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Distribution of 137Cs, 238,239+240Pu and 241Am in soils and lakes from the Central Spitsbergen

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Soils play an important role in accumulation of airborne radionuclides. Plutonium isotopes released by nuclear weapons testing are still present in the environment, especially in soils. There are several sources of radioactive contamination in the European sector of the Arctic. The most substantial include global weapons fallout, fallout from nuclear weapons testing near Novaya Zemlya and from Chernobyl accident, and discharges from the nuclear reprocessing plants Sellafield (UK) and La Hague (France).
The aim of this study was to investigate activity concentrations, activity ratios and inventories of 137Cs, 238Pu, 239+240Pu and 241Am in 8 soil profiles and 3 bottom sediment profiles from tundra lakes of Petuniabucta coast (Central Spitsbergen). The loose and poorly developed soils were collected from raised marine terraces covered with sandy-gravel sediments (PET1, PET2, PET3) and from coarse-grained screes (PET4, PET6, PET8). The Ebbadalen tundra lakes (PEL1, 2, 3) occupy shallow depressions underlain by mineral soil or thin peat in permafrost terrain.
Results obtained in this study show differences in activities of artificial radionuclides among the investigated profiles. The highest activities of 137Cs, 238Pu, 239+240Pu and 241Am observed in profile PET4, reached 123±11 Bq/kg, 0.13±0.04 Bq/kg, 3.82±0.31 Bq/kg and 1.2±0.1 Bq/kg, respectively. Artificial radionuclides in most of the tundra soils were concentrated in the upper 4 cm but in one profile (PET5) maximum activity concentrations each radionuclide was observed at 10 cm depth. The deeper occurence of radionuclides in profile PET5 can be explained by occasional accumulation of aluvial deposits in that site. Location of activity maxima points to accumulation of 10 cm thick deposits during last 50 years. The activity ratios provide important information on the origin of radioactivity in soils, as they can be used to distinguish between global (stratospheric) and regional (tropospheric) sources of these radionuclides. Isotopic analysis of plutonium reveals provenance of this radionuclide, for example whether the plutonium burdens are associated with bomb fallout or are derived from other sources. The 238Pu/239+240Pu activity ratios varied from 0.02 ± 0.01 to 0.07 ± 0.02, suggesting global fallout as the dominant source of Pu (0.03-0.05). The 239+240Pu/137Cs activity ratios varied from 0.02 ± 0.01 to 0.09 ± 0.02 and exceeded published global fallout ratio for Svalbard of 0.05. The 241Am/239+240Pu activity ratios ranged between 0.32 ± 0.04 and 1.24 ± 0.13 and exceeded the global fallout ratio for Svalbard of 0.37 due to the relatively higher geochemical mobility of Pu vs. Am and/or ingrowth of Am from the decay of 241Pu.
The 137Cs inventories in each profile were lower than the deposition fluxes (2.2 kBq/m2) reported for Svalbard. The 239+240Pu inventories varied between 20.1 ± 1.6 to 50.3 ± 5.0 Bq/m2 and exceeded values of 239+240Pu 14 - 26 Bq/m2 from atmospheric weapon testing.

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