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SHORT COMMUNICATION

Influence of freezing on physicochemical forms of natural and technogenic radionuclides in Chernozem soil

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Sharp variations of different climatic parameters influence the transport, transfer, and deposition of contaminants in nature. Investigations of the impact of environmental temperature on the fractionation of radionuclides in soil are necessary for adequate assessment of their distribution and bioavailability in case of a nuclear accident. The impact of a sharp decrease of environmental temperature shortly after radioactive contamination on the physicochemical fractionation of natural and technogenic radionuclides in Chernozem soil and its influence on their potential migration ability and bioavailability in case of subsequent warming were evaluated. The soil was contaminated in a laboratory with ^{241}Am, ^{60}Co, ^{137}Cs, ^{228}Ra, ^{234}Th, and U and two temperature regimes were used for storage. Changes of the radionuclides association with various soil phases in the first weeks after contamination were studied. Physicochemical forms of ^{241}Am, ^{60}Co, ^{228}Ra, ^{234}Th, and U were determined using two sequential extraction procedures. The ion-exchangeable forms of ^{137}Cs were evaluated by single extraction with 1 M NH_4NO_3. The data showed that the freezing, following the radioisotope contamination of the soil, causes an increase of the amount of potentially mobile forms of radiocobalt, radiocesium, radium, and thorium and has an insignificant impact on the fractionation of americium and uranium.

Keywords: radionuclides, physicochemical forms, freezing, Chernozem soil

Physicochemical forms of radionuclides in soil are determined to estimate their migration in the environment and in the food chain. Radioactive contaminants enter the soil and participate in various physicochemical processes which, depending on different factors such as pH, redox potential, chemical, and morphological composition of the soil, microbiological activity etc., lead to distribution of the radionuclides between the various soil phases and thus influence their mobility and biological uptake. Various selective reagents are applied in single or sequential extraction procedures in order to identify the way trace metals and radionuclides are attached to the different soil phases and to assess their mobility and biological availability (Filgueiras et al., 2002; Rao et al., 2008). Water soluble forms of the radionuclides represent their most mobile and bioavailable fraction. Exchangeable and carbonate-bound fractions are considered readily and potentially bioavailable, while Fe–Mn oxide and organic/sulphide fractions are relatively stable under normal soil conditions. Elements in the residual fraction are incorporated within the crystal structure of minerals and thus are practically unavailable (Wong et al., 2002). According to Koch-Steindl and Pröhl (2001), environmental conditions like temperature and humidity are important factors influencing the speciation and mobility of radionuclides. The authors considered the long-term behaviour of ^{36}Cl, ^{79}Se, ^{99}Tc, ^{129}I, ^{237}Np, and ^{238}U under increased or decreased temperatures and humidity and summarised the possible effects on their mobility regarding the processes in the soil minerals, organic matter, pH value, hydrological balance, etc. Dowdall et al. (2008) highlighted the possible role of climate-dependant variables in soil-to-plant transfer of radionuclides referring to numerous investigations on this topic. The authors pointed out

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