FAST-TEK Engineering Support Services

TECH MEMO #107: IN-SITU REMEDIATION OF HEAVY METALS:

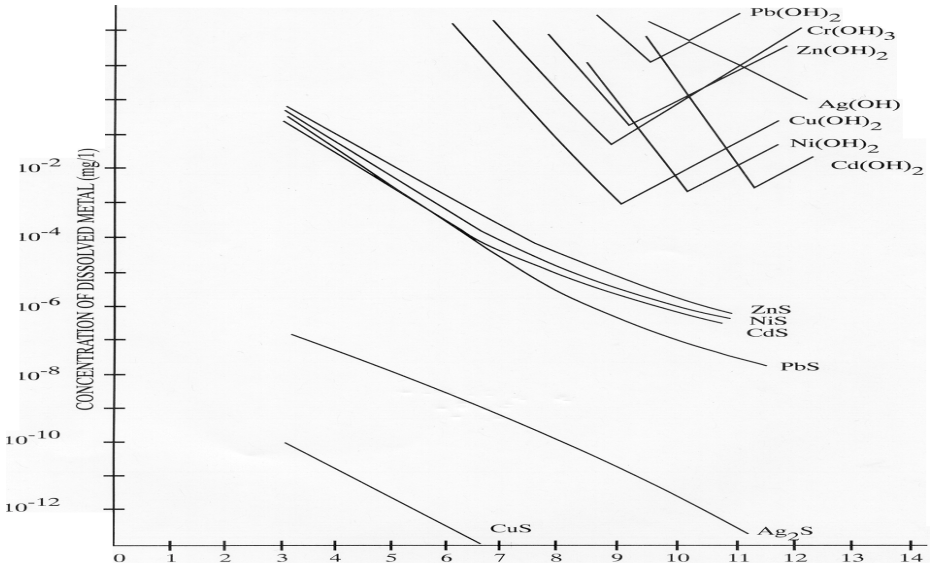
ARSENIC, LEAD, COPPER, ZINC, CADMIUM, MOLYBEDIUM, URANIUM AND CYANIDE

By Jim Jacobs, CHG, (510) 232-2728; ext. 222

THE METALS PROBLEM: Highly toxic and highly soluble metals are contained in numerous waste streams including those from power, chemical, electronics and general manufacturing plants, and mining facilities. Metals can create significant health risks to humans.

HISTORY: Arsenic, lead, copper, zinc, cadmium, molybdenum, uranium and cyanide have been used in a variety of industrial activities such as plating, circuit board manufacturing as well as mining and power waste streams, and other processes.

NEW TREATMENT TECHNOLOGY: The solubility of arsenic, lead, copper, zinc, cadmium, molybdenum, uranium and cyanide are pH dependent. Recently, sulfur-based metals treatment technologies have been the focus of an increasing number of research studies and commercial applications for treating metals contamination in soil and groundwater. A reductant, such as calcium polysulfide (CaS_4; brand name: Cascade®), precipitates the highly soluble metal as a less soluble, and non-toxic sulfide. Metal hydroxides change solubility with changes in pH. Metal sulfides remain insoluble within a pH range of about 5 to 9. Cascade® has a pH of 11.3



Solubility of Metal Hydroxides and Sulfides as a Function of pH (EPA, 1981)

to 11.5, a specific gravity of 1.273 and is deep orange-red solution. The excess calcium precipitates as calcium carbonate, gypsum, or calcium sulfate. Cascade® is soluble in water and comes as 29% concentration of calcium polysulfide. The extent of metals precipitation is a function of pH of the environment.

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DELIVERY SYSTEM: FAST-TEK's in-situ delivery method uses close spacing of the RIP® high-pressure injection ports, allowing the treatment chemicals to fully contact the contaminant. FAST-TEK uses both a direct push method as well as a specialized lance system for the delivery of treatment chemicals (Jacobs, 2001).

Metal	**Arsenic**	**Lead**	**Copper**	**Zinc**
Treatment notes:	Acid medium only	Wide range (pH: 4-9)	Close to neutral (optimal pH: 5-7)	Wide range (pH: 4-9)
Metal	**Cadmium**	**Molybdenum**	**Uranium**	**Cyanide**
Treatment notes:	Wide range (pH: 4-9)	Wide range (pH: 4-9)	Wide range (pH: 4-9)	Chemical conversion produces thiocyanate*

* Thiocyanate is treated with lime, producing calcium carbonate, gypsum and ammonia
Chromium (Cr VI) can be treated with calcium polysulfide, and the Cr (VI) is reduced to Cr (III), which is then precipitated as chromium hydroxide. For more information, see FAST-TEK Tech Memo #100.

PAST REMEDIATION OPTIONS: In the past, conventional soil remediation of soil and groundwater impacted by heavy metals has relied on soil excavation, which was expensive and disruptive. In addition, moving the soil only moved the problem, without treating the soil or reducing the long-term liability. For groundwater, pump and treat remediation relied on pumps to remove groundwater from the aquifer through a series of extraction wells or trenches. The extracted water was then treated above ground or disposed of off-site. Pump and treat methods fail to address the source of the contamination in the vadose zone. Although the construction of passive permeable treatment walls containing zero valent iron filings can reduce some metals to less toxic varieties, the passive barriers are expensive and do not treat source areas.

RECOMMENDED PLAN: FAST-TEK recommends a review of the existing physical and chemical data, including pH, permeability, lithology, and water depth, concentrations of metals, alkalinity, and other data and a simple bench test (10 working days). The in-situ remediation can occur within 10 to 15 working days after the bench test results are available.

REFERENCES:

Jacobs, J., 2001, In-Situ Liquid Delivery Systems for Chemical Oxidation, Bioremediation and Metals Stabilization, Association for Environmental Health and Sciences, 11th Annual West Coast Conf. on Contaminated Soils, Sediments and Water, March 21, 2001, San Diego, California, Abstracts.

United States Environmental Protection Agency (EPA), 1981, US EPA Chart Comparing Sulfide and Hydroxide Solubilities; EPA publication, EPA-600/2-82-OIIC.