CHEMICAL STABILIZATION OF HEAVY METALS

James Barthel and Scott Edwards
Metals Treatment Technologies (MT^2), L.L.C.
12441 W. 49th Ave., Suite 3, Wheat Ridge CO 80033, (303) 456-6977

Abstract: Heavy metals contamination can be found at battery acid recycling sites, electroplating facilities, military installations, firing ranges, brownfields redevelopment sites, and associated with mining activities. The chemical stabilization process uses non-hazardous chemical binders that permanently stabilize heavy metals. The treated soils contain stable metal-reagent compounds that eliminate the leaching of metals.

A new generation metals stabilization process that utilizes a proprietary additive to permanently stabilize heavy metals has been successfully demonstrated and implemented. The treated soils contain extremely stable metal-phosphate compounds that virtually eliminate the leaching of metals to the environment. The strength and effectiveness of the stabilization has been verified using TCLP test parameters and Multiple Extraction Procedure (MEP) tests.

Another advantage to using phosphate-based chemical stabilization is the ease of application. The reagent can be applied in a wet or dry form and can be used to stabilize metals *in situ* or *ex situ*. These varied applications make it ideal for use at a wide range of metals contaminated sites. At burn pits or firing ranges the reagents can be tilled into the soil in its dry form to stabilize metals. In a wet form, the reagents can be sprayed onto the surface of an active firing range in a topical fashion to maintain metals stabilization.

In addition to the technical and application advantages, the cost of utilizing phosphate-based chemical stabilization to treat heavy metals contamination is attractive. By being able to treat metals contamination to RCRA or UTS standards, stabilized waste can often be left on-site rather than transported off-site to a hazardous landfill. The disposal cost savings for stabilized metals can often be measured in the hundreds of dollars per ton.

Technology Description: The EcoBond™ treatment process is an EPA approved, non-hazardous chemical additive that permanently stabilizes a wide range of heavy metals. The resulting treated waste contains stable metal compounds that virtually eliminate the leaching of metals to the environment. Stabilizing the metals reduces the waste streams toxicity levels to below RCRA-regulated levels and often to below Universal Treatment Standard (UTS) levels. EcoBond™ also combines with radionuclides such as thorium, uranium, radium and cesium to create safe, stable metal-phosphate complexes. The strength and effectiveness of the EcoBond™ metals stabilization process has been verified using TCLP leaching parameters, the Multiple Extraction (leaching) Procedure (MEP) and Bioavailability testing. EcoBond™ can be applied in a wet or dry form, applied *in situ* or *ex situ*, stabilizes metals within 24 to 48 hours of application and only increases the volume of the stabilized waste by 1% to 3%.

Metal-phosphate compounds have extremely low Ksp (solubility potential) values indicating that it is virtually impossible to dissolve metal-phosphate complexes (Table 1). Phosphates have been used to stabilize heavy metals for a number of years and have proven superior to

cementation and other methods that rely on increasing the alkalinity of the matrix to immobilize the metals. Unlike many stabilizing compounds, the EcoBond™ phosphates bond directly with metals and are not subject to long-term pH related deterioration.

TABLE 1
Ksp (solubility potential) of various compounds and EcoBond™ lead-phosphate minerals

Lead Species / Mineral Name	Formula	Log Ksp
Salt	NaCl	0.0
Quartz	SiO_2	-4.0
Anglesite	$PbSO_4$	-7.7
Cerussite	$PbCO_3$	-12.8
Galena	PbS	-27.5
Fluoropyromorphite	$Pb_5(PO_4)_3F$	-71.6 *
Hydroxypyromorphite	$Pb_3(PO_4)_3OH$	-76.8 *
Chloropyromorphite	$Pb_3(PO_4)_3Cl$	-84.4 *
Plumbogummite	$PbAl_3(PO_4)_2(OH)_5H_2O$	-99.3 *
Corkite	$PbFe_3(PO_4)(SO_4)(OH)_6$	-112.6 *

* Lead-phosphate mineral

The EPA's Toxic Characteristic Leaching Procedure (TCLP) is one measure of the long-term stability of a treated waste because it simulates the leaching effect of water or acid that may come into contact with stabilized metals. To simulate a longer period of environmental exposure, the Multiple Extraction Procedure (MEP) test has been developed. The MEP test consists of multiple acid extractions and pH adjustments that are similar to the TCLP test. However, different leachates are used for each of ten separate extractions. It is estimated that each TCLP extraction simulates 100 years of stability and after ten MEP extractions, 1,000 years of metals stability are simulated.

The durability of EcoBond™ treated materials have been tested by numerous MEP tests and have been evaluated in the EPA's Superfund Innovative Technology Evaluation (SITE) program The MEP test is just one of the tests that have been conducted to establish the long-term stability of EcoBond™ stabilized waste. Other tests include SPLP (Synthetic Precipitate Leaching Procedure), redox potential, bioavailability and Germany's DIN leachate test. In each of these tests, EcoBond™ stabilized materials met or exceeded regulatory standards.

Metals Bioavailability: Bioavailability is an emerging parameter that the EPA is increasingly using to gauge the ability of the human digestive system to absorb lead from a contaminate source. EPA commissioned bioavailability testing of EcoBond™ treated lead-contaminated soils from the Crooksville, Ohio Superfund Innovative Technology Evaluation (SITE) program indicates an average reduction in lead bioavailability of 28.2%.

The EPA's bioavailability tests for EcoBond™ far exceeded the results of bioavailability testing conducted on lead contaminated soils treated with other remediation methods including concrete additives, soil washing and many chemical treatments such as silicate encapsulation and sulfates.

Treatment Results: EcoBond™ has been used to treat a wide range of metals problems. Shown on Table 4 is a sampling of metals and EcoBond™ treatment results. It should be pointed out that many new stabilization projects are being required to achieve the Universal Treatment Standards (UTS) for leachability and many of the traditional metals treatment technologies are having great difficulty achieving these objectives.

		Pre Treatment TCLP	**Post-Treatment TCLP**	**Regulatory Standards**	
Waste Stream	Metals	(ppm)	(ppm)	RCRA (ppm)	UTS (ppm)
Mill Tailing	As	2,200.0	1.03	5.0	5.0
Sludge	Cd	160.0	0.10	1.0	0.11
Mill Tailing	Cr	14.0	<0.05	5.0	0.65
Industrial Site	Ba	249.0	0.03	100.0	21
Industrial Site	Pb	980.0	0.25	5.0	0.75
Batteries Site	Pb	977.0	0.180	5.0	0.75
Mine Tailing	Zn	108.0	2.00	NA	4.3
Mill Tailing	Se	190.0	0.89	1.0	5.7
Chemical Waste	Hg	500.0	0.07	0.2	0.025

Conclusions: The Department of Defense has many sites where heavy metals contamination is a major concern. A new generation metals stabilization process that utilizes a proprietary additive to permanently stabilize heavy metals has been successfully demonstrated and implemented. The EcoBond™ process provides:

1. Better stabilized metals contaminated material
   a. Stronger chemical bonds achieve RCRA and UTS leachability standards
   b. Metal bioavailability is significantly reduced
2. Better contaminated material stabilization techniques
   a. Wet or dry application provides faster methods of stabilizing contaminated material
   b. Faster stabilization results in less expensive remediation costs
3. Cost savings
   a. *In situ* stabilization is fast and saves on operations costs
   b. Often times, stabilized materials can be left on
   c. The transportation and disposal cost savings can be hundreds of dollars per ton