Rule 57 Aquatic Values Data Sheet

6/10/2008

Chemical or product name: Strontium | *Developed by: Christopher Hull* | *FAV*: 81,000 ug/l* | *(Tier: I)*

Manufacturer (WTAs): ----- | *Approved by: D. Bush* | *AMV*: 40,000 ug/l* | *(Tier: I)*

C.A.S #: 7440-24-6 | *Approval date: 6/16/08* | *FCV*: 21,000 ug/l* | *(Tier: II)*

Literature search date: AQUIRE: 8/21/00 | *Acute CF: ----* | *Chronic CF: ----*

Clearinghouse search date: -----

ACUTE DATA

Species	Test type (EC or LC50)	Duration (hours)	Test conditions (FT,M, etc.)	Hardness mg/L	Chemical	LC50/EC50 ug/L	SMAV ug/L	GMAV ug/L	Rank	Reference
Water Flea (*Ceriodaphnia dubia*)	LC50	48	SR,M	100-616 [1]	$SrCl_2$	96,030	96,030	96,030	1	1
Brown Planarian (*Dugesia tigrina*)	LC50	96	S,U	84-870 [1]	$SrCl_2$	129,550	129,550	129,550	2	2
Fathead Minnow (*Pimephales promelas*)	LC50	96	SR,M	100-616 [1]	$SrCl_2$	144,610	166,688	166,688	3	1
	LC50	96	SR,U	100	$SrNO_3$	228,470				3
	EC50	96	S,U	82	$SrCl_2$	140,180				4
Water Flea (*Daphnia magna*)	LC50	48	S,U	100	$SrNO_3$	140,770	178,787	178,787	4	3
	EC50	48	S,U	150	$SrCl_2$	227,070				4
Amphipod (*Hyalella azteca*)	LC50	96	S,U	-----	$SrCl_2$	198,011	198,011	198,011	5	5
Midge (*Chironomus tentans*)	LC50	48	S,U	-----	$SrCl_2$	424,456	424,456	424,456	6	5
Snail (*Physa integra*)	LC50	96	S,U	-----	$SrCl_2$	537,504	537,504	537,504	7	5
Rainbow Trout (*Oncorhynchus mykiss*)	LC50	96	S,U	82	$SrCl_2$	2,348,110	2,348,110	2,348,110	8	6

(cont'd) 10/2/97

Bluegill Sunfish (*Lepomis macrochirus*)	LC50	96	S,U	-----	$SrCl_2$	6,316,556	6,316,556	6,316,556	9	5

CHRONIC DATA

Species	Test type (ELS, etc.)	Duration (days)	Study Conditions (FT,M etc.)	Hardness mg/L	Chemical	MATC ug/L	SMCV ug/L	GMCV ug/L	Rank	Reference
Water Flea (*C. dubia*)	LC	6	SR,M	100-348 [1]	SrCl2	33,580 [2]	33,580	33,580	1	1
Fathead Minnow (*Pimephales promelas*)	LSG	7	SR,M	100-348 [1]	SrCl2	132,390 [3]	132,390	132,390	2	1

* Value rounded to two significant figures.

[1] Strontium increased hardness, so the hardness reported here constitutes the range between the control and highest test concentration values found.

[2] For MATC and ACR calculations, see Table 1.

[3] For MATC and ACR calculations, see Table 2.

Chris Hall

Min. data req. met	Acute Factor
2	13
3	8
4	7
5	6.1
6	5.2
7	4.3

Rule 57 Aquatic Values Work Sheet

Chemical Name: Strontium
C.A.S. #: 7440-24-6

AQUATIC MAXIMUM VALUE CALCULATIONS, 6/08

A. Minimum 8 species requirement is **not** met (Tier II). Minimum requirements met = ___
Minimum requirements missing for Tier I =
Acute factor = ____

1. Toxicity **is not** dependent on a water characteristic

   a. FAV calculation

2. Toxicity **is** dependent on a water characteristic

   a. Slope = (Table ___)

   b. FAV equation:

3. Go to C.

B. Minimum 8 species requirement **is** met (Tier I)

1. Toxicity **is not** dependent on a water characteristic

   a. FAV calculation: Fig. 1 ; FAV = 80,637.74 ug/L.

2. Toxicity **is** dependent on a water characteristic

   a. Slope = (Table ___)

   b. Ranked genus mean acute intercepts: Table _

   c. Final acute intercept = (Att. ___)

   ln of final acute intercept =

   d. FAV equation =

C. Aquatic Maximum Value (AMV) calculation: $AMV = \frac{FAV}{2} = \frac{80,637.74 \text{ ug/L}}{2}$

$= 40,318.87$ ug/L.

Strontium :

Chris Hall

FINAL CHRONIC VALUE CALCULATIONS, 6/08

A. Minimum 8 species requirement is **not** met (Tier II). Minimum requirements met = 2 (iii, iv).
Minimum requirements missing for Tier I = 6 (i, ii, v, vi, vii, viii) (GMCV route).
1 (ACR route).

ACR route:

1. Acute to chronic ratio

   a. Number ACRs meeting minimum data requirements = 2 (Tables 1-2)

   b. Acute to chronic ratio = $\bar{X}_g$ (C. dubia ACR (Table 1), FHM ACR (Table 2), Default val.)
   $= \bar{X}_g (2.8598636, 1.0922376, 18) = 3.8309956$.

2. Toxicity **is not** dependent on a water characteristic

Tier II FCV = $\frac{\text{Tier I FAV}}{\text{Tier II ACR}} = \frac{80,637.74 \text{ ug/L}}{3.8309956} = 21,048.769 \text{ ug/L}$.

3. ~~Toxicity is~~ dependent on a water characteristic

   a. Slope = (Table __)

   b. Aquatic chronic intercept = (Table __)

   ln of aquatic chronic intercept =

   c. FCV equation =

B. ~~Minimum 8~~ species requirement **is** met (Tier I)

1. Toxicity **is not** dependent on a water characteristic

   a. FCV = ___ (Att. ___)

2. Toxicity **is** dependent on a water characteristic

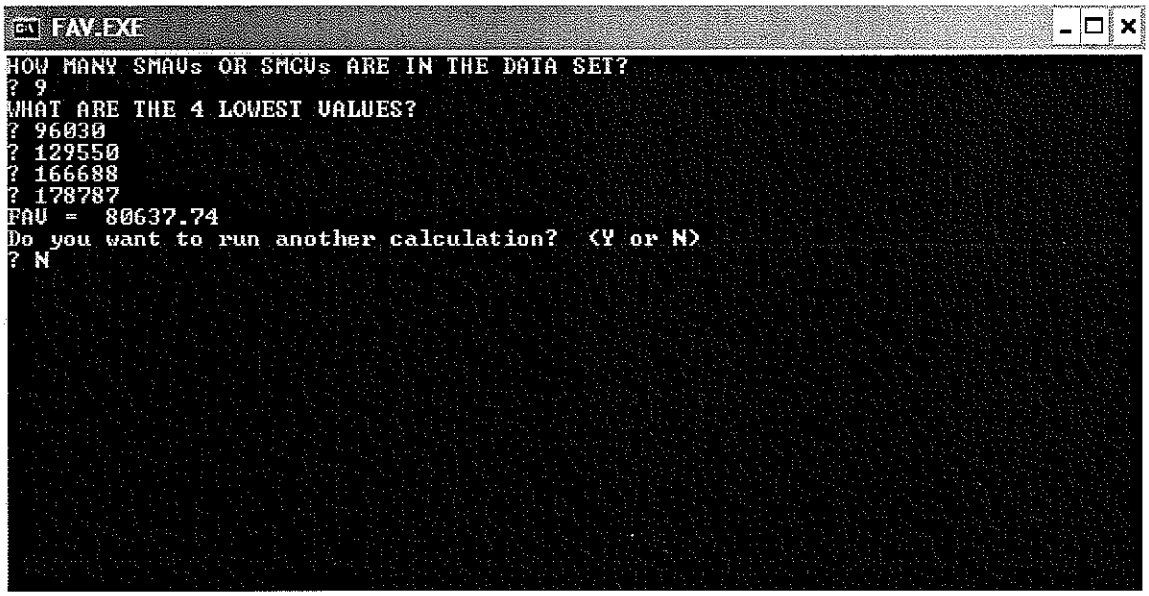
   a. Slope = (Table __)

   b. Ranked genus mean chronic intercepts: Table ___

   c. Final chronic intercept = ____ (Att. ___); ln of final chronic intercept =

   d. FCV equation =

Figure 1. Strontium Tier I FAV calculation, 6/08.



Sr.:

5/05/08

Table 1. MATC & ACR calculations for Ceriodaphnia dubia from Ref. #1.

Acute:

48-hr. LC50 = 96,030 ug/l.

Chronic:

6-day Reproduction NOEC = 24,570 ug/l; LOEC = 45,890 ug/l;

MATC = $\bar{X}_g$ = 33,578.524 ug/l

ACR = $\frac{\text{48-hr. LC50}}{\text{6-day Reprod. MATC}} = \frac{96{,}030 \text{ ug/l}}{33{,}578.524 \text{ ug/l}}$ = 2.8598636

Table 2. MATC and ACR calculations for Fathead Minnow from Ref. #1.

Acute:

96-hr. LC50 = 144,610 ug/l.

Chronic:

7-day Survival NOEC = 92,870 ug/l; LOEC = 188,750 ug/l;

MATC = $\bar{X}_g$ = 132,397.93 ug/l.

ACR = $\frac{\text{96-hr. LC50}}{\text{7-day Survival MATC}} = \frac{144{,}610 \text{ ug/l}}{132{,}397.93 \text{ ug/l}}$ = 1.0922376

STRONTIUM REFERENCES, 6/08

References Used:

1. #018158: 2008. Cook, D. Chemical-specific toxicity tests to calculate Tier II Acute-to-Chronic Ratios (ACRs) for lithium chloride (LiCl) and strontium chloride (SrCl2) using Fathead Minnow and *Ceriodaphnia dubia*. Unpubl. Rept. Global Environmental Consulting, LLC.

2. Attachment 1, this report. Michigan Department of Environmental Quality Aquatic Toxicity Evaluation Laboratory. 2008. *Dugesia tigrina* strontium aquatic toxicity test.

3. #015578: S-F Analytical Laboratories Bioassay Laboratory. 1998. Bioassay report, acute toxicity tests conducted January 7 through 11 and 14 through 16, 1998. Unpubl. Rept., Lab I.D. No. 7436, prepared for QST Environmental (for Hitachi Magnetics Corp., Cadillac, MI).

4. #015577: Owusu-Yaw, J. 1998. Acute toxicity of strontium to the water flea, *Daphnia magna*, and the Fathead Minnow, *Pimephales promelas*, under static test conditions. Unpubl. Rept., QST Laboratories, Newberry, FL, QST Proj. No. 3198202-0100-3100. In: Appendix 1—toxicity test report for strontium, in: Environmental Consulting and Technology, Inc. 1998. Acute toxicity testing for lithium and strontium. Unpubl. Rept., ECT No. 98065-0100. March, 1998.

5. #015574: Environmental Science and Engineering, Inc. 2000. Acute toxicity of strontium and lithium to *Hyalella azteca*, *Chironomus tentans*, *Lepomis macrochirus*, and *Physa integra*, under static test conditions. Unpubl. Rept., ESE No. 3100208-0100-3100. Prepared for Martin Marietta Magnesia Specialties, Inc., and Copper Range Company, Inc. July 11, 2000.

6. #016575: Harding ESE, Inc. 2001. Acute toxicity of strontium to *Oncorhynchus mykiss*, and manganese to *Physa integra*, under static test conditions. Unpubl. Rept., Harding ESE, Inc., for MFG, Inc.; prepared for Copper Range Co. Project I.D. # 311213.0100.

References Reviewed, but Not Used:

#015102: Woodward, D.F.; R.G. Riley; M.G. Henry; J.S. Meyer; and T.R. Garland. 1985. Leaching of retorted oil shale: assessing the toxicity to Colorado Squawfish, Fathead Minnows, and two food-chain organisms. Trans Amer. Fish. Soc. 114:887-894.
-WET.

#015505: Birge, W. J. et al. 1981. The reproductive toxicology of aquatic contaminants. J.Saxena and F.Fisher (Eds.). Hazard assessment of chemicals: current developments. Academic Press, New York, NY 1:59-115 .
–TDI.

#008912: Birge, W. J. et al. 1979. Evaluation of aquatic pollutants using fish and amphibian eggs as bioassay organisms. S.W.Nielsen, G.Migaki, and D.G.Scarpelli (Eds.), Symp. Animals Monitors Environ. Pollut., 1977, Storrs, CT 12:108-118 .
-TDI.

#V2999: Aleksanyan, O. M. et al. 1978. Action of strontium-90 and Metaphos on *Cyprinus carpio*. Radiobiologiya, 18(1): 131-134.
-NUE.

#V3000: Calapaj, G. G. 1973. Ricerche di laboratorio sull'inquinamento chimico dei mitili nota I: radiostronzio, radiocesio, mercurio inorganico, cromo esavalente. (Chemical... Ig. Mod., 66(3): 243-270.
–NUE.

#013973: Khangarot, B.S. 1991. Toxicity of metals to a freshwater Tubificid worm, *Tubifex tubifex* (Muller). Bull. Environ. Contam. Toxicol. 46:906-912.
-TONNA. This study, which used organisms wild-collected in India, was previously used; however, recent research concludes that this species is not cosmopolitan, and therefore, these test organisms would not be a North American species.

#V3001: Kosinova, N. R. and Aleksanyan, O. M. 1978. Study of the reversibility of the effects of strontium-90 and Metaphos on *Cyprinus carpio*. Radiobiologiya, 18(4): 630-634.
–NUE.

#V3002: Suzuki, Y. et al. 1972. Accumulation of strontium and calcium in freshwater fishes of Japan. J. Radiat. Res., 13(4): 199-207.
–NUE.

#V3003: Zhao, W. et al. 1992. Study on absorption and accumulation of 90Sr in Carp. China Environ. Sci. /Zhongguo Huanjing Kexue, 12(5): 360-364.
–NUE.

* For abbreviations used, see Appendix, attached.

APPENDIX: REFERENCE ABBREVIATIONS USED, 6/08

AMD = ambient monitoring data.
BCF = bioconcentration factor.
D = data (as a suffix to other abbreviations listed here).
DEP = depuration data.
DO = data only (as a suffix to other abbreviations listed here).
EF = environmental fate.
GWD = groundwater data.
IITM/C = insufficient information on test methods / conditions.
ISD = *in situ* data.
LD = leachate data.
LSER = Linear Solvation Energy Relationship.
MCD = microcosm data.
MIX = mixture (not chemical-specific) test data.
MED = model ecosystem data.
MET = metabolism
MOD = model (theoretical) data / analysis.
NA = not available at this time.
ND = no data (on this chemical).
NIL = not in (MDEQ) Library.
NR = not reviewed.
NUE = no useable endpoint.
O = only (as a suffix to other abbreviations listed here).
PD = phytotoxicity data.
PHYS = physiological data.
QSAR = Quantitative Structure-Activity Relationship.
RWD = receiving water data.
SD = secondary data.
SED = sediment data or testing.
SW = saltwater.
TATO = test animals too old.
TDI = test duration inappropriate.
TM/CU = test methods / conditions unacceptable.
TONNA = test organisms not North American.
TONS = test organisms not suitable.
UD or UP = uptake data.
WET = whole-effluent testing.

Attachment 1
Michigan Department of Environmental Quality Aquatic Toxicity Evaluation Laboratory
Dugesia tigrina Strontium Aquatic Toxicity Test
June, 2008

MDEQ Aquatic Toxicology Laboratory *Dugesia tigrina* Strontium Aquatic Toxicity Test

- Test Dates: 5/31-6/4/08
- Tests performed by: William F. Dimond
- Test method: SWAS Procedure # 24 with following modifications:
  - 10 replicates/concentration
  - 1 animal/replicate
  - 25 ml test solution/replicate
- Chemical source: A.C.S. Reagent grade Strontium chloride hexahydrate (Sigma-Aldrich 255521-100g, batch # 09914CH; chemical formula $SrCl_2.6(H_2O)$)
- Dilution water: Moderately Hard Reconstituted Water (MH) (target hardness 80 mg/l as $CaCO_3$), prepared using reagent grade chemicals (per USEPA EPA-821-R-02-013)
- To prepare initial test concentration, added 2,021 mg chemical to 1 L of MH
- Prepared successive dilutions by diluting initial concentration with MH at 0.6 dilution factor
- Test concentrations: definitive test used 0.6 dilution factor (see attached)
- Test concentrations are nominal
- Source of test organisms: Carolina Biological Supply; ages varied

Copies of raw data and statistical analyses attached.

Author: William F. Dimond 9 June 2008

$LC_{50} = 129.55$ mg/l Sr

MDEQ Aquatic Toxicol[illegible] Laboratory 96-h ASTM E729 Acute Toxici[illegible] Test

Test Organism: Dugesia tigrina
Test Chemical: Sr as $SrCl_2 \cdot 6(H_2O)$
Diliution Water: Reagent-grade MHRecon

Test Start (Date/Time): 5/31/08 | 1305
Test End (Date/Time): 6/4/08 | 1308

Concentration of Chemical, Units =	Day	Mortality in Replicate (0 = Alive, X = Dead) A	B	C	D	E	F	G	H	I	J	Total Dead
0	1	0										
	2	0										
	3	0										
	4	0										
	Σ	0										0
86.08	1	0										
	2	0										
	3	0										
	4	0										
	Σ	0										0
143.5	1	0										
	2	0										
	3	X	0	0	X	X	0	0	X	0	0	
	4		X	X			0	X		0	0	
	Σ	X	X	X	X	X	0	X	X	0	0	7
239.1	1	0										
	2	X						—	0	X	X	
	3								X			
	4											
	Σ	X										10
398.5	1	0	X	X	X	X	0	0	0	X	0	
	2	X					X	X	X		X	
	3											
	4											
	Σ	X										10
664.2	1	X										
	2											
	3											
	4											
	Σ	X										10

Observation Record

Staff making observation on day: 1	2	3	4
BD	BD	BD	BD

Test Chamber Water Quality of 6/4-8/08 *Dugesia tigrina* $SrCl_2.(6H_2O)$ Toxicity Test.

	Dissolved Oxygen (mg/L)				
Concentration	0h	24h	48h	72h	96h
Control	7.8		8.2		7.7
86.08	7.8		8.2		7.7
239.1	7.8		8.2		7.8
664.2	7.8		8.2		7.8

	pH (s.u.)				
Concentration	0h	24h	48h	72h	96h
Control	7.98		8.21/20		8.21
86.08	7.98		8.12		8.17
239.1	7.98		8.25		8.17
664.2	7.90		8.10		7.84

48h control pH, ≥ 8.20 #20

	Bench Temperature (°F)			
	24h	48h	72h	96h
Minimum	75	75	75	75
Maximum	80	80	80	80

	0h	24h	48h	72h	96h
Analyst	BD	BD	BD	BD	BD

MH Water Chemistries		*
Alkalinity (mg/l as CaCO3)	76	
Hardness (mg/l as CaCO3)	84	
Conductivity (umhos/cm)	320	@25.5 degrees C

*Parameters at highest test concentration attached at back.

(Form) Revised 6/9/08

TRIMMED SPEARMAN-KARBER METHOD. VERSION 1.5

DATE: 6 9 08 TEST NUMBER: 1 DURATION: 96 H
TOXICANT : Strontium as SrCl2.6(H2O)
SPECIES: Dugesia tigrina

RAW DATA: Concentration (mg/l)	Number Exposed	Mortalities
.00	10	0
86.08	10	0
143.50	10	7
239.10	10	10
398.50	10	10
664.20	10	10

SPEARMAN-KARBER TRIM: .00%

SPEARMAN-KARBER ESTIMATES: LC50: 129.55
95% LOWER CONFIDENCE: 111.72
95% UPPER CONFIDENCE: 150.22

From: William Dimond
To: Christopher Hull
Date: 6/12/2008 8:58:18 AM
Subject: Strontium Solution Chemistry Values

Per your request, I conducted water quality parameter analyses of a new strontium chloride hexahydrate solution prepared using the same recipe I used to create the original highest test solution used for my 5/31-6/4/08 *Dugesia tigrina* acute toxicity test (2,021 mg/l in MH recon water). The results of the analysis are as follows:
Alkalinity: 70 mg/l as CaCO3
Hardness: **870** mg/l as CaCO3
Conductivity: 1,950 umhos/cm @ 25.5 degrees C

Please note that the 1.142 conversion factor given by Standard Methods predicts the hardness of this solution as follows:
mg/l Sr x 1.142 + original hardness = final hardness
664.2 x 1.142 + 84 = **842** mg/l as CaCO3

The similarity of the predicted and actual hardness values indicates concentration preparation was highly accurate. In fact, the difference between predicted and actual hardness values (~ 3%) is well within the bounds of hardness titration measurement error.

The lower conductivity of this solution relative to the Lithium chloride hydrate highest concentration solution (2,554 mg/l as CaCO3) suggests that either LiClH20 contributes more to conductivity than SrCl2H20, or the decomposition of the test animals contributed to the conductivity of the Lithium test solution.

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