Antimony fate, transport, and remediation in shooting range soils

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Antimony (Sb) is a metalloid added as a hardening agent to the lead (Pb)-alloyed core of bullets. Fragmentation represents a major pathway of metal(loid) release to soil. There is growing concern that Sb accumulation in shooting range systems may pose a serious contamination risk to groundwater, surface water, plants, and site reclamation efforts. Antimony is both toxic and carcinogenic, with toxicity and mobility dependent on speciation. Understanding overall processes controlling mobilization versus retention of Sb requires understanding speciation.

The present study details a six year effort to characterize the geochemistry of Sb in solid and aqueous phase as a result of bullet weathering in different soil types. Bulk speciation analysis coupled with micro-scale spectroscopic methods show that both Sb(III) and Sb(V) are present in soil solution depending on the soil matrix and Sb(V) in octahedral coordination with 5 oxygen (O) and 3 iron (Fe) atoms is the primary species present in the weathering crust of bullets. In terms of mobility, we found Sb generally more mobile than other metals like Pb, indicating Sb is more mobile despite being present in small amounts in bullets.

In the final years of the study, we tested different Fe amendments to immobilize Sb via sorption and/or precipitation reactions. We observed than an iron-oxide type amendment may be effective at further reducing mobility depending on soil type. Overall, this research suggests Sb is an emerging inorganic contaminant at shooting ranges and highlights the natural association of Sb with Fe in soils.