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INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

Investigating Lead at Small Arms Firing Ranges

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Notice

The Technology Evaluation Group (TEG) completed this evaluation of *Lead Issues at Small Arms Firing Ranges* based on review of items listed in the "References" section of this document. The IDEM OLQ technical memorandum Submittal Guidance for Evaluation of Remediation Technologies describes criteria for performing these evaluations.

This evaluation does not approve any technology mentioned nor does it verify its effectiveness in conditions not identified here. Mention of trade names or commercial products does not constitute endorsement or recommendation by the IDEM for use.

Background

Lead is a bluish-gray metal which has been mined and utilized for thousands of years. Its use in batteries, plumbing, gasoline, and paint; and the adverse environmental and health effects associated with those uses, are well known and much publicized. The Indiana Department of Environmental Management (IDEM) has several programs in place to protect human health and the environment from the adverse effects of lead from these sources. For additional information see Lead at the IDEM website.

Shooting ranges have been found to be the second largest anthropogenic contributor to environmental pollution from lead (Pb) deposition after the battery manufacturing industry (Kelebemang R., 2017). In response to questions received about the potential adverse environmental impacts of lead deposited at outdoor shooting ranges, IDEM has prepared this guidance to address the environmental issues involved. These ranges may be public or private and operated by individuals, gun clubs, the military, state and local police departments, or the Indiana Department of Natural Resources. Due to the low mobility of metallic lead from spent ammunition, adverse effects are site-specific, largely affected by the climate and soil properties. The formation of secondary lead minerals may have implications on range management practices (Kelebemang R., 2017).

Lead is the primary projectile component of ammunition used in handguns, rifles, and shotguns. In 2004 it was estimated that 80,000 tons of lead is made into bullets and shot per year (US EPA, 2005). Lead bullets and shot may be pure lead or may consist of lead alloys containing very small amounts of tin and antimony. In many cases the lead bullet is covered with a copper or steel jacket or covering. Other waste than lead found at shooting ranges includes clay targets and non-toxic steel or bismuth shot and plastic wads from shotguns.

Outdoor rifle and pistol ranges are generally designed so all shooting is done in one direction and usually into an earthen berm or hillside for safety's sake. In such cases, spent bullets are usually limited to a relatively small area. Lead shot, clay targets and wads are generally much more widely dispersed at trap, skeet, and sporting clays ranges since these involve shooting shotguns in many directions at moving targets. Lead from a firing range is much less toxic because there are direct relationships between toxicity and lead particle size, plus chemical form. Firing range lead is in metallic form, mostly as whole or fragmented bullets, with only a small concentration of dust-sized particles. The larger particles are not as readily absorbed (Colorado Dept of Health, 1990). There are studies examining the abraded lead in berm of the range which is more available for migration and uptake more than the metallic lead of the bullet fragments (Hardison D.W., 2004).

Legal and Regulatory Issues

Since the mid-1980's, citizen groups have brought several lawsuits against range owners and have urged federal and state agencies to take action against owners and operators of outdoor shooting ranges. In EPA's opinion, the use of munitions does not constitute a waste management activity because the munitions are not ''discarded.'' Rather, the firing of munitions is within the normal and expected use of the product (62 FR 6630, February 12, 1997). The waste sent off-site for disposal could be considered hazardous if the required toxicity characteristic leaching procedure (TCLP) test determined it above regulatory limits for lead, in which case the waste is handled and disposed of under the hazardous waste rules (US EPA, 2005). It is usually more feasible to extract the lead and send it to a recycler, or to manage it on site.

Regardless of the lack of specific regulations, lead is a hazardous substance. If a given range is having adverse effects on the environment, lawsuits may be filed to seek remedies under broader "imminent hazard" provisions of RCRA Sections 7002 and 7003; the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); or state laws. These lawsuits may be initiated by private citizens or government agencies (US EPA, 2005). This environmental threat (or perceived threat), and the resultant potential liability is a factor which drives some clean ups of shooting ranges. Property transfers of rangeland can also be hindered by this liability, which may include future owners. Clean ups are sometimes performed to facilitate the sale of property. Remediation requirements should be determined on a case-by-case basis, considering site-specific risks and the planned reuse of the property.

Indiana Site Conditions

Although many factors affect the mobility of lead, it has not been a problem in site conditions normal to Indiana. Some environmental conditions that stabilize lead include:

- Cation exchange capacity: In soils, the ability to exchange cations binds lead into the soil matrix, but the process is reversible.
- Sulfides: Sulfur has a high affinity for lead, which, after reacting to form lead sulfide, precipitates out, becoming effectively insoluble.
- Sulfites and Sulfates: In the presence of water-soluble sulfites/sulfates, lead tends to precipitate out of solution.
- Phosphates: Phosphate ion sources tend to be quite effective in immobilizing lead. Lead phosphate is insoluble and is quite stable.
- Hydroxides: Free lead, in the presence of hydroxide ions, forms lead hydroxide, which is insoluble.
- Humic substances: Lead forms complexes with these high molecular weight compounds, reducing their mobility and solubility.
- Carbonates: Lead/carbonate interactions decrease the solubility of lead.
- Clays, and iron or manganese oxides (all very common in southern and central Indiana), are highly lead absorbent, which restricts mobility.

Lead bullets and shot will oxidize at a very slow rate to produce soluble compounds which can be somewhat mobile, but these forms will readily absorb to the clays, iron and manganese-rich sediments, carbonates, sulfur compounds and organic matter common to Indiana soils.

Rainwater in Indiana is slightly acidic. This will solubilize lead and increase mobility. However, the buffering action of soils and groundwater will quickly neutralize acid rain. In Indiana, the only place where persistent acidic conditions are found is in coal mine drainage, marshes, or swamps. A firing range in such an area might produce localized high dissolved lead levels, but this would be balanced by the low water flow conditions, high sediment levels, and high organic contents. The synthetic precipitation leaching procedure (SPLP) method is an appropriate test for determining the mobility of lead in the soils of shooting ranges (Hardison D.W., 2004).

The fate and migration of lead in the soil is dependent on the physical and chemical transformations lead undergoes in the soil. A detailed investigation on the various species of lead that exist in shooting range soils helps to understand better the degree of contamination posed by lead to plants, water and soil and the health hazards associated with such contaminants. Instead of total lead concentration determination, the lead associated with the different fractions such as water soluble, organic-bound, carbonate-bound, Fe-Mn oxides bound, and residual help ascertain the mobility and bioavailability of lead in the ecosystem (Kelebemang R. 2017).

Surface or groundwater contamination from firing ranges has not been a problem. Firing range lead does not migrate far from the source. Case studies have found that even in areas of extremely high shot density, most of the soluble lead absorbed to sediments or settled out within a short distance. No normal off-site transportation of lead via neutral to alkaline surface water has been observed (EA Engineering, Science, and Technology, 1996).

Health and Toxicity

For lead to be toxic to animals or humans, it must enter the body. Inhalation can be a factor when significant amount of airborne lead dusts and fumes are present, such as around lead smelters and recycling centers. Most of the cases of severe lead poisoning in children are due to exposure to lead-based paints or leaded gasoline residues, and this is the focus of much of the research and articles on lead toxicity (Xintaras, 1992; Mielke, 1999). These reports are not related to firing ranges.

Small, poorly ventilated indoor ranges firing large volumes of non-jacketed lead bullets into steel backstops have occasionally presented risks from inhalation for range employees upon long-term exposure. Excavation of the impacted areas of outdoor ranges could possibly generate lead dusts, so dust control measures should be used. Lead inhalation at outdoor ranges has not been found to present a problem, because the amount of lead dust produced and exposed is very limited.

Ingestion as the major pathway for toxic lead effects from a firing range. Drinking water is seldom affected by firing ranges because of the low solubility and restricted migration of metallic lead. Therefore, eating of lead or lead contaminated soils is the more likely pathway of exposure.

Pre-school children are the most vulnerable to lead toxicity because lead absorption in the gastrointestinal tract is greater for children than adults, children's nervous systems are more susceptible to neurotoxic effects, and children are much more likely to be in contact with, and eat, soil. Also, the lead in paints exists in the form of oxides or salts, which can be over ten times more absorbable than metallic lead (Xintaras, 1992).

If there is no contact, then there is no possibility of ingestion. A good vegetative cover helps prevent contact, but children should not be allowed to play in range impact areas (ITRC, 2005).

Ecological Risks

Smaller lead particles (shot or fragments) can be ingested by wildlife, usually when mistaken for seeds or consumed by fowl looking for gizzard grit. Even one pellet may prove toxic to some birds, so precautions should be taken to make range impact areas uninviting to wildlife (ITRC, 2005). Although rifle ranges have been implicated in certain studies where toxic effects from lead have been observed, nearly all confirmed examples of harm to terrestrial species are with lead shot from shotgun ranges, but rifle projectile fragments are often too large for ingestion (Clausen et. al., 2011).

Reclamation

The most final and complete remediation is to remove the contamination. This is most feasible if the lead is concentrated in small areas. In the case of a rifle or pistol range, most of the lead will be in the backstop behind the targets.
Shotgun ranges (trap and skeet) present a more difficult problem because the lead pellets are more widespread, but do not penetrate far beneath the surface. There are

machines that remove the top few inches of soil, extract the lead, and replace the soil. These are often used at large ranges to recover and recycle lead shot. There are firms which specialize in lead cleaning at firing ranges.

Another option is to chemically bind the lead with an on-site treatment. Several firms sell proprietary chemical mixes that will bind up the lead into insoluble forms such as lead phosphates. Some of these treatment chemicals come in solid form which can be simply tilled into the ground at any size facility. Some mixes have not performed as well as others and a pilot-study would be recommended to see if the proposed mix works at specific sites.

Land Reuse

Future land use is the most important factor in determining if remediation is necessary. The goal of remediation is to prevent lead from harming humans or the ecology. Since ingestion is the exposure pathway of concern, the remediation method must prevent contact and possible ingestion of the lead. Any situation where children are directly exposed to contaminated soil from shooting ranges merits special concern and remedial action. Obviously, a parking lot or industrial use will not present many opportunities for contact and ingestion.

Conclusion

Small arms firing ranges do not present extreme environmental hazards, nor are extensive remediation efforts usually required. If it is impractical to remove the lead, it may be successfully managed on-site. Clays have a high ionic exchange capacity will bind to lead, so covering with clay soil is quite beneficial (ITRC, 2005). A sufficiently thick soil cover, if seeded and maintained so there are no erosion problems, will also help prevent contact with lead.

An outdoor range that plans to stay open and prevent negative environmental impacts can set up an environmental management program, with a plan for lead recovery and recycling, range management, erosion prevention, etc. “Environmental Management at Operating Outdoor Small Arms Firing Ranges,” (ITRC, 2005) and “Best Management Practices for Lead at Outdoor Shooting Ranges” (US EPA, 2005) are documents that detail the best environmental operating practices for the management of an open range.

Further Information

If you have any additional information regarding these issues or any questions about the evaluation, please contact the Office of Land Quality (OLQ), Science Services Branch (SSB) at (317) 233-6593. This technical guidance document will be updated periodically or if new information is acquired.

References

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