SOLIDIFICATION/STABILIZATION CEMENT ADDITIVE and TEST METHOD

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AGENDA

- What is Solidification/Stabilization (S/S) ?
- History of S/S
- EPA Superfund Data Regarding S/S Technologies
- Materials for Solidification/Stabilization
- Treatability Mix Studies
- Case Study

What is Solidification/Stabilization (S/S) ?

- S/S treatment protects human health and the environment by immobilizing hazardous constituents within treated material
- Involves mixing a binding agent into contaminated media such as soil, sediment, sludge or industrial waste
- Physical and chemical changes to the treated material

History of S/S Treatment Uses

1950's — **Radioactive Waste Management**

1970's — **Industrial Waste Management**

1980's — **Remediation**

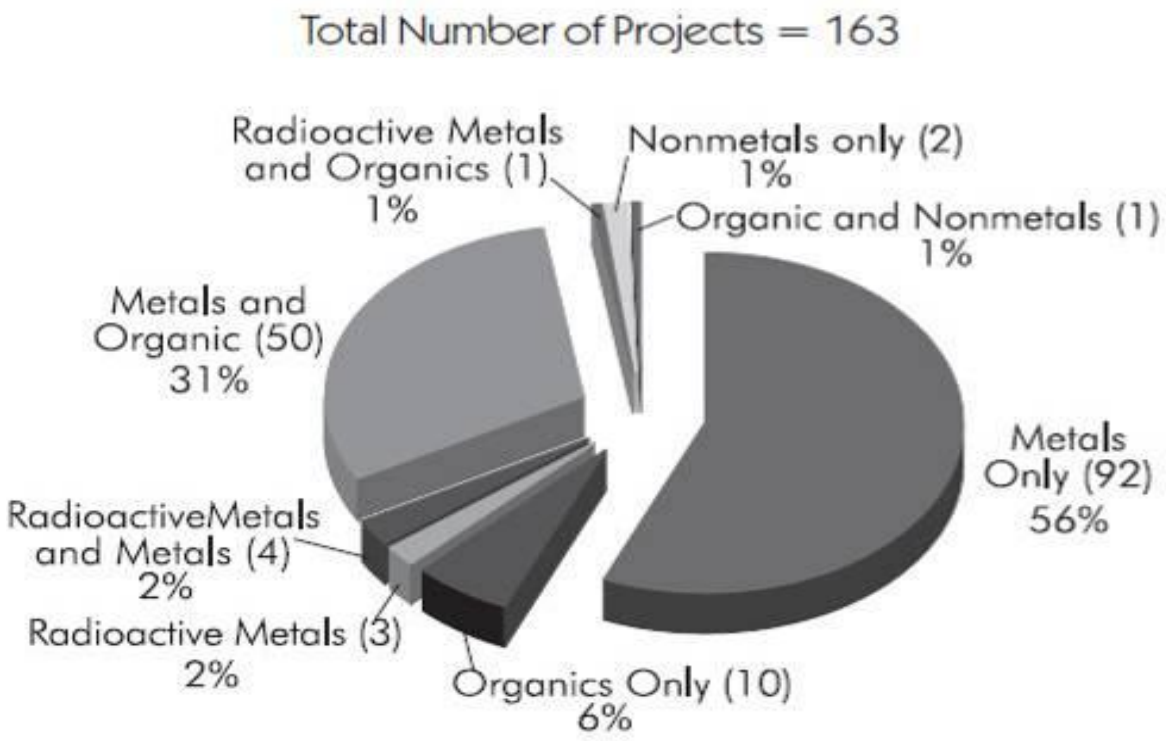
- Superfund and other programs
- Brownfields

EPA-542-R-07-012

Technology	Total number of projects[a]	Polycyclic aromatic hydrocarbons (PAHs)	Other nonhalogenated semivolatile organic compounds[b]	Benzene-toluene-ethylbenzene-xylene (BTEX)	Other nonhalogenated volatile organic compounds[c]	Organic pesticides and herbicides	Other halogenated semivolatile organic compounds[d]	Halogenated volatile organic compounds	Polychlorinated biphenyls	Metals and metalloids
Bioremediation	113	37	51	33	33	24	17	22	2	5
Chemical Treatment	29	1	2	3	4	1	4	12	4	13
Multi-Phase Extraction	46	9	3	11	6	4	8	18	1	1
Electrical Separation	1	0	0	0	0	0	0	1	0	0
Flushing	17	3	5	5	5	1	3	11	0	5
Incineration	147	27	41	33	23	36	34	52	36	6
Mechanical Soil Aeration	7	0	0	3	1	0	1	7	0	0
Neutralization	15	2	0	0	0	0	0	0	0	6
Open Burn/ Open Detonation	4	0	1	0	0	0	0	0	0	0
Physical Separation	21	4	2	1	0	3	0	0	4	5
Phytoremediation	7	1	2	2	2	1	1	4	0	4
Soil Vapor Extraction	255	15	31	107	51	3	33	217	1	0
Soil Washing	6	1	1	0	0	2	0	0	1	2
Solidification/ Stabilization	217	17	18	13	13	16	7	20	35	180
Solvent Extraction	4	2	1	0	1	1	0	2	2	1
Thermal Desorption	71	21	17	24	15	8	12	33	16	0
In Situ Thermal Treatment	14	5	0	2	0	3	3	8	0	0
Vitrification	3	0	0	1	1	0	1	3	2	1
Total Projects	**977**	**145**	**175**	**238**	**155**	**103**	**124**	**410**	**104**	**229**

Contaminant Types Treated by S/S (EPA-542-R-00-010)

Exhibit 10:



S/S Binding Agents and Additives

- Portland Cement
- Cement kiln dust
- Slag
- Fly ash
- Organoclay
- Bentonite

Portland Cement

- **Description**

  A generic material produced by over 50 companies at over 125 plants in the U.S. and Canada. The principal use of cement is in concrete for construction. Concrete is a mixture of Portland cement, aggregates (gravel and sand), and water. The cement used in S/S is the same as that used in concrete.

- **Application and Benefit**

  Portland cement is used in waste management as a binding reagent and is mixed into contaminated media or waste in order to immobilize contaminants within the treated material.

- **Comments**
  - **Manufactured to ASTM specification which ensures uniformity.**
  - **Used to treat the greatest variety of wastes since the 1950's.**
  - **Readily available in all parts of U.S. and Canada. It is economical and can be purchased in small or bulk quantities.**

Sodium Bentonite

- **Description**

  High swelling clay composed primarily of the mineral sodium montmorillonite.

- **Application and Benefit**

  Uses as an additive to Portland Cement to lower hydraulic conductivity.

- **Comments**

- Manufactured to API specifications to assure consistency.
- Available in large quantities from bentonite manufacturers and in small quantities from distributors.

Organophilic Clay

- **Description**

  Clay that is specially treated to convert it from hydrophilic to organophilic.

- **Application and Benefits**

  Uses as an additive to Portland Cement to reduce organic leaching and aid curing of cement.

- **Comments**

  - Manufacturer should provide manufacturing quality control, including treat content (ASTM D7626), to assure consistency.
  - Material used in construction should be same as material tested in treatability study to help assure effectiveness.

USEPA Solidification/Stabilization Documents

- USEPA Handbook of "*S/S of CERLA & RCRA Wastes; Physical Tests, Chemical Tests, Technology Screening, Field Tests*", EPA/625/6-89/022, Pg. 3-3. "Organophilic Clay-based S/S Processes: Recent investigations.. indicate that these organophilic binders truly bond with organic wastes."
- USEPA *S/S Technical Resource Document*, EPA/530/R-93/012, Pg. 4-13: "For certain organics, organophilic clay may improve cement-based or pozzolanic process performance."
- USEPA *Technology Performance Review: Selecting and Using Solidification/Stabilization Treatment for Site Remediation*, EPA/600/R-09/148, Pg. 2, "In applying S/S for treating organic contaminants, the use of certain materials such as organophilic clay.., either as a pretreatment or as additives in cement, can improve contaminant immobilization in the solidified/stabilized wastes."

S/S Typical Performance Criteria

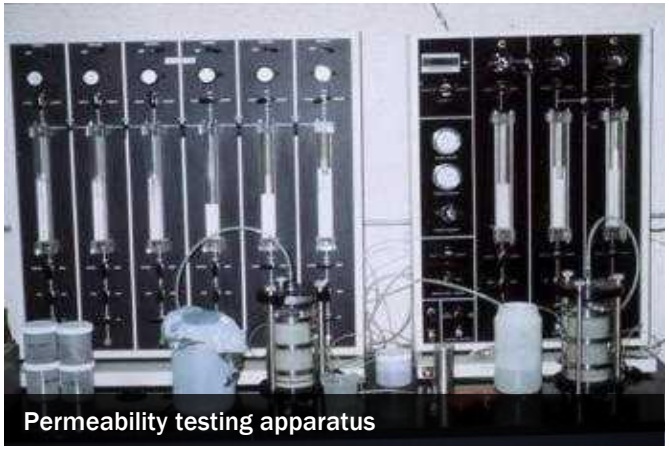
- Unconfined Compressive Strength: 50 psi
- Hydraulic Conductivity: 1×10^{-7} cm/s
- Leachability (varies based upon site risk assessment)

S/S Process: Feasibility and Mix Design Tests

Physical Testing

- Hydraulic Conductivity/ Permeability
- Unconfined Compressive Strength – measure of free liquids & durability
- Freeze-Thaw & Wet-Dry Durability
- Paint Filter Test (PFT) – free liquids
- Moisture Content
- Density

Solidified samples prepared for strength and permeability testing



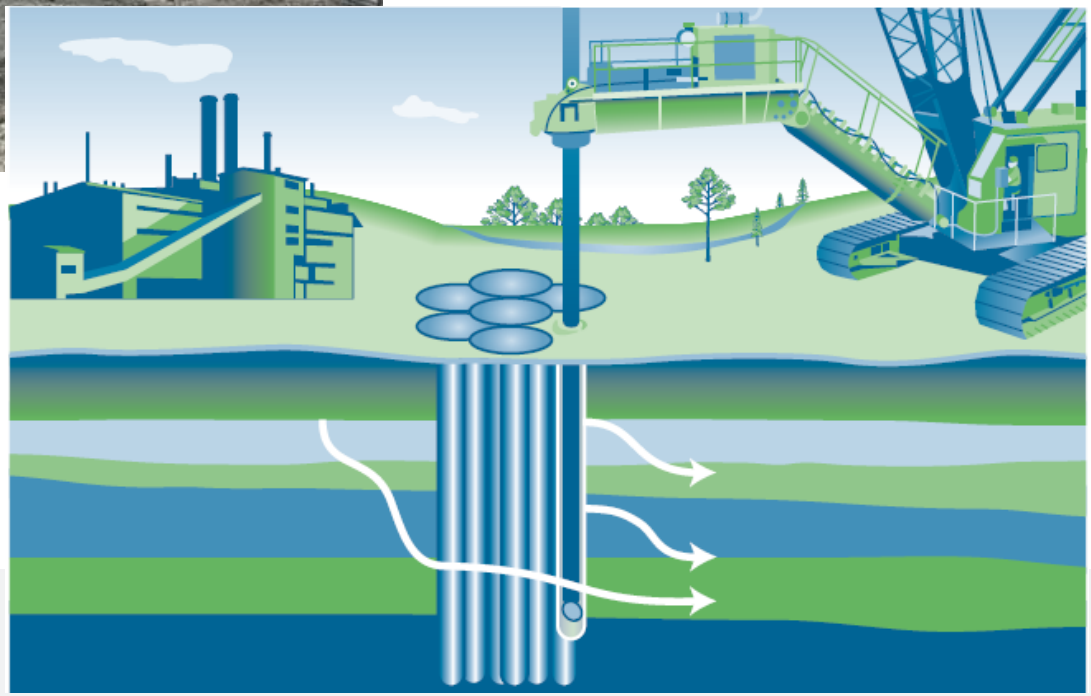
Permeability testing apparatus

Unconfined compressive strength

S/S Process: Feasibility and Mix Design Tests

Chemical (Leaching)

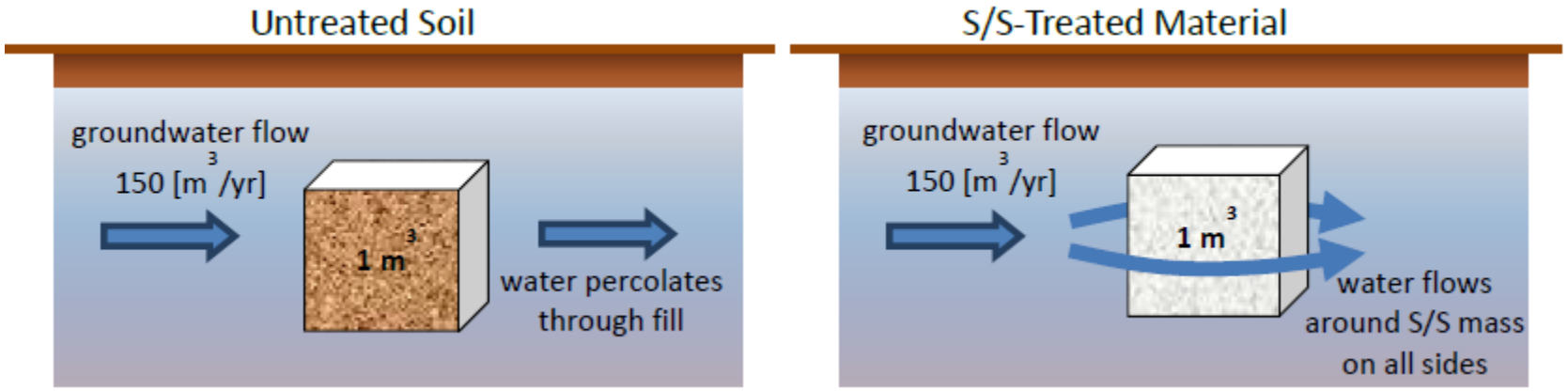
- Toxicity Characteristic Leaching Procedure (TCLP)
- Synthetic Precipitation Leaching Procedure (SPLP)
- Semi-Dynamic Leach



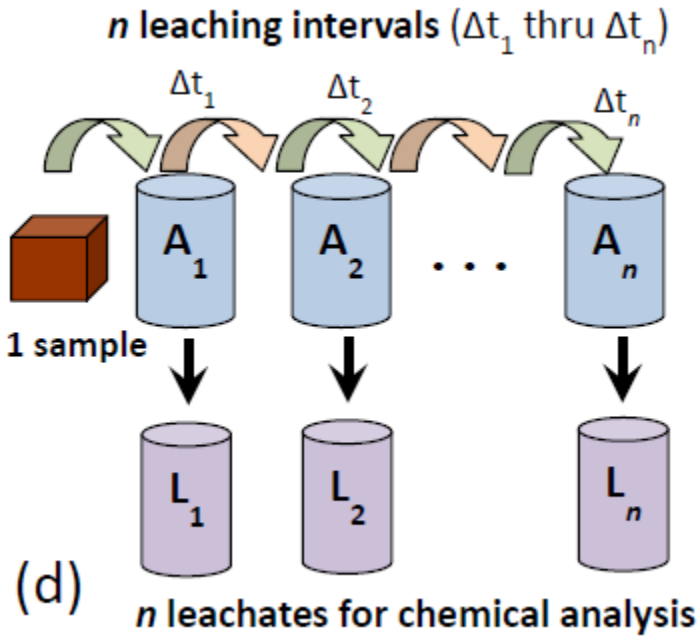
Semi-dynamic Leaching Test

- **US EPA Method 1315 (expected to be adopted by end of 2012)**
- **Determines mass transfer release rates of COC from low-permeability material under diffusion controlled release conditions.**
- **One of four leaching test methods of the LEAF Project, a collaboration of:**
  - USEPA Office of Research & Development and Office of Solid Waste
  - Vanderbilt University
  - Energy Research Centre of the Netherlands (Petten, The Netherlands)
  - DHI (Horsholm, Denmark)

Flow through untreated soil versus treated soil



Semi-Dynamic Leaching Procedure



CASE STUDY

Virginia Wood Treating Site Treatability Study Mix Design

MIX ID	Total Reagent Dose	Portland-Slag Dose	Bentonite Powder Dose	GAC Dose	OC Dose	Basis
7	9.5	8	0.5	0	1	Low OC dose
8	9.5	8	0.5	1	0	Mid GAC Dose
9	10.5	8	0.5	0	2	Mid OC dose
10	10.5	8	0.5	1	1	Mid GAC/Low OC dose
11	12.5	8	0.5	0	4	High OC dose
12	16.5	12	0.5	0	4	Increased cement, High OC dose

All data in wt%

Virginia Wood Treating Site Semi-Dynamic Leaching Study

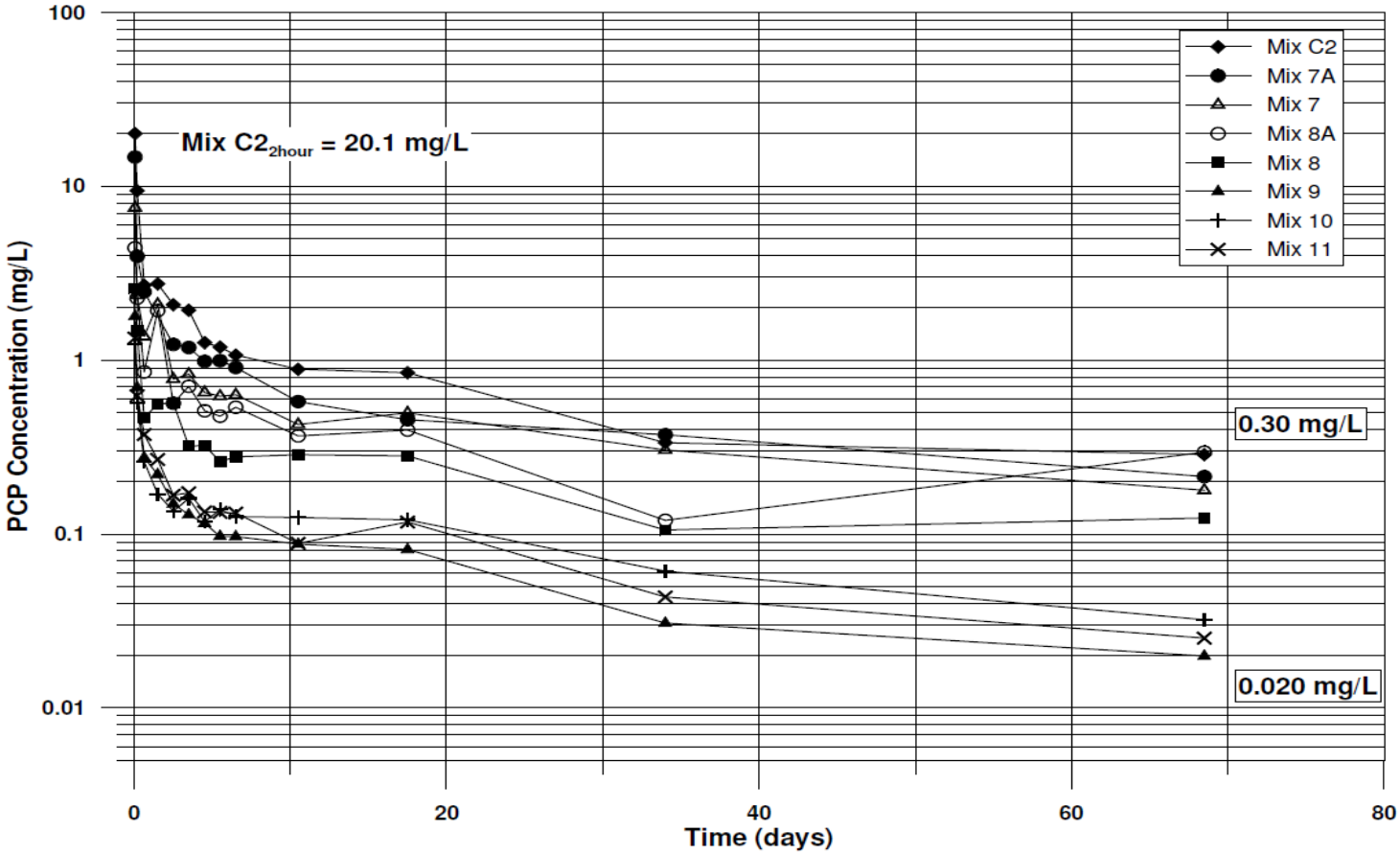


Figure 4: Day-averaged PCP concentration profiles in close proximity to S/S-treated contaminated soil surface.

Summary

- Cement-based Solidification/Stabilization is a proven technology.
- Bentonite can be added to help decrease hydraulic conductivity.
- Organophilic clay has been shown to be an effective additive for sorbing organics.
- New leachability tests show that organophilic clay can be effective at low doses of 1-2%.