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MIGRATION OF DEPLETED URANIUM CONTAMINATION THROUGH THE SOIL

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Abstract

Military use of ammunition with depleted uranium at South Serbia, caused contamination of the environment. Surface soil and soil profile around projectile with depleted uranium were analyzed three years later by high resolution alpha/gamma spectrometry. It was found that activity levels in the soil layer next to the penetrator changes to 1% of initial value at 15 cm distance. This value is about double background uranium level of the soil at the Bratoselce location.

Introduction

In a few NATO air strikes in May and June 1999, about 1300 projectiles each containing 300g of depleted uranium, have been fired into the 5400m^2 area at Bratoselce, South Serbia. [1] No widespread contamination over the surface soil was found at the location but localized points of concentrated contamination around the projectiles. Three years later the clean-up action was undertaken and hot spots investigated. Isotopes ^{238}U, ^{235}U, ^{236}U, ^{234}U, ^{239,240}Pu and ^{226}Ra are determined in the soil samples by high-resolution alpha and gamma spectrometry methods. This study should provide insight into the migration of contamination through the non-surface soil and to quantify contaminated soil to be removed from the environment within clean up.

Materials and Methods

Surface soil samples (0-15cm) and soil layers along the downward and sideward profiles were taken around depleted uranium penetrator, found at 50 cm depth. Homogenized samples are analyzed by alpha and/or gamma spectrometry.

For gamma spectrometry, samples were sealed for one month to reach the radioactive equilibrium. Measurements are performed with HP Ge detector with relative efficiency of 23%. The energies 1000 keV and 768 keV of ^{234m}Pa were used to determine ^{238}U in samples with high activities and energy 63 keV of ^{234}Th for low level activities. Low-level activities of ^{235}U were determined with 143 keV and 186 keV (common with ^{226}Ra). Isotope ^{226}Ra was determined from energies of its daughters ^{214}Pb and ^{214}Bi (295, 351, 609, 1120, 1764 keV).

For alpha spectrometry method, the prior radiochemical procedure was performed. [2] Uranium and plutonium isotopes were extracted from the soil matrix and separated from each other by procedure based on the ion exchange at Dowex 1x8 anion resin. About 0.1 Bq of ^{232}U and ^{236}Pu tracer solutions were added to samples to obtain the chemical yield. After radiochemical separation, the thin-layer alpha radioactive sources were prepared by Talvitie's electrodeposition procedure at stainless still discs.

[3] The alpha spectra were obtained using vacuum chambers with PIPS detectors of 100 and 300 mm^2 surfaces and efficiencies 7% and 15% respectively for ^{241}Am.

Results and Disscussion

Activities of analyzed soil samples are between: ^{238}U (kBq/kg)=263.40±26.34; ^{235}U (Bq/kg)=2174±370; ^{226}Ra (Bq/kg)=255±4, just next to penetrator and ^{238}U (kBq/kg)= 0.16±0.06; ^{235}U (Bq/kg)=1.2±0.2; ^{226}Ra (Bq/kg)=151±26, at 10 cm downwards. The activities ratio $^{235}U/^{238}U$ is within interval 0.008-0.003 Bq/Bq. Activity levels at 15cm distance at the side are: ^{238}U (kBq/kg)= 0.10±0.04; ^{235}U (Bq/kg)= 0.40±0.07 and ^{226}Ra (Bq/kg)= 141±20. The mean content of ^{232}Th in the samples was about 72±12 Bq/kg.

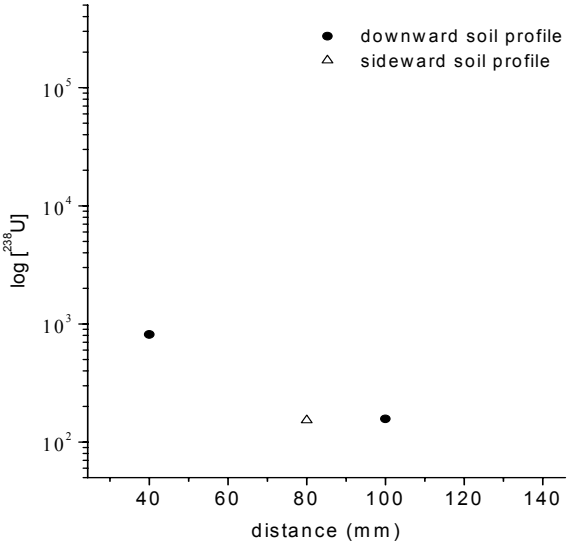

Figure 1. Content of ^{238}U in the layers of the profiles around DU penetrator

Results have shown high DU contamination in the very vicinity of the penetrator and rapid devolution with the distance through the soil layers both downward and sideward of its centerline. According to the obtained results, the distance of about 15 cm is enough to decrease DU contamination level to 1% of the initial value. The contamination gradient is almost uniform in two studied directions around the projectile. (Fig.1) Alpha spectrometry analysis of surface samples had shown the natural occurring ^{238}U values to be 50-70 Bq/kg at the investigated location, known as granite petrology region. The traces of transuranic isotopes ^{236}U, $^{239,240}Pu$ and ^{237}Np were found earlier [4] in the penetrator, indicating that "dirty" uranium was a part of depleted uranium ammunition used at the site, but there was no detectable transuranic isotopes in the analyzed soil samples.

Uranium mobility through the soil depends on the present chemical forms of uranium under certain geochemical and weathering conditions at the location. Physical-chemical behavior of uranium oxides will be affected by the change of temperature, pH, surrounding soil composition, etc. Devolution of uranium activity with the distance could be explained as the summa of successive adsorption-desorption steps of depleted uranium through the soil.

Conclusion

Three years after contamination of the Bratoselce site, depleted uranium originated from the projectile penetrators have migrated through the deeper layers of soil reaching the double background concentration value at a distance of about 15 cm. The adsorption/desorption processes under physical-chemical changes in the environment are responsible for migration kinetics.

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