN

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Abstract. The article describes the results of the radiological measurements of ^{137}Cs in the soil profile, explains vertical migration coefficients of this radionuclide and discusses internal doses of ^{137}Cs found in food and received through the food chain from soil to milk and meat. Sampling was performed in the northern part of Vilnius district and covered the territories, including Antakalniai village, territory in the south east close to Maišiagala, Mykoliškių village, Karveliškės rural region, territory in the east from Nemenčinė village and Stražninkai rural region. Radiological investigation into soil at a depth of up to 30 cm showed that the concentration of ^{137}Cs activity was in the range from 0.6±0.4 Bq/kg to 5.3±0.4 Bq/kg. The vertical migration of ^{137}Cs indicated two pikes in five sampling places. The first one is related to the contamination of the environment after the accident at Chernobyl NPP, whereas the second one – to the contamination of territory during the tests on nuclear weapons in open air in northern hemisphere. These pikes were not detected in the soil samples taken close to Antakalniai village. Thus, a conclusion that soil was disturbed during agricultural works at the sampling place was made. The highest concentration of ^{137}Cs activity is located at a depth of 5–10 and 15–20 cm where radiocesium is available for vegetation and can get through the food chain to humans. Public estimation shows that the highest dose of ^{137}Cs found in milk and meat has been discovered in Stražninkai (5.5±0.1 μSv) while the lowest one – in a small village near Maišiagala (2.3±0.1 μSv). These doses constitute only 0.5% of annual dose limit for public.

Keywords: activity concentration, dose, radiological measurements, soil, sampling, ^{137}Cs migration.

1. Introduction

The development of population is related to an increase in influence on the environment. In 1945, S. Thompson identified that people started a new nuclear epoch, and therefore a possibility that influence on the environment might increase and become a social problem raised (Nedveckaitė 2004).

Ionizing radiation is one of the most hazardous elements for humans. People are affected by natural radiation in the air, soil and atmosphere and from other man-made sources of ionizing radiation. Natural radionuclides also form the human body (Laučytė 2005).

During the last years, investigations dealing with the processes of man-made radionuclides behave in the environment is growing up in geology, geophysics, geochemistry and other scientific fields (Mažeika 2002). These studies are related to the pollution of the environment during the processes of testing nuclear materials in the northern part of the hemisphere for the period 1946–1980 and after the accident at Chernobyl NPP.

In 1945, radioactive caesium appeared in the environment for the first time. Later, its emissions depended on the extension of testing nuclear bombs. The periods of 1944–1945, 1957–1959 and 1962–1964 were the time when the highest emissions of caesium reached the environment. Later, when the tests were restricted the amount of caesium became smaller (He *et al*. 1996). The accident in 1986 at Chernobyl NPP was a new period when the environment was polluted by caesium the biggest part of which was emitted to the environment in the Ukraine, Belorussia, East Russia and North Europe. After these events, ^{137}Cs has become the major pollutant in the soils of Lithuania. Radionuclides emitted to the environment by air mass were delivered to the places far from the place of the accidents and reached soil, surface waters, food, vegetation and the human body through migration processes (Baturin 1997).

During the period 1946–1980, approximately 400 nuclear tests were performed. The emissions to the environment made ~12.5 tons of nuclear fission products. Regarding data on the activity concentrations of radioactive caesium, due to tests on nuclear bombs, they made $1300 \cdot 10^{15}$ Bq (United Nations … 1997, 1998). Other authors refer to data – 650–$1100 \cdot 10^{15}$ Bq (WHO working group 1989; Avery Simon 1996).

Before testing nuclear bombs, caesium was not important because it was not useful for practical purposes, and therefore no importance was emphasized when investigating thebehaviour of the chemical element; however, it exists almost in all live organisms (Avery Simon 1996).

Before the Chernobyl accident, no detailed investigations into ^{137}Cs found in soil was performed, and only little data indicated that the contamination of land was up to 10 Bq/kg in soil (Butkus *et al*. 1992). More lands contaminated with ^{137}Cs were in southern and west-southern parts, and less contaminated soil was in the eastern and central parts of Lithuania.

In 1987, the distribution of ^{137}Cs in the territory of Lithuania was estimated using gamma spectrometry at an airplane. The plane was flying at a height of 50 m at a speed of 180 km/h and the measurements were performed at each 5 km (Butkus 1992). Later, in 1992, the Ministry of the Environment of the Republic of Lithuania initiated the measurements of ^{137}Cs using plain MI–8 (Butkus *et al*. 1994).

During the period 1991–1992, soil sampling was performed and measured under laboratory conditions at the places where contamination with radioactive caesium was higher (according to the results of measurements by plain) (Butkus *et al*. 1992, 1994). The findings of the investigated samples show that in 1991–1992, the top layer of soil (0–5 cm) was almost all ^{137}Cs content (in percentage – 85±7%) (Butkus, Lebedytė 2000; Arapis *et al.* 1999; Butkus 1995). The vertical migration of produced radionuclides, including ^{137}Cs in soil depends on the type of soil (Aleksa 2005). Two pikes of the vertical migration of ^{137}Cs in soil were determined by Butkus and Lebedytė (2002). The authors draw conclusions that the first one is related to the emissions that appeared during the accident at Chernobyl NPP, whereas the second one – due to the pollution of the environment when the results of the tests on nuclear bombs reached the atmosphere. The influence of the biological behaviour of radionuclides on soil is more effective than external radiation (Gudelis *et al.* 2000).

A number of different investigation techniques were applied for establishing ^{137}Cs in soil. Sampling was typically performed at the places where surface contamination was more serious.

Less contaminated regions of the country were not in the scope of interest, thus the main objective of this article is to describe the results of the radiological measurements of soil in the less contaminated region of Lithuania and the results of estimating the vertical migration of ^{137}Cs. The paper considers the coefficients for the migration of this radionuclide in soil layers and takes into account the dose of ^{137}Cs found in soil for inhabitants using milk and meat in the region where sampling was performed. The main reason of the conducted research is testing the simulation of ^{137}Cs vertical migration in soil using a typical mathematical simulation of the soil in the regions where contamination was less than the average values of contamination.

2. Investigation procedures

2.1. Description of procedures for soil sampling and measurement

Soil sampling was performed in the northern part of Vilnius region at 6 sampling points in the same latitude. Each point was in distance to the next at 9–11 km at territories: Antakalniai village, territory in the south east close to Maišiagala, Mykoliškių village, Karveliškės rural region, territory in the east from Nemenčinė village, Stražninkai rural region (sampling points are shown in the map in Fig. 1).

The location of sampling points was selected in a way so that no cultivation of land was performed at those places taking a distance of at least 10 m with no trees in the area (open and flat area).

The sampling area of 10×10 m at the selected sampling place was marked by sticks using the method indicated in Fig. 2. Sampling was performed at a depth of up to 30 cm applying special devices – sampling tubes (3.8×24 cm, the total volume of soil – 226 ml). Radiological measurements were performed using gamma spectrometry with a pure germanium detector (Lietuvos Respublikos … 2000). The volume of the sample made 50 ml and measurement time lasted 0.5–2 days depending on the activity concentration of ^{137}Cs in the sample.

Fig. 1. Sampling points indicated in the map of the northern part of Vilnius district

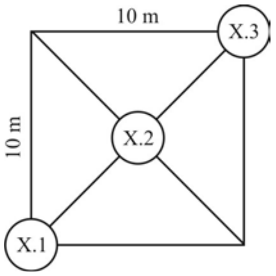

Fig. 2. Soil sampling in one of the sampling places

2.2. Procedure for estimating transfer factors and the ratio of ^{137}Cs activity concentration in the vertical nearby layers of soil

The ratio of ^{137}Cs activity concentration in the vertical nearby layers of soil was estimated using the equation:

$$K_{N-N+1} = \frac{A_{N+1}}{A_N}, \quad (1)$$

where K_{N-N+1} – the ratio indicating ^{137}Cs activity concentration in the vertical nearby layers of soil; A_{N+1} – activity concentration of ^{137}Cs measured in soil layer $N + 1$, Bq/kg; A_N – activity concentration of ^{137}Cs measured in soil layer N, Bq/kg.

The coefficients of 6 layers were calculated at a depth dividing the sample into 6 subsamples, the layer of sample 1 makes 0–5 cm, the layer of sample 2 – 5–10 cm, the layer of the last sample 6 – 25–30 cm. The layers are marked as K_{1-2}, K_{2-3}, etc.

The coefficient of the transfer factor of ^{137}Cs from the top of soil to the depth was estimated using the equation:

$$K_{1-N} = \frac{A_N}{A_1}, \quad (2)$$

where K_{1-N} – transfer factor indicating the difference in the activity concentration of ^{137}Cs at the top layer of soil and an in depth layer. A_N – activity concentration of ^{137}Cs measured at the soil layer, Bq/kg; A_1 – activity concentration of ^{137}Cs measured at the top soil layer, Bq/kg.

2.3. Procedure for estimating the dose due to the transfer of ^{137}Cs through the food chain

For estimating the transfer factors of ^{137}Cs in the food chain, general methods for estimating of the transfer of radionuclides were used (International Atomic... 2001).

The activity concentration of ^{137}Cs in animal feed was estimated using the equation:

$$C_a = f_p C_v + (1 - f_p) C_p, \quad (3)$$

where C_a – activity concentration of ^{137}Cs in animal feed, Bq/kg; C_v – activity concentration of ^{137}Cs in pasture, Bq/kg, when $t_h = 0$; C_p – activity concentration of ^{137}Cs in the stored feed, Bq/kg, when t_h = 90 days (substituting $C_v \approx C_p$), f_p – the fraction of the years that animals consume fresh pasture vegetation; t_h – time interval in days representing the time interval between the harvest and consumption of vegetation.

The total activity concentration of ^{137}Cs in vegetation at the time of consumption is estimated using the equation:

$$C_v = (C_{v1} + C_{v2}) \exp(-\lambda t_h), \quad (4)$$

where C_{v1} – activity concentration of ^{137}Cs due to the direct contamination of the radionuclide in vegetation, Bq/kg. C_{v2} – activity concentration of ^{137}Cs in vegetation due to uptake from soil, Bq/kg; λ – the rate constant for the radioactive decay of ^{137}Cs, d^{-1}; t_h – time interval in days representing the time interval between the harvest and consumption of vegetation.

The activity concentration of ^{137}Cs in vegetation due to uptake from is estimated using the equation:

$$C_{v2} = F_v C_s, \quad (5)$$

where F_v – the concentration factor of the uptake of ^{137}Cs from soil considering the edible parts of crops, Bq/kg; C_s – activity concentration of ^{137}Cs in dry soil, Bq/kg.

The activity concentration of ^{137}Cs in milk is estimated using the equation:

$$C_m = F_m (C_a Q_m + C_w Q_w) \exp(-\lambda t_m), \quad (6)$$

where C_m – activity concentration of ^{137}Cs in milk, Bq/L; F_m – the factor of animal daily intake of ^{137}Cs that appears in each litre of milk at equilibrium, d/L; C_a – ^{137}Cs activity concentration in animal feed, Bq/kg; C_w – ^{137}Cs activity concentration in water, Bq/m^3; Q_m – the amount of feed in dry matter consumed by the animal per day, kg/d; Q_w – the amount of water consumed by the animal per day, m^3/d; λ – the rate constant for the radioactive decay of ^{137}Cs, d^{-1}; t_m – the average time between collection and human consumption of milk.

The activity concentration of ^{137}Cs in meat is estimated using the equation:

$$C_f = F_f (C_a Q_f + C_w Q_w) \exp(-\lambda t_f), \quad (7)$$

where C_f – activity concentration of ^{137}Cs in meat, Bq/kg; F_f – the factor of animal daily intake of ^{137}Cs that appears in each kg of flesh at equilibrium, d/kg; C_a – ^{137}Cs activity concentration in animal feed, Bq/kg; C_w – ^{137}Cs activity concentration in water, Bq/m^3; Q_f – the amount of feed in dry matter consumed by the animal per day, kg/d; Q_w – the amount of water consumed by the animal per day, m^3/d; λ – the rate constant for the radioactive decay of ^{137}Cs, d^{-1}; t_f – the average time between slaughter and human consumption of meat.

An ingestion dose for adults is calculated using the following equation:

$$E_{ing,\,p} = C_p H_p DF_{ing}, \quad (8)$$

where $E_{ing,\,p}$ – the annual effective dose from the consumption of ^{137}Cs in food, Sv; C_p – activity concentration of ^{137}Cs in food at the time of consumption, Bq/kg or Bq/L; H_p – the consumption rate for foodstuff, kg/a or L/a; DF_{ing} – the dose coefficient of radionuclide ingestion, Sv/Bq.

2.4. Modelling the vertical migration of ^{137}Cs in soil

For theoretical modelling, the model of convection – dispersion was employed. The dispersion of ^{137}Cs in soil was simulated using the equation:

$$C_V(x,t) = Q \cdot \exp(-\lambda_r \cdot t) \left\{ \frac{1}{\sqrt{\pi \cdot D_S \cdot t}} \cdot \exp\left[-\frac{(x - v_S \cdot t)^2}{4 \cdot D_S \cdot t} \right] - \frac{v_S}{2 \cdot D_S} \cdot \exp\left[-\frac{v_S}{D_S} \cdot x \right] erfc\left[\frac{x + v_S \cdot t}{2 \cdot \sqrt{D_S \cdot t}} \right] \right\}, \tag{9}$$

where C_V – ^{137}Cs activity concentration, Bq/m^3; Q – surface density of ^{137}Cs in soil, Bq/m^2; λ_r – the decay constant of ^{137}Cs, s^{-1}; t – time in s.

D_S was calculated using the equation:

$$D_S = \frac{D_W}{1 + \frac{\rho_S}{\varepsilon_S} K_d}, \tag{10}$$

where D_W – the coefficient of diffusion, m^2/year; ε_S – soil porosity; ρ_S – soil density, kg/m^3; K_d – the coefficient of dispersion, m^3/kg.

v_S was calculated using the equation:

$$v_S = \frac{v_W}{1 + \frac{\rho_S}{\varepsilon_S} K_d}, \tag{11}$$

where v_W – velocity of convection speed, m/year.

Modelling was done using MATCART.

3. Results of investigations

3.1. Vertical migration of ^{137}Cs in different types of soil

Fig. 3 and 4 illustrate the vertical migration of ^{137}Cs activity concentration in soil at the places where sampling was performed. The maximum activity concentration of ^{137}Cs measured in soil was not higher than 5.3 Bq/kg considering dry weights.

Fig. 3 shows the average values of the single sampling place (average of 3 single samples at one point) with the confidence of two standard deviations.

The made measurements show that the vertical migration of ^{137}Cs indicates two pikes at all sampling places (except near the village of Antakalniai), which is because of two time periods when the emissions of ^{137}Cs were the most harmful – due to the tests on nuclear bombs and emissions as a result of the accident at Chernobyl NPP.

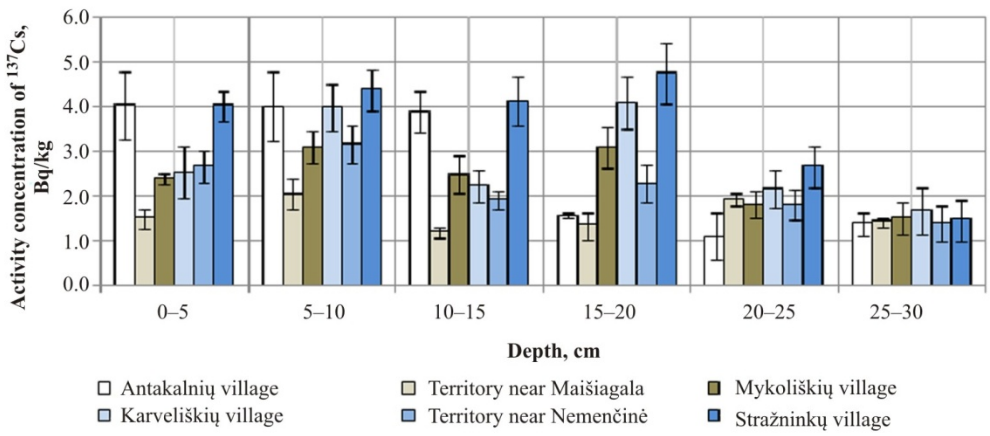

Fig. 3. Activity concentration of ^{137}Cs in the soil profile at 6 sampling places

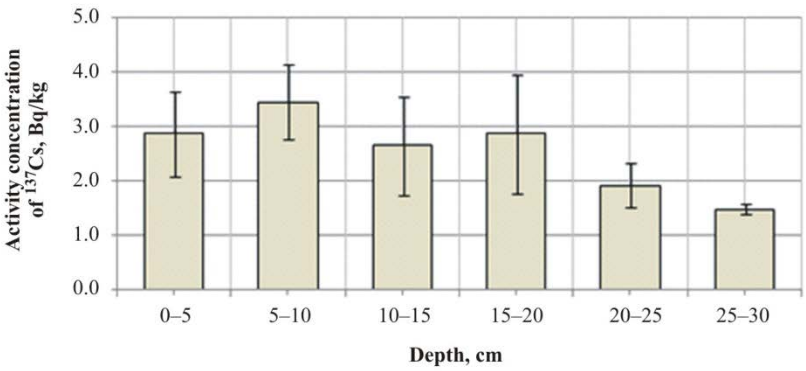

Fig. 4. Average activity concentration of ^{137}Cs in soil according to the depth from the top layer (vertical migration)

Fig. 4 indicates the average activity concentrations of vertical migration – the location of two pikes in the vertical migration of ^{137}Cs in soil. The first pike is located in the layer at a depth of 5–10 cm from the top, whereas the second – at a depth of 15–20 cm.

Evidently, the above distances from the top soil layer are easily to reach by vegetation roots, and therefore the transfer of ^{137}Cs to food through the food chain is possible.

These two pikes were not detected in soil in the sampling place near Antakalniai village, thus the reason may be the cultivation of land or other activity that disturbs soil layers (Fig. 3).

When the calculation of the coefficients of vertical migration and the ratio in the nearby layers of soil were performed, the measurement results obtained in this place were not used for calculating the average value.

3.2. Estimating the ratio of ^{137}Cs activity concentration in the vertical nearby layers of soil and the coefficients of vertical migration

The average values of the ratio of ^{137}Cs activity concentration in the vertical nearby layers of soil are indicated in Fig. 5.

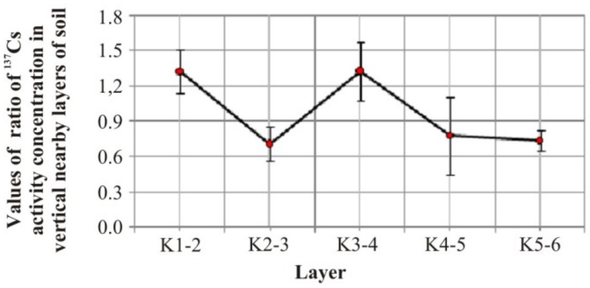

Fig. 5. Average values of the ratio of ^{137}Cs activity concentration in the vertical nearby layers of soil

The highest average values are from the top layer to the layer at a depth of 5–10 cm and those from the layer at a depth of 10–15 cm to the layer at a depth of 15–20 cm. The average coefficients of the vertical migration of ^{137}Cs in soil are shown in Fig. 6.

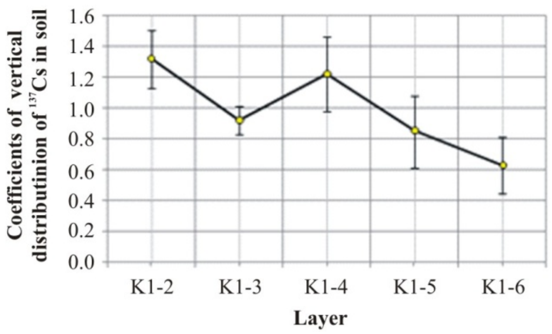

Fig. 6. Average coefficients of the vertical migration of ^{137}Cs in soil

The average values of the coefficients of vertical migration indicate that the largest differences are found in the top layers and the layer at a depth of 15–20 cm, which indicates that the maximum vertical migration and migration of ^{137}Cs in soil is up to a depth of 30 cm.

3.3. Modelling the Vertical Migration of ^{137}Cs in Soil

The results of practical measurements were compared with those obtained by mathematical modelling using MATCARD and equations (9)–(11). Modelling was performed considering environment pollution with ^{137}Cs for three main periods: 1955–1958 (due to testing nuclear bombs in the atmosphere), 1961–1963 (due to testing nuclear bombs in the atmosphere) and 1986 (due to the accident at Chernobyl). Average values $Ds = 0.18 \cdot 10^{-4}$ m^2/year, $v_s = 0.14 \cdot 10^{-2}$ m/year (Butkus *et al*. 2001) were used. Average contamination density at the soil surface was calculated using the data available worldwide (United Nations 1993) regarding which and the latitude of 50–60^0 the density of soil surface contamination was 4624 Bq/m^2 and the total power of explosion was 545 Mt. Calculations were made so that 1 Mt typically results in the contamination of 8.48 Bq/m^2. Regarding information, obtained for the period 1955–1958, 84 Mt power of nuclear bomb testing was noticed. As for the period 1961–1963, the estimation of 97.5 Mt (Styro, Butkus 1998) of average contamination was done. For the periods 1955–1958 $Q_{(1955–1958)}$ – 712 Bq/m^2 and 1961–1963 $Q_{(1961–1963)}$ – 827 Bq/m^2 were accepted. For modelling the migration of ^{137}Cs in soil resulting from pollution after the accident at Chernobyl NPP, the average density of ^{137}Cs was 1190 Bq/m^2 in the most contaminated areas and 310 Bq/m^2 in the less contaminated areas (Lebedytė 2002). The last value was used for modelling purposes.

Figures 7, 8 and 9 show the vertical migration of ^{137}Cs emitted to the territory of Lithuania for the main three pollution periods. Modelling shows that ^{137}Cs emitted during the period of testing nuclear bombs to the territory of Lithuania is mostly located at a depth of 5–10 cm and reaches the depth of 20 cm. ^{137}Cs contaminating the land after the accident at Chernobyl NPP is still mostly located at a depth of 0–5 cm and migration to deeper layers goes more slowly. Modelling shows good compatible results with the results of practical investigations. However, modelling the density of contaminating the top soil layer gave the results not adequate for the practical ones. The process of modelling, when the average pollution values were used, is not applied for less contaminated territories; thus, more detailed pictures of soil surface contamination in the regions of the country are required for reconstructing pollution density and modelling.

3.4. Estimating the internal dose due to the transfer of ^{137}Cs through the *milk / meat* food chain

Two different types of the main food were analysed for transferring the radionuclide from soil. Due to ^{137}Cs found in vegetables, the dose was not estimated because there were no fields where the vegetables were produced nearby sampling places.

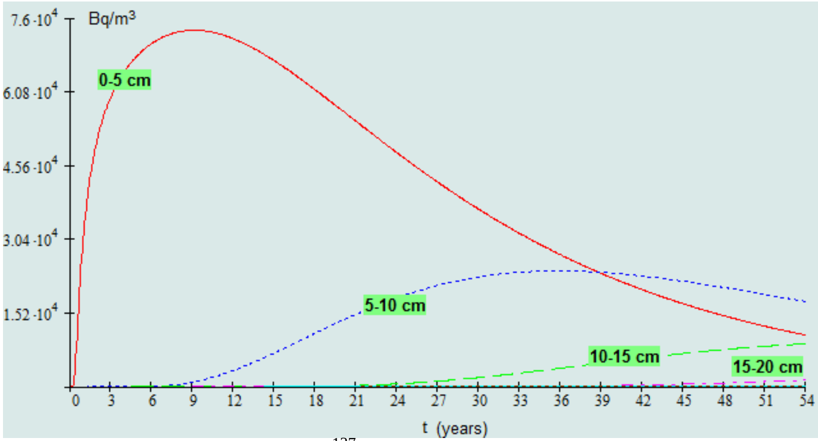

Fig. 7. Vertical migration of ^{137}Cs in soil up to a depth of 0–30 cm emitted to the environment during the period 1955–1958 up to now (for the period of 54 years)

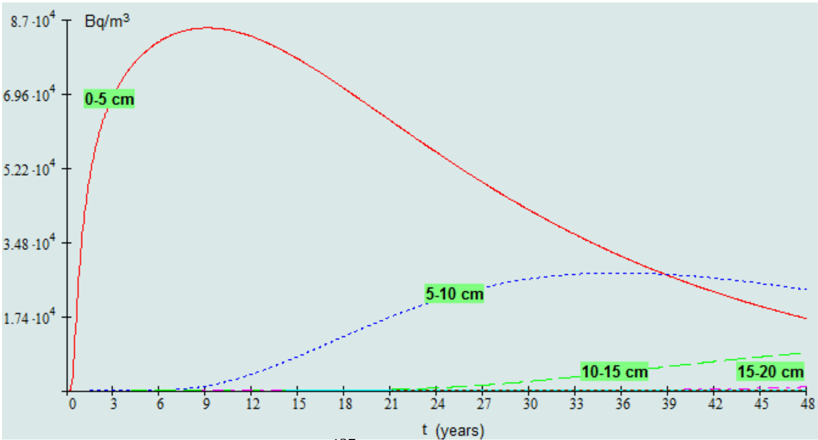

Fig. 8. Vertical migration of ^{137}Cs in soil up to a depth of 0–30 cm emitted to the environment during the period 1961–1963 up to now (for the period of 48 years)

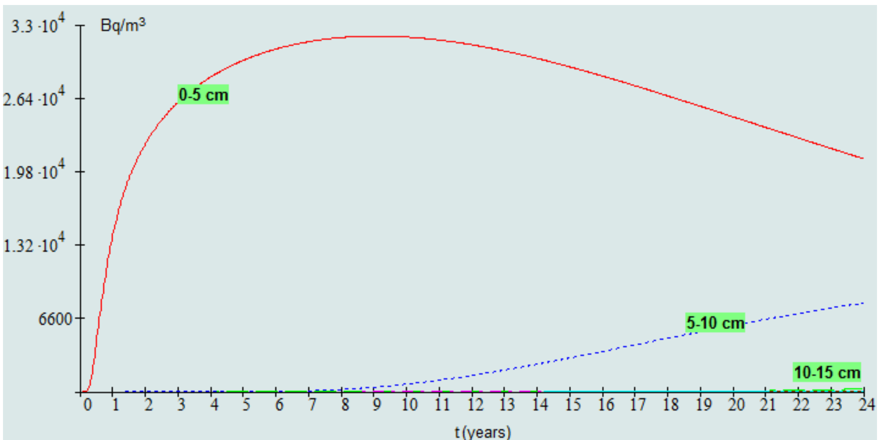

Fig. 9. Vertical migration of ^{137}Cs in soil up to a depth of 0–30 cm emitted to the environment during the accident at Chernobyl NPP in 1986 up to now (for the period of 24 years)

Figs 10 and 11 indicate the values of the internal dose for adults living in the region near sampling places. Fig. 10 clearly shows that due to ^{137}Cs found milk, the dose is higher than that in meat. Fig. 11 displays that the highest dose of ^{137}Cs in milk and meat has been established to be used by the inhabitants from Stražninkai rural area (5.5±0.1 µSv) and the lowest – by the inhabitants from a small village of Maišiagala (2.3±0.1 µSv). The average dose due to ^{137}Cs found in milk and meat for the inhabitants in Vilnius region because of transferring ^{137}Cs from soil to food makes 4.1±0.92 µSv when estimation is conservative (animals consume vegetation from the fields near forests). Investigations showed that the maximum doses estimated due to ^{137}Cs found in milk and meat for the people living in places where soil sampling was performed made only 0.5% of dose limitation according to Lithuanian legislation (1 mSv) (HN 73:2001).

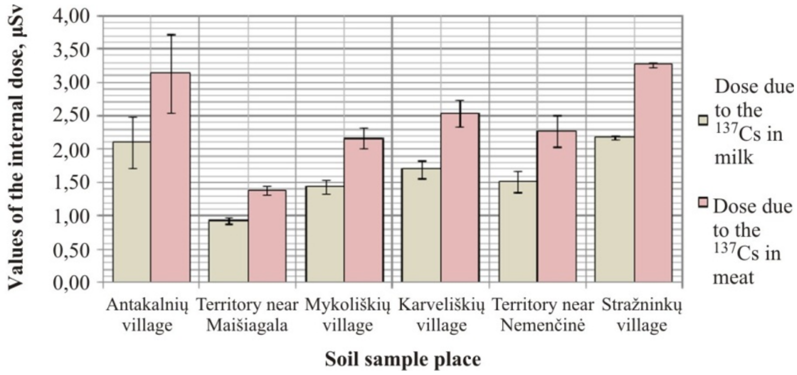

Fig. 10. Annual effective dose due to ^{137}Cs found in milk and meat for adults living in the places where soil sampling was performed (including 6 territories)

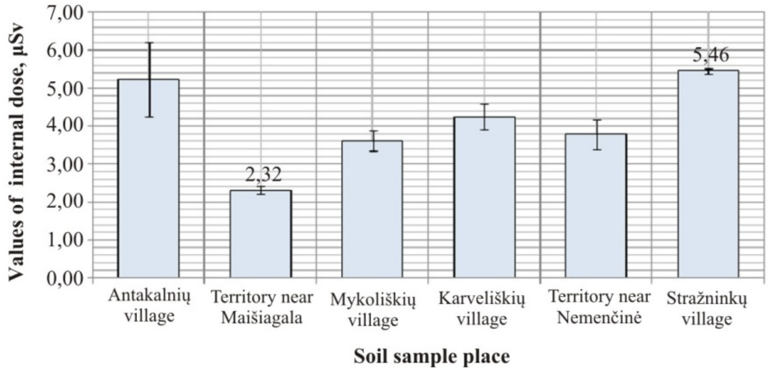

Fig. 11. The total average annual effective dose due to ^{137}Cs found in milk and meat for adults

4. Conclusions

1. Investigations into ^{137}Cs activity concentration in an uncultivated soil in Vilnius region has disclosed the maximum depth of ^{137}Cs vertical migration making up to 30 cm.

2. Two pikes of ^{137}Cs activity concentrations in the depth were estimated due to the two pollution periods in Lithuanian territory – at the time of nuclear bomb testing in atmosphere and accident at Chernobyl NPP.

3. Pikes have been identified at a depth of 5–10 and 15–20 cm; the layers of such soil are typically reached by the roots of vegetation, thus, transfer to food is possible.

4. The estimated average annual effective dose due to transfer of ^{137}Cs from soil through vegetation roots to milk and meat at the territories where soil sampling was performed makes 4.1±0.9 µSv, which is only 0.5% of the dose limit for public.

5. Modelling using data on soil surface contamination at different periods of pollution showed good adequacy to measurement results of ^{137}Cs found in soil layers in vertical migration. However, for modelling purposes, more detailed data on surface soil contamination are required.

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^{137}Cs SAVITOJO AKTYVUMO VILNIAUS REGIONO DIRVOŽEMIO PROFILIUOSE TYRIMAI IR GYVENTOJŲ APŠVITOS DĖL ^{137}Cs PERNAŠOS MITYBOS GRANDINĖMIS VERTINIMAS

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Santrauka

Apžvelgiami radiologinių tyrimų rezultatai, analizuojant dirvožemio mėginius pagal profilinį giluminį pasiskirstymą. Nustatyti skirtingų dirvožemio sluoksnių ^{137}Cs savitųjų aktyvumų santykio bei migracijos iš viršutiniojo į gilesnius dirvožemio sluoksnius koeficientai. Įvertinta ^{137}Cs radionuklidų sukeliama efektinė apšvita, kurią gali patirti žmogus, ^{137}Cs iš dirvožemio mitybos grandinėmis patekus į organizmą. Dirvožemio mėginiai atrinkti Vilniaus rajono šiaurinėje dalyje, Antakalnių gyvenvietėje, teritorijoje į pietryčius nuo Maišiagalos, Mykoliškių gyvenvietėje, Karveliškių kaime, teritorijoje į rytus nuo Nemenčinės bei Stražninkų kaime. Mėginiai imti iš iki 30 cm gylio ir dalyti į 6 sluoksnius po 5 cm. Ištyrus dirvožemio mėginius nustatyta, kad kintant gyliui ^{137}Cs savitasis aktyvumas kinta nuo 0,6±0,4 Bq/kg iki 5,3±0,4 Bq/kg. Penkiose iš šešių tirtų vietovių imtuose vertikaliuosiuose dirvožemio mėginiuose užfiksuota ^{137}Cs savitojo aktyvumo padidėjimas. Pirmasis sietinas su ^{137}Cs, į aplinką patekusiu ir dirvožemyje gilyn migravusiu po Černobylio atominės elektrinės katastrofos, antrasis – į aplinką patekusiu ir dirvožemyje migravusiu po šiaurės pusrutulyje atviroje atmosferoje vykdytų branduolinių bandymų. Antakalnių gyvenvietėje imtuose mėginiuose ^{137}Cs savitojo aktyvumo vertikaliojo pasiskirstymo nenustatyta, todėl daryta prielaida, kad toje vietoje buvo vykdoma ūkinė veikla, ir dirvožemio struktūra suardyta. Vidutiniškai didžiausi gretimų dirvožemio sluoksnių savitųjų aktyvumų santykio koeficientai gauti iš 1 (0–5 cm) į 2 (5–10 cm) bei iš 3 (10–15 cm) į 4 (15–20 cm) sluoksnius. Taigi didžiausioji dirvožemio tarša ^{137}Cs tebėra dar pakankamai negiliai, t. y. 5–10 bei 15–20 cm gylyje, lengvai prieinama augalų šaknims, tad per maistą gali patekti žmogui. Įvertinta, kad didžiausią metinę efektinę dozę, ^{137}Cs patekus į pieną bei galvijų mėsą, gauna Stražninkų kaimo gyventojai (5,5±0,1 μSv), mažiausią – gyventojai, įsikūrę netoli Maišiagalos (2,3±0,1 μSv). Ši apšvita nėra reikšminga radiacinės saugos požiūriu, nes net didžiausios ^{137}Cs savitojo aktyvumo dirvožemyje ir žolėje vertės gali lemti apie 0,5 % Lietuvos higienos normų leistinos gyventojui metinės apšvitos.

Reikšminiai žodžiai: radionuklidas, savitasis aktyvumas, apšvitos dozė, radiologiniai tyrimai, dirvožemis, mėginiai, ^{137}Cs migracija.

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