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Specific features of the recent accumulation of 137Cs in tree roots of forest ecosystems within the zone of radioactive contamination

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Despite numerous studies of the accumulation of technogenic radionuclides in the root systems, no clear regularities of this process have been established. The tendencies found in the works of Russian and foreign researchers are rather discrepant. Some authors argue that the accumulation of radionuclides in the roots is more pronounced than that in the aboveground parts of the plants (Skovorodnikova, 2005; Romantseva, 2012; Sennerby et al., 1994; Mamikhin, 2002; Fircks et al., 2002}. Other works attest to a higher accumulation of radionuclides in the aboveground pars (Juznic et al., 1990; Chibowski, 2000; Zhianski et al., 2005), which is also typical of the stable isotopes of these elements, including 133Cs (Dong Jin Kang, YongJin Seo, Tsukasa Saito et al,2012). It is also stated that the accumulation of radionuclides in the aboveground and underground parts of plants may differ in dependence on the soil-ecological conditions and other factors (Kozhakhanov et al., 2011; Grabovskyi et al., 2013). The aim of our study was to evaluate the accumulation of 137Cs in the root systems of arboreal plants in forest ecosystems within the near zone of the Chernobyl fallout on the plots with similar soil and phytocenotic features.

Pine and birch stands were studied within the 30-km-wide exclusion zone of the Chernobyl Nuclear Power Station in Ukraine in 1992–1993, when the density of the radioactive contamination of the upper (0–20 cm) layer with 137Cs reached 2153.8 kBq/m2), and in Bryansk oblast of Russia in 2013–2014, when the density of contamination varied from 1458.4 kBq/m2 (pine stand) to 2578.3 kBq/m2 (birch stand). The tree layer in these ecosystems was dominated by Pinus sylvestris (L.) and Betula pendula (Roth.), respectively. Quercus robur (L.), Picea abies (L.), and Sorbus aucuparia (L.) were also present. The specific activity of 137Cs was measured in the samples from the aboveground parts of model trees and their roots differentiated by size (0–3, 3–10, 10–20, and > 20 mm), and 10-cm-deep soil horizons down to the depth of 70 cm.

At the initial stage of our studies (in 1992–1993), we found that the mean weighted values of the specific activity of 137Cs in the roots was 1.5–2.0 times higher than that in the aboveground parts of the trees and also exceeded the specific activity in the adjacent soil mass. These differences increased with the depth: the activity of the roots was two times higher in the upper 10 cm and up to 100 times higher in the layer of 30–70 cm (Shcheglov, 1999; Rafferty, Kliashtorin, Kuchma, Ruehm, Shcheglov, 1996; Shcheglov, Tsvetnova, Kliashtorin, 2001).

The studies performed in 2013-2014 the stage of active uptake by the roots is characterized by somewhat different regularities of the distribution of radionuclides, In conifers, including pine, the specific activity of fine roots (<3 mm) was close to the specific activity of small branches, and the specific activity of coarse roots (3–10 mm) was close to the activity of large branches. For broadleaved species, such as birch, the activity of fine roots exceeded the activity in all the aboveground organs, and the specific activity of coarse roots was close to that in small branches. More detailed studies were performed for oak and mountain ash trees. They showed that the specific activity of fine roots (<3 mm) is close to that of the small branches. The ratios of the specific activities of the coarse roots to the specific activities in different aboveground organs may differ in dependence on the species composition of tree stands. In oak and birch trees, the specific activity of coarse roots is close to the specific activity of small branches; in mountain ash, it is closer to the specific activity of small branches.