General Population and Community Issues

Strategies for the Remediation of Lead Contaminated Soil

1. Introduction

Lead Mine Wastes and Smelting Residues present a potential risk to the environment and populations if they are not managed in a responsible manner. A Modern Environmental Management System (EMS) provides a framework for the control of leaded wastes and residues and minimize the risk of environmental pollution and population exposure. Unfortunately, this was not always the case. Sites of abandoned lead mines and disused lead smelters, whose owners have either gone into liquidation or moved to another site, are often contaminated with leaded wastes and untreated residues. These sites, if left to the elements, are likely to leach leaded waste into the environment and in arid areas contaminate the surrounding area with lead bearing dust.

Such legacies of the past, such as abandoned lead mines and smelters, and disused lead plants represent a potential environmental liability and a financial burden to the state, because in the absence of legitimate owner, the government is likely to have to bear the cost of rendering these sites environmentally benign.

Any remediation plan should provide a framework to identify, evaluate, and remediate used or abandoned lead mines sites and lead smelters in order to mitigate the effects of past practices.

2. Principles

- Remediation plans need to be designed in accordance with local population exposures and specific site contamination.

- It is essential that local populations, especially young children, living close to either abandoned lead mine sites or lead smelters undergo a medical assessment to determine their lead in blood levels.

- Remediation options should provide for the use of locally sourced materials wherever possible, especially bio-waste and indigenous plants.

- Treatment remedies should be sensitive to local conditions, that is, whether the area is primarily rural, agricultural, industrial or urban.

- Only proven technologies and methodologies should be considered.

- Cost minimization is always a prime consideration and every opportunity should be made to use long-term low maintenance solutions.
- Where there are local populations living close to a contaminated site every effort should be made to consult and involve them in the preparation of the plan and its implementation.

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3. Strategies

Unlike organic compounds that can be transformed, heavy metals, such as lead, can only be covered, buried, removed and recycled, moved to a safer location, or transformed into a less toxic or inert form. One of the most common remedies used worldwide for lead contaminated soils, for example, has been to mix the soils with chemical binders such as Portland cement and to transfer the contaminated waste to a secure landfill site. Landfill strategies are, however, becoming increasingly unacceptable solutions and an expensive option where it is permitted.

The chemical form of lead contamination in soils and waste residues is an important consideration in determining the appropriate strategy. Some industrial lead compounds are toxic, whereas certain naturally occurring forms have a lower toxicity because many natural mineral forms of lead have a low bioavailability. This low bioavailability means that the naturally occurring forms of lead can pass through the human digestion system virtually unabsorbed. It follows therefore that if toxic lead compounds can be converted to naturally occurring forms then a contaminated site could be rendered safe, even for human habitation and possible agriculture, although crop selection will be limited to those plants with low lead uptake.

Soil and residue characterization will be a key element to determine an appropriate remediation strategy. It must take into account the mineral form, the particle size, the toxicity and the encapsulation of the lead contaminant, because these features will have a direct impact on solubility and bioavailability. As these characteristics are site specific it is very important to prepare remediation strategies and models on real field sampling, monitoring and accumulated exposure data.

Essentially there are four main remediation strategies to consider and the most appropriate or combination of the most useful of the four strategies should be selected.

a. Removal and replacement of contaminated soils by either:
   - Removal and treatment to decontaminate the soils to safe lead levels and then return the treated soils to the original site
   - Removal of contaminated soils and replacement with uncontaminated soil.

b. Treatments involving the transformation of contaminants.
   - Thermal, biological, and chemical treatment methods that can be applied on or offsite.

c. Immobilization of contaminants
   - Including capping of landfill residues, chemical[1] and "in-situ[2]" stabilization , solidification, and containment technologies.

d. Extraction, separation and recovery of contaminants
   - Including soil treatment by, soil washing[3], thermal extraction[4], and phytoremediation[5] extraction using "in-situ" phytoextraction using specially selected plants to "pull" the lead out of the soil. Where appropriate ground water treatment using gravimetric separation, ion exchange, and bio-chemical or phytoremediation[6] extraction.

[1] Investigations in Military Range Sustainability, G L Fabian, Military Environmental Technology Demonstration Center, U.S. Army Aberdeen Test Center, "Lead Immobilization Using Phosphate-Based Binders", February 2001, (http://www.che.msstate.edu/mis-stap/bios%20and%20abstracts/fabian.pdf).

[2] Interstate Technology and Regulatory Cooperation (http://www.itrcweb.org/), Work Group, Metals in Soils Work Team, Inactivation Project, "Emerging Technologies for the Remediation of Metals In Soils - Insitu Stabilization / Inplace Inactivation ", December 1997, (http://www.itrcweb.org/mis-3.pdf).

[3] Interstate Technology and Regulatory Cooperation (http://www.itrcweb.org/), Work Group, Metals in Soils Work Team, Regulatory Guidance Project, "1998 Technology Status Report", December 1998, (http://www.itrcweb.org/mis-6.pdf) and Metals in Soils Work Team Soil Washing Project, "Technical and Regulatory Guidelines for Soil Washing", December 1997, (http://www.itrcweb.org/MIS-1.pdf).

[4] Emerging Technology Report: Reclamation of Lead from Superfund Waste Material Using Secondary Lead Smelters, EPA 540-R-95-504: NTIS: PB95-199022 (Project Summary: EPA 540-SR-95-504), (http://www.clu-in.org/products/site/complete/chmrsmlt.htm).

[5] US Army Environmental Center, Pollution Prevention and Environmental Technology Division, "Innovative Technology Demonstration, Innovation and Transfer Activities", February 1993, (http://aec.army.mil/prod/files/p2etd-fy00.pdf).

[6] Interstate Technology and Regulatory Cooperation (http://www.itrcweb.org/), Work Group, Metals in Soils Work Team, Inactivation Project, "Emerging Technologies For The Remediation Of Metals In Soils In-situ Stabilization / In-place Inactivation", December 1997 (http://www.itrcweb.org/mis-5.pdf).

Anticipate that a single technology or methodology might not adequately remediate an entire site and be prepared to consider several different treatment technologies that can be integrated to reduce if not eliminate the risk of lead exposure from all the sources of contamination.

4. Work Plan

During the initial remediation planning stages the abandoned lead mine site and/or lead smelter must be visited and inspected to ensure that any remediation plan addresses the potential lead exposure problems and issues associated with any population exposure or environmental contamination.

A logical work plan should:

> Characterize the contaminated site and the surrounding area.

> Establish the environmental impact and the likely extent of any population exposure.

> Identify the most appropriate remediation technique(s) to be employed.

> Determine logistical problems associated with remote locations, arid condi tions and equipment needs.

> Sequence the remediation work

> Suggest the agenda for a suitable workshop to acquaint those involved in the process and the local community with the appropriate remediation tech niques and methodologies.

5. Maintenance and Aftercare.

To ensure that a site remediation process continues to provide a safe environment it is important that any remediation pan considers maintenance and aftercare issues. For example if any one or combination of the strategies outlined in section 3 above is appropriate, it will provide a safe, but sterile environment that is liable to erosion by wind and rain. In order to compliment soil abatement strategies for lead contaminated sites and inhibit erosion by the elements the plan must incorporate a number of agronomic options to encourage plant growth in treated areas to keep soil in place.

Agronomic options to consolidate the top soil and improve soil fertility should consider the use of domestically available and digested biosolids as well as several other options that might be considered to cap certain areas where an agronomic option is inappropriate.

In most cases specific plants will have to be selected to sequester pollutants in their roots and inhibit any subsequent migration or leaching of stabilized lead compounds in the treated soil or capped residue dumps. Plants that sequester pollutants can be harvested and treated as pollutants, but in the long-term such plants will decontaminate the soil.

6. Regulatory Issues

In order to ensure compliance with the appropriate national, federal, municipal and local regulations for the remediation of lead contaminated used or abandoned lead mines sites and lead smelters the plan must include a section detailing the requirements of the various legal instruments applicable to the site. This section must also include the monitoring and testing regime necessary to ensure that the remediation plan will be in and remain in compliance with the appropriate regulations.

7. Publication and Distribution

It is recommended that once the Plans for the Remediation of Used or Abandoned Lead Mines Sites and Lead Smelters have been prepared that they should be made available for distribution to the Offices of the National and local Government Regulators, any interested Academic Institutions and the local community representatives for their consideration.

Initial publication of the remediation plan should be treated as a period of consultation and feedback. Any comments, concerns or suggested improvements should be considered carefully and where appropriate the plan amended accordingly.

8. Links or Contacts for Information on Successful Remediation Projects

Coeur d'Alene Basin, including mine site reclamation.

Progress Report - http://www2.state.id.us/deq/AboutDEQ/Progress_Report_10_01_01.pdf
Strategic Plan - http://www2.state.id.us/deq/AboutDEQ/StratPlan_2002.pdf

The Doe Run Company - calcareous lead/zinc mine tailings.

Research report - http://www.rtdf.org/public/iinert/minutes/ii62996.htm

Executive Editors Inc. - "in situ" stabilization of lead.

http://www.environmental.usace.army.mil/library/success/itsucc/executve/executve.html

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