HAZARDOUS SUBSTANCE RESEARCH CENTERS

Heavy Metal Stabilization in Soil

Great Plains - Rocky Mountain
Hazardous Substance Research Center

Soil Heavy Metal Stabilization

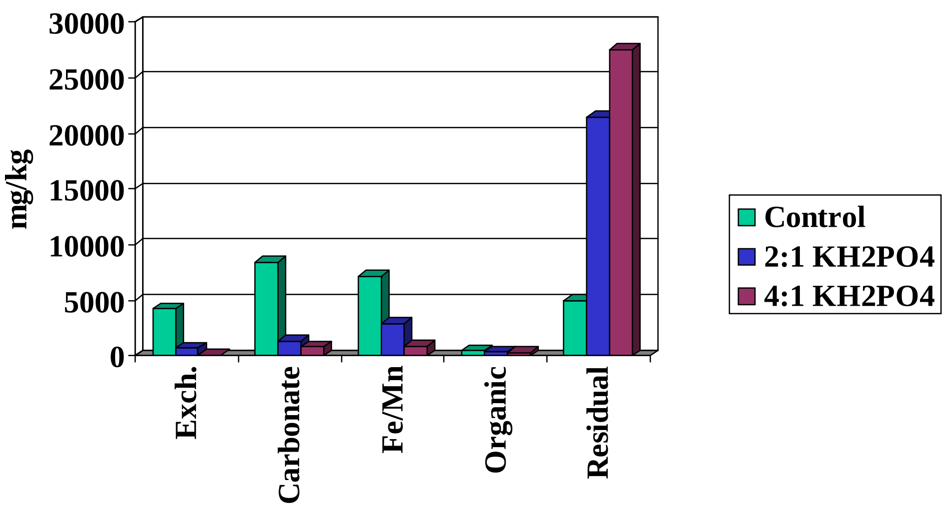
Excavation and removal

Removal of lead-contaminated soil in Joplin, Missouri (photo courtesy G. Pierzynski, KSU).

- Traditional remediation method
- Most expensive option
- Most environmentally disruptive
- Long-term waste storage problem

Soil Heavy Metal Stabilization (con't.)

In Situ fixation



- - - decreasing *bioavailability* - - - >

Lead content in mg/kg (parts per million) of smelter slag from Dearing, Kansas, after 24 weeks of incubation with phosphate amendments. *From* Lambert, *et al*., 1998.

- Treats contaminated soil in place.
- Benefit: much less disruptive and less expensive
- Goal: make heavy metals less *bioavailable* thru use of soil amendments..
- Disadvantage: a new technology with uncertain public response.

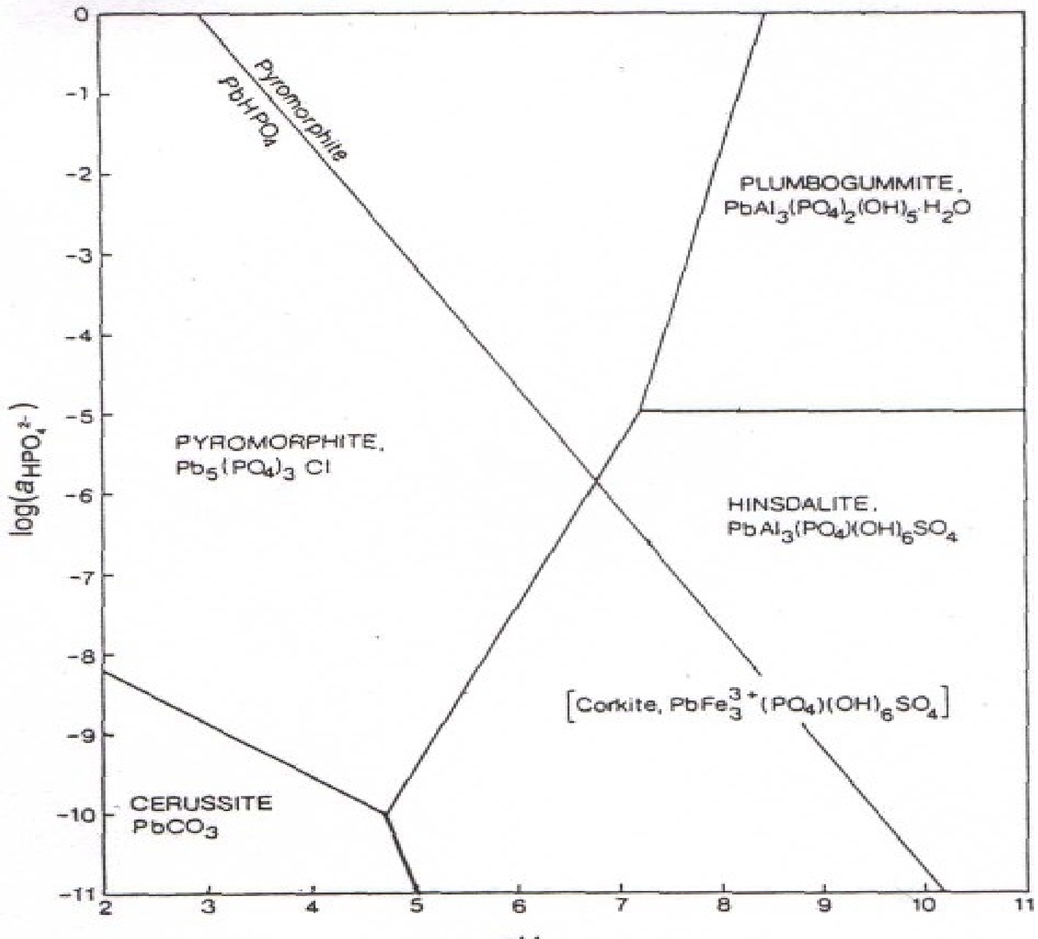
Solubility Products of Selected Heavy Metal Minerals

MINERAL	CHEMICAL FORMULA	LOG Ksp
Cerrusite	$PbCO_3$	-12.8
Fluoropyromorph.	$Pb_5(PO_4)_3F$	-76.8
Hydroxypyromor.	$Pb_5(PO_4)_3OH$	-82.3
Chloropyromorp.	$Pb_5(PO_4)_3Cl$	-84.4
Hinsdalite	$PbAl_3(PO_4)(OH)_6SO_4$	-99.1
Plumbogummite	$PbAl_3(PO_4)_2(OH)_5H_2O$	-99.3
Corkite	$PbFe^{+3}_3(PO_4)(OH)_6SO_4$	-112.6

From **Lindsay, 1979, and Nriagu (1972, 1973, and 1984)**

Diagram Showing the Stability of Lead Minerals in Soil

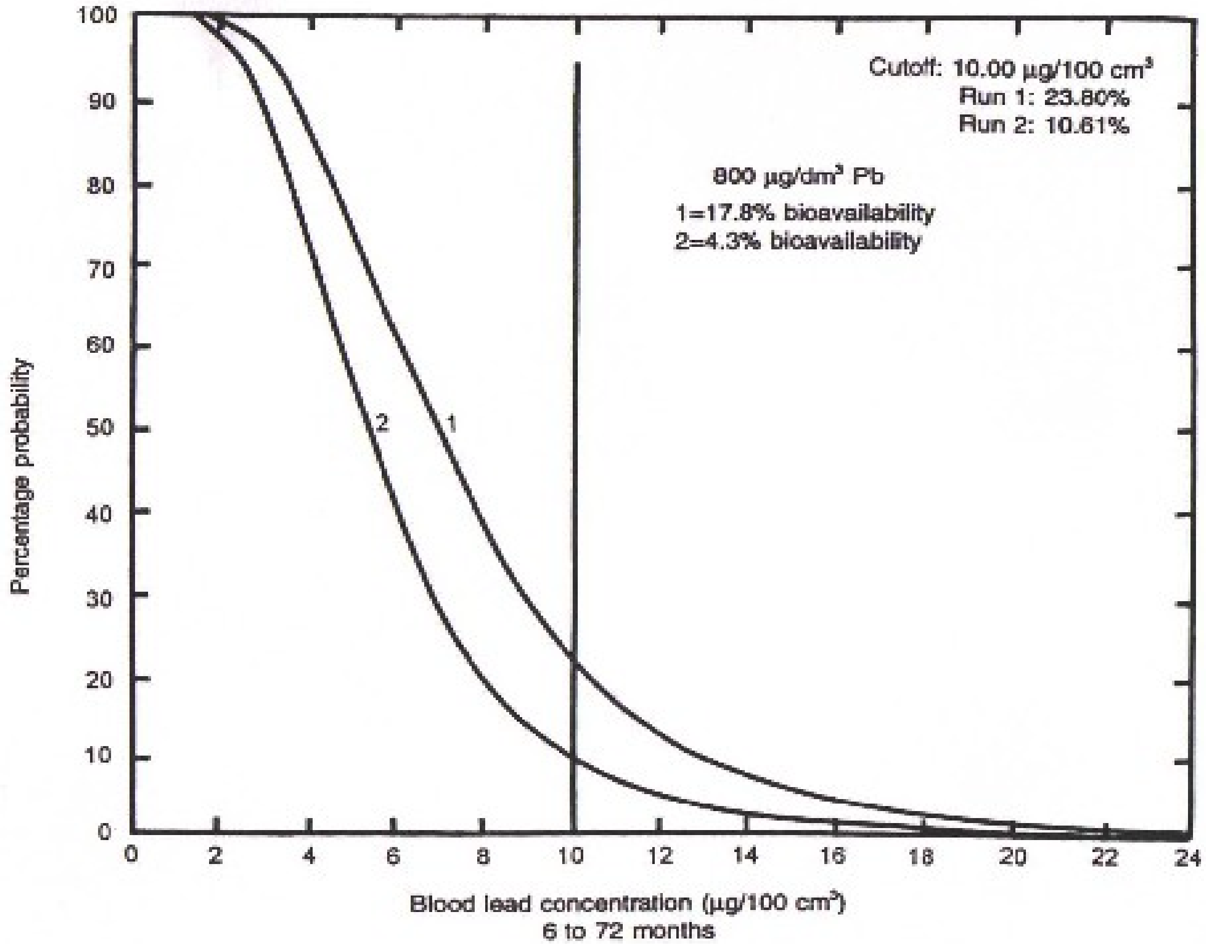
Figure 1 Stability fields of lead minerals in soils. Ionic activity constraints are: activity of SO_4^{2-} = activity of HCO_3^- = 10^{-3}; activity of Al^{3+} = 10^{-6}; and activity of Pb^{2+} = 10^{-6}. Minerals with similar compositions and stabilities, such as hinsdalite and corkite, occupy the same stability field. Chloropyromorphite [$Pb_5(PO_4)_3Cl$] has the largest stability field. (Adapted from Nriagu[20])



After Lambert, Pierzynski, Erickson, and Schnoor, 1997

Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Soil

Figure 6 An Integrated Exposure Uptake Biokinetic (IEUBK) model output for a soil with 800 mg kg^{-1} soil lead. Two different levels of bioavailability are assumed: 17.8% (corresponding to no phosphate remediation) and 4.3% (corresponding to phosphate stabilization of soil lead). All other model parameters are default values. Phosphate remediation under these conditions results in a decrease of children with blood lead levels above EPA guidelines from 23.80% to 10.61% of the children.



After Lambert, Pierzynski, Erickson, and Schnoor, 1997

Soil Heavy Metal Stabilization (con't.)

Phytoremediation

Phytostabilization of mine spoils (*chat*) in Galena, Kansas. Without revegetation, wind and rain can spread heavy metals beyond initial site of contamination. *From* Lambert, *et al*., 1999).

- Phytostabilization (revegetation) of heavy metal - contaminated land.
- Phytoextraction (sequestration) of heavy metals by plants.
- Benefit: Low cost and environmentally friendly.
- Disadvantage: length of time for remediation; disposal of harvested heavy metal biowaste.

Comparative Costs for Different Types of Heavy Metal Soil Stabilization

Type of Stabilization	Cost / cu. m	Time Required (months)
Excavation and removal	$100 - $400	6 - 9 months
In Situ fixation	$90 - $200	6 - 9 months
Phytoextraction	$15 - $40	18 - 60 months

From Schnoor, 1997

Other Heavy Metal Soil Stabilization Techniques

- PHYTOVOLATILIZATION
- MICROBIAL BIOREMEDIATION
- EXTRACTION OF HEAVY METALS

Research Supported by Great Plains - Rocky Mountain Hazardous Substance Research Center

(http://www.engg.ksu.edu/HSRC/research.html)

- METALS RESEARCH
- DETECTION AND REMEDIAL RESEARCH
- BIOREMEDIATION RESEARCH
- FATE & TRANSPORT