RADIONUCLIDE TRANSFER TO MEADOW VEGETATION

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Summary

In the paper results of radioecological monitoring of natural plant populations in the 30-km zone of the Chernobyl Nuclear Power Plant (Polesky State Radioecological Reserve) during the period from 1987 to 1998 are presented. The level of radiation background in experimental areas varied from 0,1 to 30 mR/h that corresponded to the total soil activity of 300-24000 kBq/m^2 (for May 1997). Monitoring was carried out including the radionuclide migration in natural plant complexes and transfer of ^{137}Cs between some plant organs.

1.Introduction

The number of documented soil-to-plant transfer factors of radionuclides for semi natural ecosystems is very limited. One of the main objective of this work was to collect data in these environments and identify the main parameters influencing soil-to-plant transfer. On the basis of ecological characteristics, meadows have been classified as follows:

Dry meadows: characterised by very low moisture content. Underground watertable is deeper than 3 m. Rain water and water from melted snow are fully used by plants. Soil type are content due to intensive leaching of soils by atmospheric precipitation.

Flood plain meadows: located in flooding areas of rivers. These meadows are annually flooded. Soils are mainly of alluvial origin.

Lowland meadows (wet meadows): located on terraces, low valley, flat depression with stagnant water. These meadows are flooded regularly in spring. Soil cover is characterised by soddy horizons and partly podzolic and gleyic soils, as well as peaty-gley and peaty soil. Peat lands are located in watersheds of lakes, near terraces of river. Soils are peats or peaty-gleys. Moisture content is very high. Groundwater table is at a depth of 0.5-1.5 m. Transfer of ^{137}Cs and ^{90}Sr to different species of vegetation show a large variation. Transfer factors were determined for different species growing on peaty-gley soil. ^{137}Cs content in the most abundant species composing the meadow, determines the contamination of the total biomass of vegetation. In the conclusion in this investigation, soil type and species composition contribute respectively to transfer factors variability by a factor more than 100, and about 20.

2.Materials and methods

The ^{137}Cs contents were measured by direct gamma-spectrometry using the high-purity Ge(Li) detector with volume 190cm^3 and the multichannel analyser NUC with 8192 channels [Knatko et al., 1996].

The radioactivity content in the different plant fractions (Bq/kg dw) was related to the soil contamination level expressed on a surface basis (Bq/m^2), referred to as the transfer factor.

3.Results and discussion

Radioecological monitoring in the natural plant complexes of Polesky State Radioecological Reserve showed that the radionuclides of Chernobyl outburst are concentrated by 90-95% in the upper part of the soil profile in the layer of 0-5 cm of soil. According to our calculation, phytomass accumulates up to 5% of total radionuclide content of soil in forest stands. Nearly 20% of absorbed radionuclides (from leaves, needles, branches, bark, seeds, cones) are returned annually in forest soil and about the same quantity is again absorbed. Thus, plants of natural complexes delay vertical and horizontal soil radionuclide migration [Matsko et al.1991].

Gamma-spectral analysis of soil samples from 0-5 cm soil layer and dominant plant samples chosen in 1987-1992 at the test areas with various density of contamination have shown that generally the content of radionuclides in plants reflects their content in the soil.^{137}Cs, ^{134}Cs, ^{144}Pr, ^{106}Ru are the main dose forming elements ^{95}Zr and ^{95}Nb are to a lesser extent contributors to the total dose of gamma-radiation. It is important to note that with time the specific activity of the meadow vegetation and soils undergoes larger changes. This is connected with the decay of short-lived radioisotopes and changes of mobility of radionuclides in soils (Table 1).

Table 2 gives the results of observations at three stations with various levels of contamination of meadow soils with radionuclides ranging from 560 kBq/m^2 to 2440 kBq/m^2. From 1988 to 1993, considerable changes in the specific activity of vegetation was observed, three-fold as minimum, which were explained by reduction of ^{137}Cs mobility due to its fixation by clay minerals in the soil. The observations of ^{90}Sr in meadow grasses have shown the opposite picture, that means, the accumulation of the radionuclide increases with time. This is explained by the increase of ^{90}Sr mobility in soils owing to dissolution of its almost inaccessible forms (Table 3).

Table 1. The density of contamination with gamma-emitters and their contents in soil and vegetation on the various stages of monitoring (Babchin,Polessky State Radioecological Reserve).

Radionuclid	Soil (% of total)		Plants (% of total)	
	1987	1989	1987	1989
^{137}Cs	18	42	56	76
^{134}Cs	8	12	26	20
^{144}Ce	20	17	-	-
^{144}Pr	20	17	-	-
^{106}Ru	9	12	12	4
^{95}Zr	9	-	-	-
^{95}Nb	16	-	6	-
Total	100%	100%	100%	100%

Consistency of calculated and measured values was 100% ± 5%

Table 2. Change of specific activity (SR) ^{137}Cs (kBq/kg) of meadow vegetation with time

Species of plant	Soil (kBq/m^2)	S.A., kBq/kg		
		1988	1990	1993
Festuca pratensis Hds. Holub	2440	137.4	4.8	4.4
Potentilla anserina		252.0	48.0	9.9
Vicia crocca L.		70.0	30.0	5.0
Festuca pratensis Hds. Holub	550	141.0	6.0	14.8
Potentilla anserina		170.0	78.0	15.5
Vicia crocca L.		44.4	24.0	0.7
Festuca pratensis Hds. Holub	560	204.0	11.5	8.5
Potentilla anserina		126.0	98.9	18.5
Vicia crocca L.		76.0	104.0	0.9

P≤10 %

Table 3. Changes of ^{90}Sr contents in vegetation of meadow phytocenosis with time

Species of plant	Soil (kBq/m^2)	S.A , kBq/kg 1988	1990	1993
Festuca pratensis Hds. Holub	1850	2,7	5,2	6,7
Potentilla anserina		3,5	8,9	7,4
Vicia crocca L.		3,2	12,6	15,4
Festuca pratensis Hds. Holub	444	0,7	7,9	8,6
Potentilla anserina		4,0	17,0	24,0
Vicia crocca L.		12,2	26,7	30,0

P≤10

Table 4. Change of concentration ^{137}Cs of meadow plants in 1991-1992 (averaged indices of dominants).

The type of the meadow	S.A. kBq/kg	
	1991	1992
The flood plain of Goryn river	6,8	3,2
The flood plain of Pripyat river	19,2	4,8
Low ground meadow	10,4	2,5
The flood plain of Sosh river	4,0	2,1

P≤10%

Radionuclides reach the plants with water flow. Therefore, in dry years, in automorphic and semihydromorphic soils, where vegetation undergoes shortage of moisture, the plant specific radioactivity decreases to a great extent. This gives the possibility of forecasting the levels of activities in plants. In the given example the vegetation period of 1992 has been dry, the quantity of precipitation has been 40% below the average annual norm. Water nutrition of plants has been unsatisfactory and radionuclides have poorly entered the plant bodies. Therefore, specific radioactivity in averaged indices of dominants have decreased by a factor of 2-4 (Table 4). In dry years, the decrease of specific activity of vegetation and of the total uptake of radionuclides is expected in automorphic and semihydromorphic soils.

Table 5. Accumulation of ^{137}Cs by dominant species of meadow phytocenoses at the beginning of the vegetation period (3rd Ten-days of May 1990)

Species of plant	Soil type, pH	S .R soil (kBq/kg)	S.R. plant (kBq/kg)	C.A.
Trifolium pratense L.			12,8	0,11
Achiller millefolium L.			13,6	0,11
Untica dioica L.	Peaty-gley ,	119.0	7,5	0,06
Festuca ovina L.	7,7.		3,2	0,03
Festuca rubra L.			1,1	0,01
Trifolium pratense L.			27,0	0,33
Achiller millefolium L.			16,9	0,21
Untica dioica L.	Peaty-gley,	79,5	9,7	0,12
Festuca ovina L.	6,8.		4,5	0,06
Festuca rubra L.			2,4	0,03
Trifolium pratense L.			172,9	0,59
Achiller millefolium L.	Turf-podzol,		106,7	0,37
Untica dioica L.	weak podzol	290,3	54,8	0,19
Festuca ovina L.			31,7	0,11
Festuca rubra L.	sandy loam,		28,8	0,10
	5,6			
Trifolium pratense L.			104,2	0,78
Achiller millefolium L.	Turf-podzol		59,9	0,44
Untica dioica L	weak-podzol	134,5	21,6	0,16
Festuca ovina L			16,8	0,12
Festuca rubra L.	sandy loam,		14,4	0,10
	4,6			

P≤10%

Our investigations give the possibility to forecast the radioecological situation in nature and vegetation complexes of Polesky State Radioecological Reserve and to estimate the way of regulation of accumulation of radionuclides by vegetation.

The obtained results show that species peculiarities of plants in assimilation of radionuclides have a distinct influence on contamination levels. Thus, samples being selected within phytocenosis during the same phase (the beginning of vegetation period, the 3 rd Ten-days of May) on the same types of soil (peaty-gley and turf-podzol,weak podzol sandy loam) had a great influence on coefficients of accumulation : **Trifolium pratense. L** .- 0.78-0.11, **Achillea millefolium L.** – 0.44-0.11, **Urtica dioica L** – 0.16-0.06,.**Festuca ovina L.** – 0.12 – 0.03, **Festuca rubra L.** –0.10 –0.01. The received results testify (Table 5) the existence of a positive correlation between acidity of soil and the coefficient of accumulation of ^{137}Cs by grasses of Polesky State Radioecological Reserve. The correlation between C.A. of ^{137}Cs by plants and pH of soil were observed also by Schuller et al. (1988).

4.References

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