RADIOACTIVE CARRY-OVER BY HERBS IN THE CONDITIONS OF ENVIRONMENT CONTAMINATION

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Abstract

There were evaluated accumulation levels of 90Sr and 137Cs by herbaceous plants from the soils contaminated as a result of the accident at PA “Mayak” on 1957. The plots located at a distance 13 and 86 km from the accident epicentre were studied. The results have shown that the right proportional dependence between accumulation of the radionuclides by aboveground mass of the herbaceous plants and radionuclides content in the soils hadn’t been revealed. At maximal level contamination of the soils by radionuclides, aboveground mass of herbs are carried out only 0.09% of 90Sr and 0.06% of 137Cs in account from their amounts accumulated in the soil. The radionuclides are accumulated by the forest litter to a greater extent than that aboveground mass of herbs. Their entering to the litter depends, to a large extent, on the level of the soil contamination.

INTRODUCTION

The problem of the environment radionuclide contamination is actual. Representing chemical analogues of stable elements, radioactive isotopes become part of biogenic cycles and create radiation load on objects of natural environment. The initial phase of this exchange is associated with primary producers i.e. the plants. On the one hand, the long-term depot of radionuclides is formed through their accumulation in the tissues of perennial trees and shrubs. On the other hand, herbaceous plants and annual leaf litter enable prompt export of radioactivity into biogenic cycles.

MATERIALS AND METHODS

The study was done in the Eastern Ural Radioactive Trace (EURT) zone which was formed in 1957 as a result of an accident at the nuclear plant of “Mayak”. Currently, 90Sr is the main contaminant in EURT area. Additional EURT contamination by 137Cs occurred in 1967 as a result of the silt and fine sand transfer from the shores of shoal Lake Karachay used as an open storage for radioactive waste (Aarkrog et al., 1997). Surveys were done along the central axis of the trace at distances of 13 and 86 km from the explosion centre (the impact-p and buffer plant coenopopulations). The background plot with a soil contamination density of 1.5 kBq/m2 for 90Sr and 4.2 kBq/m2 for 137Cs was outside of any man-induced impact and was similar to other plots in terms of geobotanical characteristics (Molchanova et al., 2009; Pozolotina et al., 2010).

RESULTS

At the studied areas, the concentrations of 137Cs and 90Sr in soils differ significantly ranging 5.0–380, to 10–9000 kBq/m2 accordingly (Figure 1).

We found no any direct proportionality between export of isotopes into aboveground phytomass and their abundance in soils the radioactive contamination gradient. It is shown in Figure 2 that the values of 90Sr and 137Cs enrichment ratios in plants are below the bisector, which corresponds to increased radionuclide contents ratio in soils. The data above reflect the presence of a biological barrier at the plant root system level that prevent studied isotopes from direct involving in aboveground biogenic exchange.
The effectiveness of this barrier is most evident when mobilization of $^{137}$Cs from soil occurs. Continual deposition of radionuclides is accompanied by their firm fixation in the soil absorbing complex. Only small portion of these tightly bound isotopes is partly available for plants and can be involved into active biogenic exchange. In case of $^{90}$Sr, the proportion of this mobile fraction depends on its total content in soils. For example, when the maximum contamination occurs (2000–9000 kBq/m$^2$) the plants can stand only 0.09% of soil-deposited contents. With the smaller soil contents of this radionuclide (10–40 kBq/m$^2$), 0.4% in average migrate into the phytomass.

In case of $^{137}$Cs, with the nuclide soil concentration being ranged from 5 to 350 kBq/m$^2$, a practically permanent proportion of 0.06% of soil-deposited contents migrates into aboveground plants. Thus, long-lived radionuclides ($^{90}$Sr and $^{137}$Cs) that had been deposited in soils half a century ago continue to be actively involved into biogenic exchange.

The forest litter also takes part in biogenic exchange of radionuclides with the exception to their export to aboveground phytomass. Due to permanent formation, mineralization and humification ion of the litter, a pool of macro- and microelements and also long-lived radionuclides necessary for plants is formed. The total content of radionuclides in the litter exceeds their number in live plant biomass (Figure 3).

When analyzing the forest litter as the main biogenic depot of radioactivity, it is possible to estimate the proportion of soil radionuclides being involved in prompt exchange (migration of radionuclides in the aboveground plant mass and then into the litter). Figure 4 suggests that with soil content of $^{90}$Sr up to 50 kBq/m$^2$ the litter could contain 8 to 16% of this amount. With higher content of this isotope, no more than 4% of this amount could be mobilized from soil to biogenic exchange. It suggests, in the case of the litter as well, the presence of a barrier restricting biogenic exchange.

**DISCUSSION**

Thus, long-term radioactive environment contamination having been lasting many decades continues to be not only the source of external irradiation but also the functioning of plants results in formation of prompt pool of radionuclides that migrate into aboveground and underground biomasses. Availability of these isotopes for consumers of higher rank creates conditions for internal exposure of all natural ecosystems trophic levels.

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