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A Site Specific Study on the Distribution and Mobility of Tungsten at the Shooting Range Wichlen Alp

Wichlen Alp is one of two tank shooting ranges of the Swiss army where Armor Piercing Fin Stabilized Discarding Sabots consisting of tungsten-alloys are used for training purposes. The presented study is a site-specific research that focused on the distribution and the mobil- ity of tungsten in this specific area. Scanning electron microscopy analysis of bullet pieces collected in the field were done and showed evidence of tungsten corrosion and dissolution. X-ray powder diffraction identified Scheelite in the corrosion products of samples analyzed. On the site itself, the uppermost soil of a backstop was sampled according to a grid using portable and laboratory X-ray fluorescence analysis. Tungsten was present in the soil up to values of 540 mg/kg. Highest concentrations where detected at the edge of the impact area. Values decreased with increasing distance from the backstop, but even at 100 meters dis- tance from the backstop tungsten was present, indicating a large spatial distribution. Tung- sten in the sub soil decreased bellow detection limit within the first meter. Surface waters analyzed by Inductively Coupled Plasma Mass Spectrometry showed values of up to 570 µg/L. Concentrations in surface waters were highest in waters collected close to, or in back- stops. In general concentrations in water scatter a lot (0 to 570 µg/L). Soil water gained using suction cups indicated a rapid decrease of tungsten content within the uppermost 20 cm. Nevertheless, tungsten concentrations at 80 cm depth exceeded the background concentra- tions of 0.1 µg/L by at least one order of magnitude.

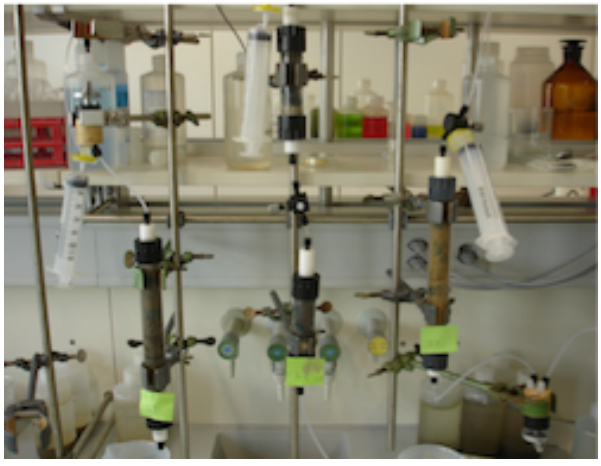
Column experiments performed in the laboratory with soil samples collected in the field indi- cated both, a high sorption capacity of the soil on one hand, and on the other, a relatively rapid release of tungsten out of the soil. Within the 107 days of the sorption experiments, more than 80% of the absolute tungsten input adsorbed on clays and iron hydroxides in both, surface and subsurface soils. In the column experiment addressing leaching of a contami- nated soil, almost 50% of the initial tungsten present in the soil was extracted within the 107 day of the experiment. Batch experiments showed extreme tungsten extraction within the first few hours to days. Concentrations decreased dramatically with time. Concentrations seem not to equilibrate before 70 to 80 day. The amount of tungsten released further is strongly dependent on the initial tungsten concentration of soil as well as on the solid/ liquid ratio chosen.

Modeling calculations with a simplified groundwater system indicate an oversaturation of the water with respect to Scheelite.

In general, the study proofed tungsten to be able to dissolve out of APFSDS in contact with the surface and soil waters present at the site. Further, tungsten shows a wide areal distribu- tion in the clay rich upper soil, but a limited penetration in depth. Laboratory experiments proofed both, a high mobility on leaching on one hand and a large retardation capacity of the soil on the other hand.

Too little is known about the eco-toxicity of tungstate to put these findings into a context of environmental impact.

Picture of the backstop with the sampling points.



The three columns Left to right: Leaching experiment, uncontaminated top soil, uncontaminated bottom soil.

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