Contamination at Shooting Ranges

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Lead is deposited at shooting ranges as spent lead shot (pellets) at clay target shooting ranges, and spent lead bullets in soil berms at rifle/pistol shooting ranges. The lead is *not* insoluble in the soil environment, but is readily released in a soluble form. Soil lead concentrations >10,000 mg Pb kg^{-1} soil are commonly reported at shooting ranges around the world, including in New Zealand, USA, England, Germany and Scandanavia. For lead, the ANZECC guideline limit for further investigation is 300 mg kg^{-1}. It is the norm, rather than the exception, that shooting ranges are contaminated with lead.

THE PROBLEM WITH LEAD

Lead has a range of health effects in humans:

- Damage to the brain and nervous system
- Behavioural problems and learning disabilities
- Reproductive problems
- Memory and concentration problems
- Muscle and joint pain

DISTRIBUTION OF LEAD AT CLAY TARGET RANGES

Lead shot can easily be distinguished on the soil surface at clay target shooting ranges, particularly where soil is not ploughed. The shot-fall area commonly consists of a number of hectares, and extends over 200 m from the traps. There is a common pattern of lead shot distribution and associated lead concentrations in the soil at these ranges.

MAGNITUDE OF LEAD INPUT

- Annual lead shot deposition at clay target ranges can be expected to be in the range 0.5-10 tonnes/year, depending on level of use.
- In the UK, annual inputs of lead onto agricultural land from lead shot far outweigh more recognised sources of lead contamination, such as atmospheric deposition, and biosolid application. A similar situation is expected in Australasia.

IMPACT OF LEAD DEPOSITION: WETLAND *VS.* DRYLAND

The deposition of lead shot onto dryland shooting ranges has very different chemistry, and therefore different effects:

Wetland environments:

- Predominantly an anaerobic environment
- Little or no corrosion of pellets as a result
- Minor sediment contamination
- Visual effects: waterfowl toxicosis

Dryland environments:

- Aerobic environment
- Corrosive environment for pellets as a result
- High to extreme soil contamination
- No obvious visual effects

EFFECT OF LEAD AMMUNITION ON THE SOIL SYSTEM

The soil environment is significantly altered by presence of lead ammunition:

Uncontaminated soil:

- Soil 'soaks up' lead;
- Very low concentrations of lead in the soil solution as a result;
- Little potential for lead leaching.

Contaminated shooting range soil:

- Too much lead for the soil to soak up;
- Much higher concentrations of lead in the soil solution as a result;
- Chronic leaching of lead from the topsoil likely to occur.

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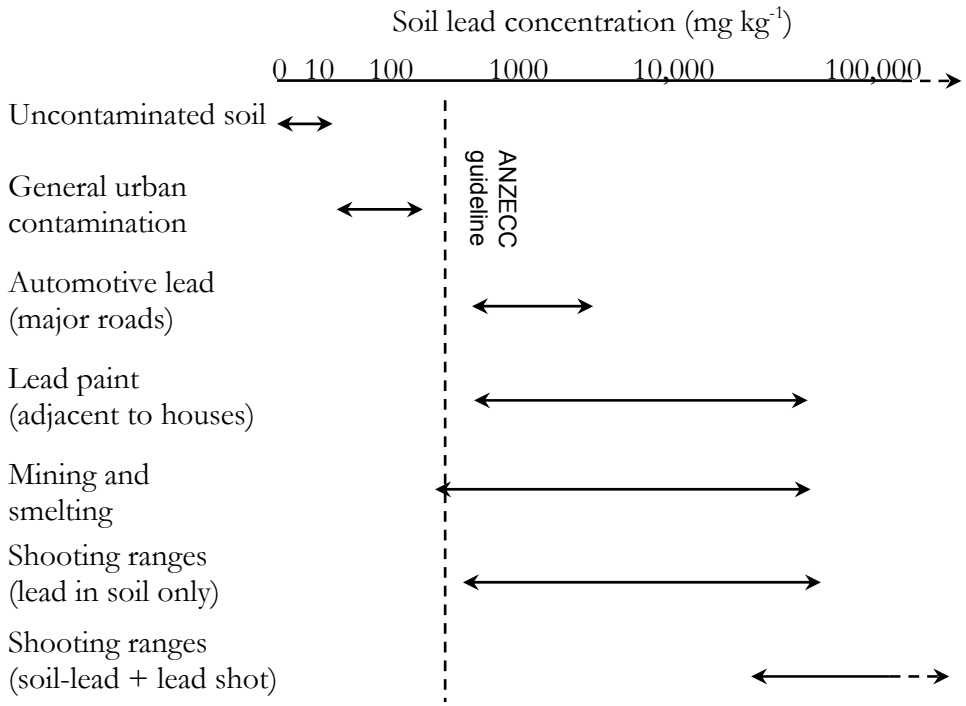
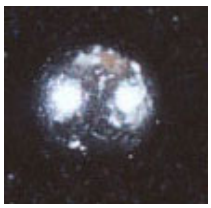
COMPARISON WITH OTHER CONTAMINATION SOURCES



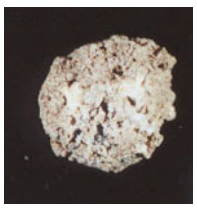
LEAD SHOT CORROSION

When lead ammunition contacts with soil, it corrodes, similar to a car rusting. The lead oxidises to form corrosion products, precipitate onto soil particles and as a layer around the pellets. The corrosion products are able to dissolve into the soil water (soil solution), and the soil soaks up (fixes) some of the lead. The corrosion process is effectively dissolving the pellets into the soil.

- How long does each pellet take to dissolve? Over 10,000 years in temperate climates; estimated >1000 years (at least) in tropical climates.



New lead pellet



Corroded lead pellet

The corrosion products consist largely of lead-carbonates, -sulphates, and -oxides. While lead-carbonate is insoluble in pure water, it is relatively soluble in the soil environment, and therefore lead readily dissolves into the soil water (soil solution) at shooting ranges.

New lead pellets consist of over 90% lead, 1-7% antimony, <2% arsenic and <0.5% nickel. The corrosion process will also release these other undesirable metals and metalloids into the soil environment.

FORMS OF LEAD IN THE SOIL

Most of the lead at shooting ranges is still present as intact lead shot:

		Approximate proportion (%) of total lead at a range
1	Intact lead shot	90
2	Lead in corrosion products around lead shot	5
3	Lead in corrosion products in soil, and fixed by soil	5

- The corrosion products on the lead shot (2) are highly soluble.

- A large proportion (30-50%) of the lead associated with the soil (3) is also highly soluble. For comparison, <5% of lead is soluble in uncontaminated soils.

- **The corrosion products represent a large reservoir of highly soluble lead.**
- **The intact lead shot that is yet to corrode represents an even larger reservoir of lead yet to corrode.**

LEACHING OF LEAD AT RANGES

- At present, there will be movement of lead from the topsoil in water draining through the soil at clay target shooting sites.
- Subsoil may provide some degree of retardation of lead movement.
- There is potential for lead to enter groundwater; free-draining soils above shallow, unconfined aquifers present the greatest risk.
- While substantial concentrations of lead can be leached, the annual amount leached is a very small proportion (<0.1%)of the total lead burden, due to the large amount of lead at ranges.
- There is potential for arsenic and antimony to be leached, although this has yet to be quantified.

OTHER RISKS OF LEAD CONTAMINATION AT SHOOTING RANGES

Where shot-fall areas are used for agricultural production, lead will be readily taken up by the pasture or crops.

- Grazing animals will also ingest lead shot from the soil surface on a daily basis, particularly where the pasture is grazed closely. Animal deaths have occurred (internationally).
- Root crops are especially at risk from great amounts of lead uptake from the soil.
- It is advised that any crops, particularly root crops, intended for human consumption be tested for lead concentrations.
- Silage made from grasses and maize growing in shot-fall areas, and containing lead pellets, has led to animal deaths after feeding out.

CAN THE CONTAMINATION AND LEACHING BE REDUCED?

Yes, but there is no easy, cheap answer.

Recent research has led to significant progress in understanding the behaviour of lead at ranges. **Much of the range management information contained in US Best Management Practices manuals is now incorrect.** The following management methods are considered the most sound.

1. Eliminate soil contamination at new ranges:
   - This can only be achieved if contact between ammunition and soil is eliminated, as this begins the chain reaction of corrosion and transfer into the soil.
   - For example: a concrete pad or geotextile covering the entire shot-fall area, and a drainage collection system
   - While expensive, such measures will be far cheaper than dealing with the soil contamination if soil is exposed to lead shot
   - Control measures for berms at static target ranges are more developed, particularly in the US, and include bullet traps to collect the ammunition.
2. Control the amount of lead leaching:
   - There is a promising technique for reducing the solubility of the lead in the soil, and therefore reducing the leaching, but it may not be suitable for use at all sites.
   - Lead leaching is not eliminated, but it may serve as an interim control strategy.
   - The technique is unlikely to control arsenic and antimony leaching.
3. Remove the lead shot:
   - The process of mechanically separating lead shot from soil results in the highly soluble corrosion products being returned to the range with the soil.
   - Lead shot removal will only be successful if the soil is also chemically washed before return to the range, and if further contact between lead shot and soil does not occur.

DO SHOOTERS HAVE TO USE LEAD?

No, but current 'non-toxic' alternatives are also likely to cause contamination, and further investigation is required.

- Steel shot: Iron corrodes about 5 times faster than lead, and the ammunition contains substantial heavy metal impurities, including chromium and copper, that have the potential to be released by corrosion.
- Frangible ammunition: Newly introduced in the US, but appears to contain compressed, powdered metals which are likely to undergo the same corrosion and release process as lead shot.

For further information see contact details on page 1.