Short Course: Mine Water Treatment – Technologies, Case Studies and Costs

Arsenic and Antimony Removal

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Arsenic and Antimony

EPA Maximum Contaminant Level (MCL): ■ Arsenic (As) – 10 ppb (0.010 mg/L) ■ Antimony (Sb) – 6 ppb (0.006 mg/L) Both contaminants exist in two forms: ■ Trivalent (III) Pentavalent (V) Toxicities of As (better-known metalloid) relative) and Sb are similar

The Periodic Table

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 CI	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	³⁴ Se	35 Br	з6 Кг
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	⁵² Te	53 	54 Xe
55 Cs	56 Ba	57-71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 TI	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	⁸⁸ Ra	89-103	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 FI	115 Uup	116 Lv	117 Uus	118 Uuo
		57 La	58 Ce	⁵⁹ Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

Jerritt Canyon Mine

- Operated by Veris Gold
- 1 hour north of Elko, NV
- Goal is to dewater Smith Mine in order to access more ore
- Possible flow of 6,000 gpm

Representative Water Quality

		Concentration (mg/L)					
Category	Parameter	July 2013	4/2/14	5/6/14			
Common ions	pН	7.6	7.6	7.8			
	Ca	140	94	72			
	Na	12	13	18			
	Mg	78	64	47			
	F	<1.0	<1.0	<1.0			
	Cl	<25	<25	<25			
	SO_4	490	190	300			
	alkalinity	220	130	180			
	TDS	880	760	610			
Metals	As	0.230	0.120	0.094			
	Ba	0.027	0.031	0.051			
	Cd	< 0.002	< 0.002	< 0.002			
	Cu	< 0.02	0.061	< 0.02			
	Fe	< 0.3	< 0.3	< 0.3			
	Mn	0.017	0.013	0.012			
	Pb	0.005	< 0.005	< 0.005			
	Sb	0.120	0.051	0.036			
	Se	< 0.005	< 0.005	< 0.005			
	Tl	0.0021	0.0028	0.0019			
	Zn	0.14	0.12	< 0.10			

Most Promising Technologies

- □ Coagulation/filtration (CF)
- □ CF at pH 4.5 (for Sb)
- Adsorptive media (AM): several types
- Dissolved air flotation (DAF)
- Reverse osmosis (RO)

Jerritt Canyon Pilot



Six-inch columns with clear PVC enable evaluation of several types of adsorptive media in parallel

Jerritt Canyon CF Results



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Jerritt Canyon CF Results



Jerritt Canyon CF Data



Overlaid Contour Plot of Antimony and Iron as a function of pH and Iron Dose

Jerritt Canyon Adsorption Results



Jerritt Canyon RO Results

Parameter	Feed	Permeate	Rejection
Na	18	1.9	89%
Mg	47	2.9	94%
К	2.2	0.25	89%
Са	72	4.3	94%
Mn	0.012	0.0025	79%
As	0.094	0.0064	93%
Sb	0.036	0.0015	96%
Ва	0.051	0.0065	87%
TI	0.0019	0.0005	74%
SO ₄	300	31	90%
TDS	610	36	94%

Arsenic/Antimony Summary

- All four technologies evaluated (CF, DAF, AM, RO) were successful
- High concentrations of As and Sb
- For these high concentrations, CF followed by AM polishing was most economical
- Titanium dioxide was the best adsorptive media evaluated

Lessons Learned

- Antimony is more difficult to remove via chemical processes than is arsenic.
- Oxidation was not required for RO process.
- RO capital costs are decreasing while recovery rates are increasing.
- RO may be economical if brine stream can be managed.