Testing Your Outdoor Range—Using the Right Tools

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Abstract

Lead and arsenic are the principle contaminants of concern at shooting ranges. Compounds of both elements are analyzed easily and relatively inexpensively. For outdoor ranges, measurement of soil properties relevant to the retention of metals and water also is an important component of the following activities: preparing a Best Management Practices program; conducting a risk assessment for lead and arsenic in soils, water and aquatic sediments; and as part of a range cleanup action. Total lead and arsenic residues should be analyzed in addition to soil properties such as pH, cation exchange capacity, phosphorus content and organic matter. Outdoor ranges have suffered unnecessarily when the Toxicity Characteristic Leaching Procedure (TCLP) is misused to exhaustively extract lead and arsenic from active shooting range soils. These results often exceed the 5 parts per million regulatory limit, which could classify the soil as a hazardous waste. A more desirable method to measure the mobility of lead and arsenic in shooting range soils is the Environmental Protection Agency's (EPA) Synthetic Precipitation Leaching Procedure, EPA Method 1312. This method simulates acid rain. Costs for single tests are minimal, but a complete site assessment can be quite expensive.

Introduction

The principle component of most ammunition shot at shooting ranges is lead. Arsenic often co-occurs with the lead. Arsenic also has been added intentionally to lead shot to increase the surface tension of the metal, which helps make a more perfect spherical shape during manufacture. Lead and arsenic compounds can be very toxic to humans, aquatic organisms and terrestrial wildlife, depending on the environmental matrix and the specific form of the metal (Final Toxicological Profile for Lead, U.S. Department of Health and Human Services, Atlanta, Georgia, 1999; Toxicological Profile for Arsenic, U.S. Department of Health and Human Services, Atlanta, Georgia, 1993).

Many ranges around the country have been closed either as a direct or indirect result of regulatory testing of air, soil and water. This can happen directly, though rarely, when appropriate testing indicates a significant environmental hazard, which then triggers a regulatory closure order. More frequently, testing by regulatory agencies raises serious concerns that must be addressed via costly owner-sponsored environmental testing and legal representation. This indirectly leads to range closure when the gun club runs out of money or dissolves once it fully anticipates the cost required to maintain operations.

Dr. Stuart Cohen is President of Environmental and Turf Services, the first company in the U.S. to develop a risk assessment and management plan for a shooting range (1991). ETS's Best Management Practices programs help range owners and operators manage lead and arsenic contamination from shot and bullets by providing site-specific recommendations. Dr. Cohen also lectures on lead compliance issues for the National Rifle Association. He has 24 years of experience as an environmental professional, including 11 years in EPA's Office of Pesticides and Toxic Substances.

Testing of shooting range soils is recommended even when regulators are not investigating. This should be done as part of a proactive environmental stewardship program called a Best Management Practices (BMP) program. The purpose of a BMP program is to protect the surrounding environment from unreasonable impacts resulting from range operations. BMP plans for shooting ranges typically have four components: a recycling program for spent munitions; stormwater management structures; vegetation management to control erosion and recycle metals; and soil amendments to chemically fix/stabilize lead and arsenic. The choice of appropriate types and amounts of soil amendments is determined by laboratory and field testing.

The purposes of this paper are to describe the tests appropriate for analyzing soil and water at outdoor shooting ranges, and to educate range managers about possible misuses of these tests that could have regulatory impacts.

However, it is much easier to understand these topics if one has some background in the chemistry of lead and arsenic in soil and water. Therefore, a brief tutorial on this subject precedes the discussion of testing methods.

Brief Summary of Lead and Arsenic Chemistry

The following information was adapted from EPA and Occupational Safety Hazards Administration (OSHA) Compliance Guide for Small Arms Ranges (Cohen et al. 1997).

Lead in its pure metallic or alloy form is not *mobile in the environment, and it is* not *bioavailable. Before lead becomes mobile and bioavailable, i.e., can be absorbed into the blood stream, it must oxidize (oxidation is the process whereby iron rusts and energy is produced from glucose in our bodies) to the cation form, a rather slow process. Even then, oxidized lead frequently forms compounds such as lead phosphate or lead sulfide that also are immobile. For example, a recent study demonstrated that several different forms of environmental lead were only 1.5 to 38.5 percent bioavailable (Davis et al. 1997). This conversion process can take several years (Jorgensen and Willems 1987). Observable evidence of this phenomenon is the crust on lead shot that has been lying on the ground for many years.*

The extent to which lead oxidizes and migrates in the environment depends very much on the chemistry of the local environment, i.e., the pH (acid content), oxygen availability and other aspects of soil chemistry. For example, lead from shot is likely to become mobile quicker on top of fertilized soil than under pond sediments. Thus, it is a leap of faith for someone to assume that the presence of lead pellets automatically results in exposure to lead. Following is a brief discussion of two of the most important factors controlling lead movement in soil, pH and phosphorus content. The organic matter and clay content of soil also can be important; lead is bound tighter to soils when the concentrations of both are higher.

Arsenic compounds tend to be more mobile in the environment than lead compounds. Arsenic typically exists in the arsenate form in aerobic environments (moderate to high oxygen concentrations; oxidizing conditions) and in the arsenite form under anaerobic or very low oxygen (reducing conditions). It is readily sorbed to iron compounds (e.g., Welch et al. 2000). We generally observe a much more dramatic decline of lead concentrations with increasing depth in soil compared with arsenic concentrations.

pH

pH is a measure of acidity. It is recorded on a scale of 1 to 14 as illustrated below. Lead is more mobile in the environment, i.e., more likely to dissolve into water, in acid environments below pH 6.

pH1 2 3 4 5 6 7 8 9 10 11 12 13 14

stomach acid, lemons (3) — *neutral* (8) — *concrete, some detergents* (12)

← *increased lead mobility*

However, recent work by our firm (Reid and Cohen 2000) and others indicates that this relationship changes above pH 7 in soils with moderate to high organic matter contents. The relationship between pH and arsenic solubility is more complex and will not be discussed here.

Testing Methods

There are two categories of test methods relevant to this discussion. One category is certain physical and chemical properties of soils that determine the extent to which metals and water will migrate through the soils. The second category is actual measurements of total arsenic and lead, as well as mobile (soluble) fractions thereof.

Soil Properties

A soil texture analysis determines the relative proportions of sand, silt and clay in the soil. Sandy soils are less likely to bind lead and arsenic, other factors being equal. Sandy soils also are less likely to retain water. Any soil testing lab and many chemical analysis labs can do this test. Tests generally cost only a few dollars when part of a testing package.

Organic matter, phosphorus content, pH and cation exchange capacity all are important for predicting metal mobility in soil. These parameters typically can be analyzed for $20 to $25. (Note: This organic matter analysis usually is the Walkley-Black method, not the total organic carbon (TOC) method run by many labs for analysis of petroleum spills.)

Metals Analyses

EPA Methods 7060A and 206.2 can be used to analyze total arsenic residues in soil or water using atomic absorption spectroscopy. EPA Method 200.7 can be used to analyze lead and arsenic with inductively coupled plasma spectrometry. Lead also can be analyzed using methods 7420 or 239.1. All methods involve an acid digestion of the soil in the lab prior to analysis. These procedures generally cost $7 to $25 per sample, depending on the lab and the number of samples.

A relatively new technology using X-ray fluorescence can be applied in the field. Real-time analyses can be done by sieving soil, placing it in the device and obtaining a reading. Costs for *a few days of analyses can be several thousand dollars, but it would be cost-effective if the alternative is dozens or hundreds of lab samples with a two-week turnaround time.*

Toxicity Characteristic Leaching Procedure (TCLP): Use and Misuse

TCLP is part of EPA's waste disposal law, the Resource Conservation and Recovery Act (RCRA). The application of this test by EPA and state environmental agencies has been controversial at times, particularly for shooting ranges. This procedure is only supposed to be used to determine whether a solid waste is hazardous, i.e., when a substance is being disposed. This determination is critical, because the tracking, shipping and disposal requirements are more rigorous if a waste is hazardous.

TCLP is EPA test method 1311. Basically, soil or waste is mixed with a dilute acetic acid solution that is similar to vinegar and is supposed to simulate the acid fluid at the bottom of a landfill. The mixture is shaken for 18 hours, filtered, and the filtrate (extract) is analyzed. If it contains lead or arsenic at or greater than 5 parts per million (ppm; mg/L; 1 ppm=0.0000002 lb/quart) or other listed substances at specified concentrations, the waste is hazardous (40 CFR Section 261.24).

A typical valid TCLP application on a shooting range follows. A facility decides to reconfigure the range and expand the parking lot to the area that currently is the short range pistol berm. The soils of the berm have to be disposed; they are not needed for the new berm. They are tested and fail the TCLP test. Therefore, a qualified hazardous waste contractor is hired, the proper paperwork is completed and the waste is disposed at a permitted facility.

Let's discuss a misuse of this test. A citizen files a complaint under RCRA against a modest size shooting range. An EPA or state technician or contractor who understands neither lead chemistry nor shooting range operations samples the soil in the impact zone and submits it for TCLP analysis. This is done despite the fact that the range is active, the soil is not slated for disposal, and management has just begun implementing a Best Management Practices program to retain all lead in the surficial soils, berms and detention basins. To no one's surprise, the soil fails the TCLP criterion for lead. The range comes under intense regulatory scrutiny. The legal and consulting fees drive the club out of business.

What could the range managers have done differently? First, spend a little money to retain legal counsel and an expert environmental chemist. They may help convince the regulators that surficial soil sampling is pointless. If that fails, the informed chemist will at least be able to make a strong case that the TCLP test is inappropriate, with the SPLP test being the alternative.

Synthetic Precipitation Leaching Procedure (SPLP)

The SPLP test (EPA test method 1312) is almost identical to the TCLP test except that the extraction fluid simulates acid rain rather than an acid landfill leachate. The major difference is that the SPLP test is much less efficient in extracting lead from soil. In our experience, TCLP lead concentrations typically are 5 to 100 times greater than SPLP lead concentrations.

SPLP is much preferred for active ranges as a measure of the leaching potential of lead and arsenic from soil.

Conclusions and Recommendations

- *Most lead and arsenic contamination stays at the surface, although arsenic is more mobile.*
- *Ground water contamination by range activities appears to be a rare event.*
- *Test your soil before you are forced to test.*
- *Consider surface water and sediments.*
- *Use a professional.*
- *Don't allow your range's soils to be tested by TCLP unless the results will remain confidential and/or SPLP is run concurrently.*

References

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