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Examination of 238Pu, 239,240Pu and 137Cs radionuclide diffusion in soils and lake bottom sediments

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Application of an appropriate model and transfer parameters for radionuclide migration in soils and fresh water ecosystems (e.g. lakes) to predict the long-term radionuclide behaviour is of great concern. Transfer of radionuclides in lake ecosystem is mostly governed by the processes of diffusion, perturbation of soil or lake bottom sediments and transport of long- lived radionuclides with the water flows. In order to evaluate values of diffusion coefficients 3 core samples were taken in the vicinity of Vilnius city (Lithuania): in upland and flooded soils (to the depth of 30 cm) as well as in lake bottom sediments (to the depth of 40 cm). 238Pu, 239,240Pu and 137Cs activity concentrations in profile layers were measured. Two radionuclide activity concentration peaks were characteristic in flooded and upland soil cores. In sediments, single radiocesium and plutonium activity concentration peaks were observed at the same depth, which depends on the sedimentation rate in the lake (~4.7 mm•y-1). The activity concentration 238Pu/239,240Pu and isotopic 240Pu/239Pu ratios have shown the global fallout from nuclear weapons testing to be the main Pu contamination source in the studied environmental systems. 137Cs/239,240Pu activity concentration ratio values were sufficient for the evaluation of the contribution of Chernobyl-derived radiocesium.

Fitting the deepest slopes of the vertical profiles in the lake bottom sediments of the respective radionuclide activity concentration peaks with Gauss functions, it was found that effective diffusion coefficients (for the period from 1963) of plutonium and radiocesium were ~0.21 and ~0.16 cm2·y-1, respectively. According to deeper slopes of radiocesium activity peaks the determined diffusion coefficients in cores of the flooded and upland soil samples were also about the same (~ 0.06 and ~0.07 cm2•y-1, respectively). Deepening rates of the activity concentration peaks related to the supposed mobile fraction of both radionuclides were larger in the flooded soil core from the old channel (~0.27 cm•y-1). In the upland soil core they were equal to ~0.16 and to ~ 0.12 cm•y-1 for plutonium and radiocesium, respectively.

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