

TRIUM

Soil Stabilization /Solidification (S/S) Technology as a Cost Effective Tool for Heavy Metal Risk Management

RemTech 2017

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AGENDA

- Risk based Approach for Heavy Metals
- Total Metals vs. Leachable Metals
- Background - Soil Stabilization /Solidification
- Project Objectives
- Approach and Activities
- Performance Verification Tests
- Findings and Discussion

Exposure Pathways and Control



Soil Direct Contact

DUA / FAL?

Background – S/S

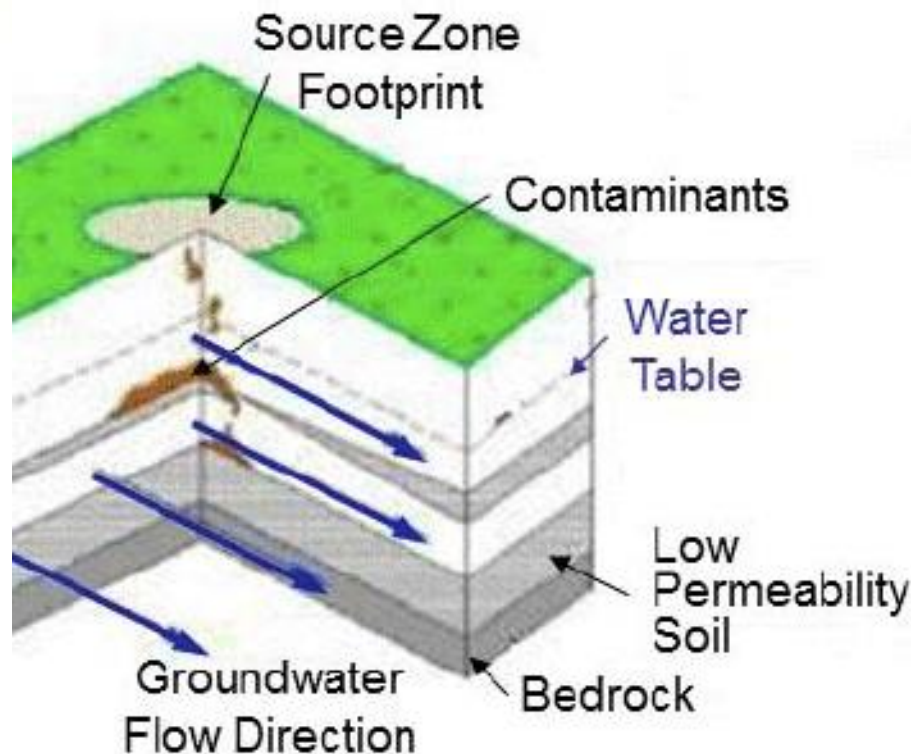
Total vs. Leachable Metals

Metal	Arsenic	Copper	Chromium	Lead	Zinc
AB Tier 1 Total Metal (mg/kg) Agricultural, Fine	17	63	64 0.4 (6+)	70	200
AB Landfill Criteria TCLP (mg/L)	5.0	100	5	5	500

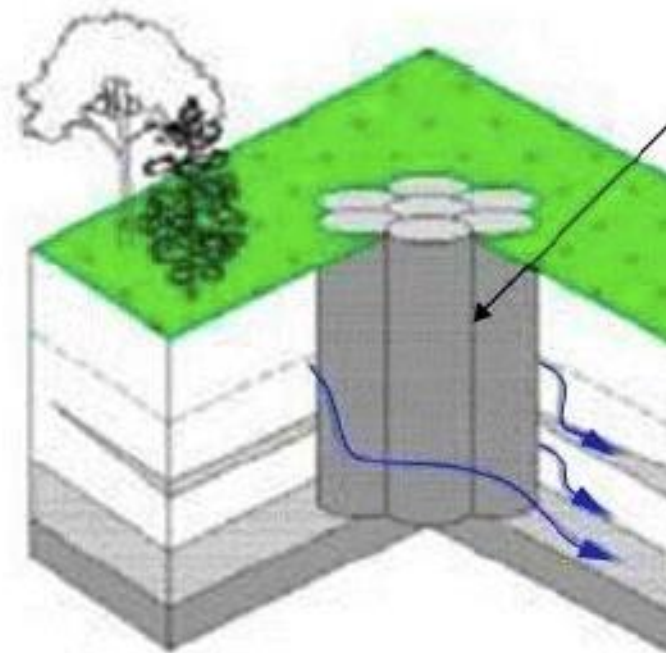
Total Metal Based Approach



Leachable Metal Management Approach



Before S/S



After S/S

Leachable Metal Management Approach

- Most common approach (solidification) involves incorporating inorganic cementitious and/or pozzolanic based reagents to:
 - ☐ Increase compressive strength
 - ☐ Lower hydraulic conductivity/permeability
- Adverse effects
 - ☐ Bulking & weight
 - Commonly 8% to >20% added
 - ☐ Limited reclamation capabilities

Definitions

- **Solidification** – “processes that encapsulate contaminated material to form a solid material and restrict contaminant migration by decreasing surface area exposed to leaching and/or by coating the contaminated material with low-permeability materials”
- **Stabilization** – “processes where chemical reactions occur between the reagents and contaminated material to reduce the leachability of contaminated material by transition into a stable insoluble form”

Approach & Activities

Understanding of Fundamental Mechanisms



Literature Research



Remedial Selection - Lab Bench Scale Test



Applications and Validation Field Pilot Test

Project Objectives

- Reduced Mass (S/S Reagents)
- Reduced Leachability (i.e. precipitation and adsorption)
- Neutral pH
- Rapid Dewatering Capacity
- Maintain Soil Structure & Strength
- Favorable Conditions for Vegetation
- Reusable Material and Cost Effectiveness
- Less Toxicity

Selection of Amendments

- Dehydration and stabilization
- Precipitation & adsorption of metal(s)
- Dehydration and stabilization
- pH control
- Maintain soil structure
- Low Ecological Toxicity
- Reduced mass of applied reagents

Performance Verification Tests

- Unconfined Compressive Strength
- **Hydraulic Conductivity**
- **Leachability**
 - **Total Characteristic Leaching Procedure (TCLP)**
 - **Synthetic Precipitation Leaching Procedure (SPLP)**
 - and other methods such as Liquid-Solid Partitioning (LSP), Flux based Leaching Test

Performance Verification Tests

- Moisture Adsorption
- Turbidity
- Stabilization
- Vegetative Capacity
- Aquatic Eco Toxicity (TU)

Test Preparation



Test Batch Preparation



+ 40% H₂O



Add



MIX



T-SS

Performance Verification Tests

Source 1	Soil baseline	Pre	Post	Pre	Post
	(mg/kg)	TCLP (mg/L)		SPLP (mg/L)	
Pb	934	0.082	0.032	0.027	0.009
Cu	225	0.072	0.015	0.026	0.013
Cd	10.29	0.112	0.021	0.013	0.02
Cr6+	345	0.281	0.037	0.177	0.036
As	50	ND	ND	ND	ND
Zn	2450	ND	ND	ND	ND

Performance Verification Tests

Sample ID	TP-15-2-1				TP-15-4-1					Referenced Guidelines		
Parameters	Soil baseline	Pre	Post 7 days	Post 29 days	Soil baseline	Pre	Post 7 days	Post 29 days	DL	BC	AB	SK
	mg/kg	TCLP (mg/L)			mg/kg	TCLP (mg/L)			mg/L	TCLP (mg/L)		
Antimony	503	< 1.0	< 0.1	< 0.1	722	< 1.0	< 0.1	< 0.1	0.1	NG	500	NG
Arsenic	344	< 1.0	< 0.1	< 0.1	572	< 1.0	< 0.1	< 0.1	0.1	2.5	5.0	2.5
Cadmium	799	25.0	< 0.05	< 0.05	338	9.04	< 0.05	< 0.05	0.05	0.5	1.0	0.5
Copper	3090	47.2	0.1	< 0.1	881	2.83	0.1	0.1	0.1	100	100	NG
Lead	45100	41.7	--	< 0.1	19900	9.98	0.2	0.1	0.1	5.0	5.0	5.0
Mercury	-	0.0940	< 0.01	< 0.01	-	0.157	< 0.01	< 0.01	0.01	0.1	0.2	0.1
Zinc	20500	86.2	< 0.5	< 0.5	34000	932	< 0.5	< 0.5	0.5	500	500	NG

Note:

TCLP: Toxicity Characteristic Leaching Procedure

mg/L: milligrams per litre

DL: Laboratory Detection Limit

NG: No Guidelines Established

Number: Above the referenced guidelines

BC: British Columbia

AB: Alberta

SK: Saskatchewan

Performance Verification Tests

Sample ID	TP-15-2-2			
Parameters	unit	Pre	Post 7 days	Post 29 days
<i>Bulk Hydraulic Conductivity</i>	m/s	3.48×10^{-5}	4.96×10^{-5}	-
<i>Moisture</i>	%	40.0	28.2 ^a	16.9 ^b

Note:

m/s: meters per second

%: Percentage

a: Post 4 days

b: Post 7 days

	RB4-Control	RB4-7%
Hydraulic Conductivity (m/s)	0.00000160	0.00000384

Performance Verification Tests

Metals (Soil)	SB-PP01	SB-PP02	SB-PP03	SB-PP04	Alberta Tier 1 Guidelines
Antimony (Sb)	2.02	1.45	0.65	5.12	20
Arsenic (As)	6.59	5.39	6.96	5.08	17
Barium (Ba)	1580	2050	865	176	750
Beryllium (Be)	0.46	0.30	0.59	0.48	5
Cadmium (Cd)	3.17	3.50	1.61	0.48	1
Chromium (Cr)	18.3	13.3	24.5	21.6	64
Cobalt (Co)	6.67	4.76	12.0	8.46	20
Copper (Cu)	64.9	31.0	35.7	26.3	63
Lead (Pb)	5970	8760	3330	1540	70
Mercury (Hg)	2.6	0.59	0.82	0.35	7
Molybdenum (Mo)	0.74	0.53	0.39	0.55	4
Nickel (Ni)	12.9	7.87	27.9	15.9	45
Selenium (Se)	0.34	0.28	0.28	0.30	1
Silver (Ag)	0.61	0.66	0.37	0.15	20
Thallium (Tl)	0.06	0.05	0.06	0.08	1
Tin (Sn)	26.7	33.9	8.8	3.0	5
Uranium (U)	0.39	0.24	0.37	0.46	23
Vanadium (V)	32.2	22.2	47.1	46.4	130
Zinc (Zn)	1840	2040	967	438	200

Performance Verification Tests

TCLP	TSS-PP01-0DAY	TSS-PP01-PS-7DAYS (Test 1)	TSS-PP02-0DAY	TSS-PP02-PS-7DAYS (Test 1)	TSS-PP03-0DAY	TSS-PP03-PS-7DAYS (Test 1)	TSS-PP04-0DAY	TSS-PP04-PS-7DAYS (Test 1)	TSS-PP04-2-PS-7DAYS (Test 1)	TSS-PP04-PS-7DAYS (Test 2)	Referenced Guidelines		
											AB	BC	SK
Lead (Pb)	3.75	<0.50	3.64	<0.50	1.16	<0.50	8.21	8.46	6.53	2.83	5.0	5.0	5.0
Zinc (Zn)	9.2	<5.0	11.0	<5.0	<5.0	<5.0	<5.0	8.6	5.8	5.4	500	500	NG

Performance Verification Tests



Sediment Samples



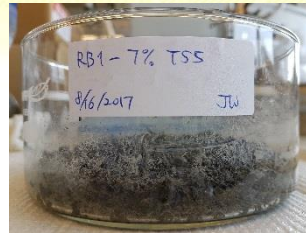
Performance Verification Tests

RB1-Control-Day 0

RB1-7% Day 0

RB1-9% Day 0

☐ Day 0 (RB1)



Performance Verification Tests

☐ Turbidity Test (Control – 1)

0.5 min



1 min



1.5 min



2 min



2.5 min



3 min



3.5 min



4 min



4.5 min



5 min



10 min



20 min



30 min



1 hr



4 hr



Performance Verification Tests

☐ Turbidity Test (TSS-1)

0.5 min



1 min



1.5 min



2 min



2.5 min



3 min



3.5 min



4 min



4.5 min



5 min



10 min



20 min



30 min



1 hr



4 hr



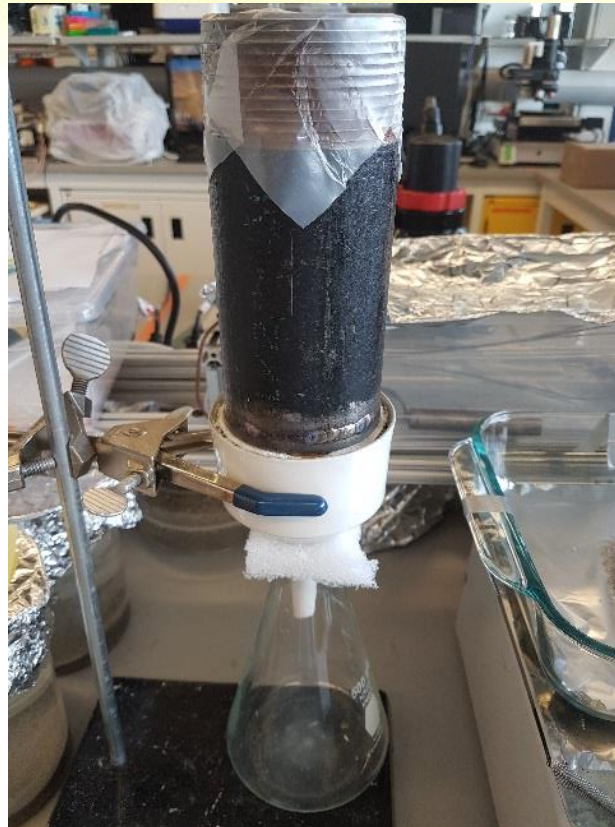
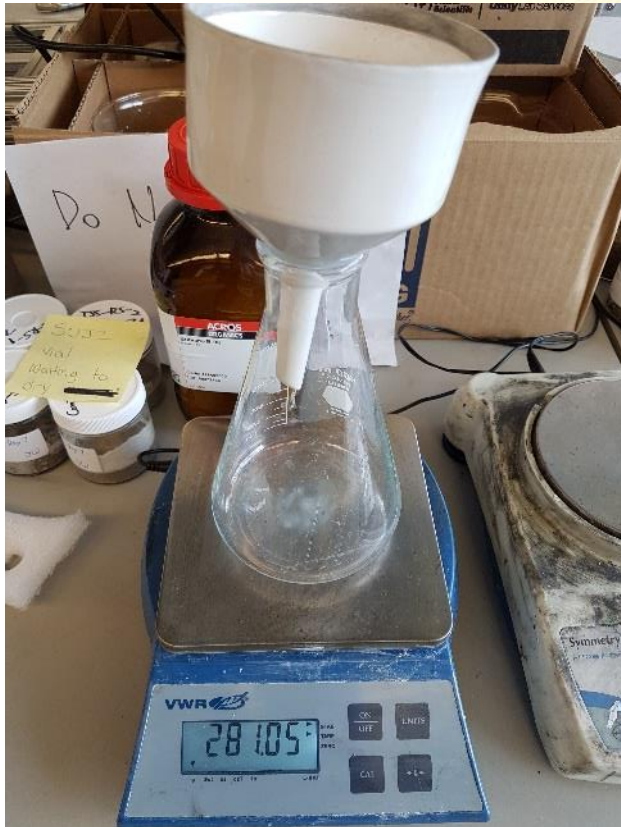
Performance Verification Tests



Shake
for a
day



Performance Verification Tests



Performance Verification Tests

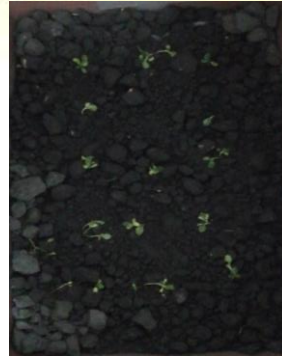
Control

Lime based

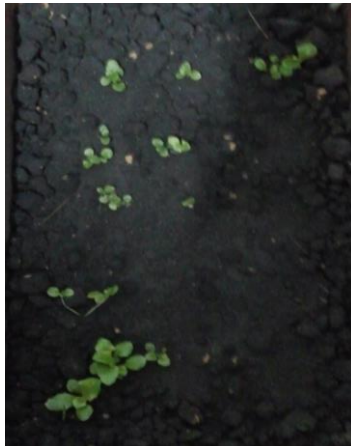
Cement based

New Reagent

Jan. 25



Feb. 17



Performance Verification Tests

- Aquatic Eco Toxicity Test - Water Flee

Metal	TU (Pre)	TU (Post)
Lead (Pb)	4.0	1.9
Arsenic (As)	6.1	2.0

Field Testing – Dredged Marine Sediments



Field Testing – Dredged Marine Sediments



Findings and Discussion

Application Parameters	Subject Blending	Cement	Lime	Polymer
pH	Neutral	Alkaline	Alkaline	Neutral
Permeability (porosity)	Normal	Poor	Poor	Poor
Compaction	Good	Good	Poor	Poor
Leachability	Reduced	Reduced	Reduced	Reduced

Findings and Results

- 3 component recipe of naturally occurring materials
 - Precipitation & adsorption of metal(s)
 - Dehydration and stabilization
 - Ideal for soils, sludge and dredge materials
 - Stabilizer is effective for moisture absorption to allow effective handling post process
 - pH control
 - Maintain soil structure
 - Less Toxicity
 - Reduced mass of applied reagents
 - <7% by vol. with specific gravity <1
- Have confirmed performance with 2 Major Formulas

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R&D and Commercialization Specialists

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