Impact of Soil Organic Matter on the Formation of ^{137}Cs and $^{239,240}Pu$ Secondary Peaks in Vertical Soil Profiles

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Technogenic radionuclides, such as ^{137}Cs and $^{239,240}Pu$, on the soil surface are transported to deeper levels and may be adsorbed by soil constituents through a variety of processes, including ion exchange, binding to carbonates and (hydro)oxides, adsorption to clay particles, and complexation with organic material. Organic substances act as temporary reservoirs, binding radionuclides before decomposition releases them into the soil solution, potentially forming new compounds with soil adsorbents (Ota et al., 2016). In waterlogged soils, several concentration peaks have been identified in vertical profiles (Łokas et al., 2013; Lukšienė et al., 2014). However, the mechanisms driving radionuclide transfer to deeper layers and the origin of secondary peaks remain unclear.

This study investigates the role of soil organic matter (SOM) in the formation and characteristics of secondary radionuclide peaks in vertical soil profiles. Sequential extraction was employed to determine geochemical forms, while radionuclide activity concentrations were measured used alpha and gamma spectrometry. The results indicate a strong correlation between radionuclide activity and SOM content, highlighting SOM's key role in radionuclide mobility.

Plutonium isotopes exhibited higher mobility in waterlogged, organic-rich soils but were more stable in non-boggy environments. In contrast, clay-rich soils significantly restricted ^{137}Cs migration but had little effect on plutonium movement (Kazakevičiūtė-Jakučiūnienė et al., 2021) This study emphasizes the complexity of radionuclide migration, revealing that soil structure and organic matter content are critical factors. Understanding these interactions is essential for assessing long-term radionuclide behaviour in ecosystems and can counsel in remediation and environmental risk management strategies selection.

References

Kazakevičiūtė-Jakučiūnienė, L., Druteikienė, R., Maceika, E., Lukšienė, B., Juškėnas, R., Pakštas, V., Žukauskaitė, Z., Gvozdaitė, R., Tarasiuk. N., 2021. Impact of soil organic matter on Pu migration in five Lithuanian surface soils. Journal of Environmental Radioactivity 237, 106702.

Łokas, E., Mietelski, J.W., Ketterer, M.E., Kleszcz, K., Wachniew, P., Michalska, S., Miecznik, M., 2013. Sources and vertical distribution of 137Cs, 238Pu, 239+240Pu and 241Am in peat profiles from southwest Spitsbergen. Appl. Geochem. 28, 100–108

Lukšienė, B., Maceika, E., Tarasiuk, N., Koviazina, E., Filistovič, V., Š, Buivydas, Puzas, A., 2014. On peculiarities of vertical distribution of 239,240Pu, 238Pu and 137Cs activity concentrations and their ratios in lake sediments and soils. J. Radioanal. Nucl. Chem. 300, 277–286.

Ota, M., Nagai, H., Koarashi, J., 2016, Modeling dynamics of 137Cs in forest surface environments: Application to a contaminated forest site near Fukushima and assessment of potential impacts of soil organic matter interactions, Science of The Total Environment, 551–552, 590-604.