

ORIGINAL PAPER

Physicochemical fractionation of americium, thorium, and uranium in Chernozem soil after sharp temperature change and soil drought

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A sequential extraction procedure was used to study the changes in the physicochemical forms of americium (Am), thorium (Th), and uranium (U) in laboratory-contaminated Chernozem soil as a result of sharp variations of the environmental temperature and soil moisture. The influence of freezing and soil drought on the radio-ecological hazard was evaluated three months after radioactive contamination with aqueous solutions of ^{241}Am , ^{234}Th , and U. The subsequent changes in the physicochemical forms of the actinides, caused by sharp increases in the environmental temperature and soil moisture, were examined for one month. The data showed that continuous freezing increased the potentially mobile forms of Am and Th but had the opposite effect on U. Prolonged soil drought did not influence the fractionation of Am and Th but led to the redistribution of U between the carbonates and organic matter and caused its immobilisation. The sharp increase in the temperature of the frozen soil caused the immobilisation of Am and Th and increased the potential mobility of U. The warming and enhanced humidity of the dry soil led to the immobilisation of Am and redistribution of U between the soil phases.

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Introduction

Determination of the physicochemical forms of Am, Th, and U in the soils is important for evaluation of their migration and bioaccumulation abilities, needed for radio-ecological risk assessment. They are of particular concern due to their carcinogenicity, long half-life and potential mobility in nature. ^{241}Am is an artificial radionuclide produced during the nuclear fuel cycle and belongs to the group of radionuclides with very high radiotoxicity. It can be released into the environment from nuclear reactors, nuclear explosions, radioactive waste storage facilities and accidents, as well as from the manufacture of products containing Am. Americium is a by-product of plutonium production. Because ^{241}Am has a long half-life, it will be present in the environment for a long time (ATSDR, 2004). Uranium and thorium mining, milling and processing, tin processing, phosphate rock

processing and phosphate fertiliser production, and coal-fired utilities and industrial boilers are the primary anthropogenic sources of Th in the atmosphere and in surface waters (ATSDR, 1990). Uranium is fundamentally important to the nuclear fuel cycle, starting as a source and ending as a final waste component. Uranium released into the environment is predominantly in the hexavalent form as mobile, aqueous uranyl ion (UO_2^{2+}) under standard environmental conditions. Hence, U is a subject of great concern as a potentially hazardous pollutant to the environment (Ren et al., 2010).

Partitioning of the elemental contaminants between soil phases depends on the mechanical, physical, chemical and microbiological properties of the soils. However, the chemical state of actinides released to the environment, combined with the complexity and diversity of their environmental behaviour, creates difficulties in modelling their behaviour over the life-

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