

# MBT TREATMENT OF LEACHABLE HEAVY METALS IN MINE-RELATED SOLIDS: LABORATORY & FIELD ENGINEERING-SCALE TRIALS

**Technology:** MBT Treatment of Solids Leachable Heavy Metals

**Media Types:**

- AMD Lime-treatment solids,
- Mine-ore tailings,
- AN™ AMD treatment solids

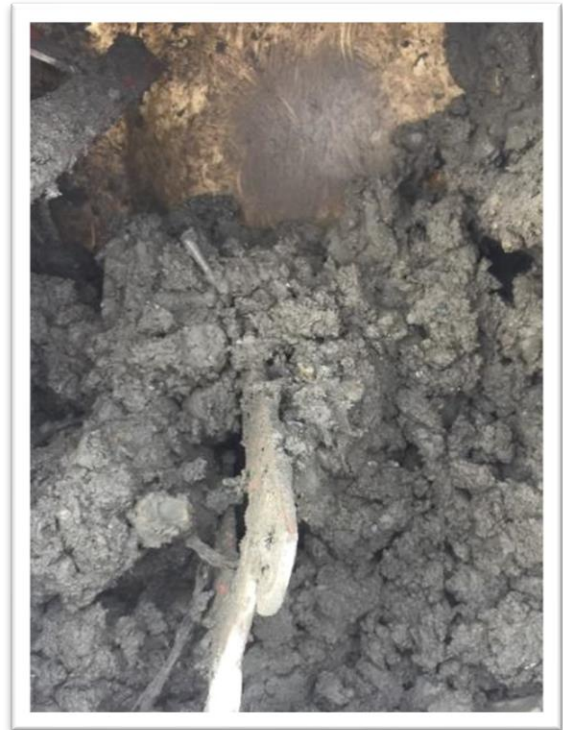
**Sources:**

- 1) Bunker Hill Mining & Metallurgical Complex NPL Site, Kellogg ID
  - South CDA River Bank
- 2) Bonita Peak Mining District NPL Site (BPMD), Silverton/Gladstone, CO
  - Mogul Mine AN™ Solids
  - USEPA GKM Lime Solids
  - Eureka Flotation/Jig Tailings
  - Prospect Gulch

**Contact:** Karl Yost  
karlyost@ybtechs.com

**Scale:** Lab Studies & Field Pilot

**Mode:** Batch



## MBT PROCESS FOR LEACHABLE HEAVY METALS IN MINE-SOURCED SOLIDS

- MBT - Molecular Bonding/Binding Technology™ for leachable heavy metals in soils, sediments, and solids.
- Reduces leachability of RCRA metals and those under the CERCLA umbrella for hazardous substances
- Treated solid material retain heavy metals when exposed to acid-rain (EPA Method 1312), TCLP fluid (Method 1311), and modified Method 1312 where AMD is used as the extraction fluid
- Heavy metals in MBT treated material are stable to long-term exposure to AMD when AMD contacts treated materials (modified Method 1320 – Multiple Extraction Procedure).
- Treated material is suitable for onsite management, or in-mine disposal and will remove heavy metals from AMD and other acidic mine-site fluids
- Destroys sulfides and other pyrrhotic minerals that can be converted to acidic fluids in the presence water, oxygen, and certain bacteria
- MBT treatment chemistry can be modified using MBT-SE reagents to enhance physical strength of end-products
- Applied insitu to small batches, near surface lifts, deep subgrade mixing secant columns, or using exsitu methods in small batches to large-scale 250+ ton per hour systems.
- With optimization, MBT processing will reduce leachable heavy metal concentrations from treated solids to below acute and chronic toxicity standards for aquatic life and meet RCRA Landfill Disposal Restrictions (LDR's)
- The MBT process will manufacture an end-product useful in treating other solids materials that contain leachable heavy metals, or for construction materials for use on mine sites or legacy remedial project locations.
- MBT does not utilize sulfide-containing reagents that can be degraded to acid forming constituents.
- MBT does not utilize cement/pozzolanic reagent components that contribute mass from calcium or water by means of hydration reactions.
- MBT reagent chemistry does not form metallic hydroxides that require alkaline pH conditions to maintain long-term stability.

# MBT

## Comparison of R-Hydroxide Solubility Products (Ksp)

vs.

## Ksp Values for R-MBT Anions

Metal	Quicklime Ksp R-Hydroxide	MBT Ksp R-MBT	Comment
Aluminum	$3 \times 10^{-34}$	$9.8 \times 10^{-21}$	amphoteric
Arsenic	soluble	N/A	oxidation state
Cadmium	$5.3 \times 10^{-15}$	$2.53 \times 10^{-33}$	
Cobalt	$1.1 \times 10^{-15}$	$2.05 \times 10^{-35}$	
Copper	$1.6 \times 10^{-19}$	$8 \times 10^{-37}$	
Iron (II)	$4.9 \times 10^{-17}$	$3.6 \times 10^{-41}$	oxidation state
Iron (III)	$2.79 \times 10^{-39}$	$1 \times 10^{-88}$	
Lead	$1.43 \times 10^{-20}$	$7.9 \times 10^{-43}$	amphoteric
Manganese	$2.1 \times 10^{-13}$	$1 \times 10^{-22}$	oxidation state
Mercury	$3.1 \times 10^{-26}$	$2 \times 10^{-53}$	oxidation state
Nickel	$5.5 \times 10^{-16}$	$4.74 \times 10^{-32}$	
Zinc	$4.1 \times 10^{-17}$	$1.0 \times 10^{-32}$	amphoteric

NOTES:

- 1) Amphoteric properties and valence state of metal ions are critical to solubility
- 2) Ksp values are nominal, but typically accepted in the literature
- 3) Quicklime can be substituted with any hydroxide contributing source or pozzolanic alkaline reagent

# MBT TREATMENT EXAMPLES

## MBT Treatability Study - Technology Viability Evaluation Results Bonita Peak Mining District NPL Site Eureka Fluvial Tailings, Upper Animas River – Middleton/Eureka, CO

MBT Treated and Untreated Tailings: Metals as Totals in Method 1311 (TCLP) Extract  
Sample Depth Profile: 0-24"  
Untreated vs. MBT Treated Material

Metal	Untreated		Compliance Status		Solid Waste Regulatory Limits		MBT Treated Samples									Comments
	Totals in Tailings (mg/kg)	TCLP (mg/L)	RCRA Hazardous Waste	EPA LDR/UTS	RCRA Haz Waste (mg/L)	EPA LDR/UTS (mg/L)	Sample ID: MBT 1348			Sample ID: MBT 1446			Sample ID: MBT 1510			
							TCLP (mg/L)	RCRA Hazardous Waste	EPA LDR/UTS	TCLP (mg/L)	RCRA Hazardous Waste	EPA LDR/UTS	TCLP (mg/L)	RCRA Hazardous Waste	EPA LDR/UTS	
Al	8389	1.83					0.05			0.12			0.19			
As	48.7	<1.00	NO	PASS	5.0	5	0.10	NO	PASS	0.34	NO	PASS	0.08	NO	PASS	MBT treated samples met all Federal/State limits for solid waste. Viability phase performed to identify/confirm MBT reagent family for solid waste compliance regulations. Refined MBT reagent dosing may be applied to meet CDPHE WQS-TV5 for Aquatic Life in other extraction fluids, if required.
Cd	10.6	<0.500	NO	PASS	1.0	0.11	N/A	NO	PASS	N/A	NO	PASS	N/A	NO	PASS	
Cu	1440	12.6					0.52			2.95			0.46			
Fe	32,600	<0.500					0.17			0.18			0.2			
Pb	10,900	202	YES	FAIL	5.0	0.75	0.10	NO	PASS	0.22	NO	PASS	0.1	NO	PASS	
Mn	47,600	36					3.92			16.6			2.90			
Ni	<5.00	<0.500	N/A		N/A	11	N/A	N/A	PASS	N/A	N/A	PASS	N/A	N/A	PASS	
Zn	1680	8.4	N/A	FAIL	N/A	4.3	0.24	N/A	PASS	1.9	N/A	PASS	0.23	N/A	PASS	

TCLP analyses by Edge Analytical, Burlington, WA via USEPA Methods

N/A - Not Applicable/Not Analyzed

LDR - Land Disposal Restriction

UTS - Universal Treatment Standard for Hazardous Waste under LDR regulations



**MBT Treated AN Solids - Compressive Strength (ASTM C-39)**

<u>Material</u>	<u>Treatment</u>	<u>Dose (% wt.)</u>	<u>7-day</u>	<u>28-day</u>	<u>Calculated* 28-day</u>	<u>Comments</u>
AN Solids	PC Typ I/II	20	0	30	N/A	7-day broke during stripping
AN Solids	MBT-ES	20	820	N/A	1262	no filler aggregate added
AN Solids	MBT-ES	20	710	N/A	1092	no filler aggregate added
AN Solids + Fluvial Tailings	MBT-ES	20	1240	N/A	1908	w/tailing blend at 50:50

\* 7-day psi extrapolated to 28-day assuming 7-day achieved 65% of strength at 28-days  
 Testing performed by GeoTest, Arlington, WA



# Gold King Mine AMD Treatment: EPA Lime-Polymer Solids AMD Bonita Peak Mining District NPL Site Silverton/Gladstone, CO

## Gold King Mine, Gladstone CO

April 13, 2016 – USEPA Settling Pond/Lime/Polymer and Solids Dewatering System



### Comments:

- 1) 50 gallons of Gold King Mine AMD collected in 5-gallon buckets for AN treatability study using laboratory bench-scale treatment system in Lebanon, OR
- 2) No conventional water treatment reagent additives utilized
- 3) No filtration after AN treatment. 100-minute floc maturation time and settling prior to sampling.

### GKM Lime Solids w/MBT-ES



**GLM Lime Solids and Kittimac Tailings Quicklime and MBT Treatment Results**  
**BPMD NPL Site, Silverton CO (vicinity)**  
HMR Solutions, Inc.  
April-May 2018 (as of 5/15/2018)

SAMPLE ID	Condition	Units	Method	pH (S.U.)	Al	As	Cd	Cu	Fe	Pb	Mn	Ni	Zn	Comments
<b>TOTAL METALS IN UNTREATED MATERIALS</b>														
GKM Lime Solids	Untreated	mg/Kg	Total	8.29	60,100	70.5	175	13,100	246,000	64.1	22,600	103	39,200	
Kittimac Tailings	Untreated	mg/Kg	Total	8.11	2162	5.37	<0.89	253	4686	3540	43.6	<0.89	161	
<b>TCLP METALS IN ALL MATERIALS</b>														
<b>Untreated</b>														
GKM Lime Solids (LS)	Untreated	mg/L	TCLP	8.29	9.11	<0.103	0.579	21.3	<0.102	0.022	107	0.0291	152	
Kittimac Tailings (KT)	Untreated	mg/L	TCLP	8.11	0.51	<0.100	<0.025	0.77	3.47	62.6	0.14	<0.01	0.83	RCRA Hazardous Waste for Pb
LS + KT	Untreated	mg/L	TCLP	7.91	7.98	<0.0005	0.25	12.8	1.6	17.1	47.7	NT	0.15	RCRA Hazardous Waste for Pb
<b>Quicklime (CaO) Treated</b>														
GKM Lime Solids (LS)	Untreated	mg/L	TCLP		9.11	<0.103	0.579	21.3	<0.102	0.022	107	0.0291	152	
Kittimac Tailings (KT)	CaO	mg/L	TCLP	12.08	14.9	<0.100	<0.025	2.10	22.5	67.7	0.24	<0.010	0.80	RCRA Hazardous Waste for Pb
LS + KT	CaO	mg/L	TCLP	11.57	11.0	<0.100	0.14	8.17	5.00	15.1	11.1	0.08	33.8	RCRA Hazardous Waste for Pb
<b>MBT Treated</b>														
GKM Lime Solids (LS)	MBT	mg/L	TCLP	8.64	0.09	<0.100	<0.005	0.04	0.28	0.034	0.035	<0.010	0.03	Non-haz. Meets UTS under LDR's
Kittimac Tailings (KT)	MBT	mg/L	TCLP	9.11	<0.046	<0.103	<0.250	<0.113	<0.102	<0.018	0.356	<0.10	0.027	Non-haz. Meets UTS under LDR's
LS + KT	MBT	mg/L	TCLP	10.26	<0.010	<0.100	<0.025	0.020	0.11	<0.050	0.60	<0.02	0.02	Non-haz. Meets UTS under LDR's

**NOTES**

NR - no result

LS - Lime Solids

KT - Kittimac Tailings

All metal analyses performed by Edge Analytical, Burlington, WA (lab reports available upon request) in accordance with USEPA methods

*The MBT technology owned by HMR Solutions, Inc. of Lakewood, NJ is patented/patents-pending in the US and Abroad*