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Calculator: Elisabeth Harrahy

SECONDARY VALUES FOR NAPHTHALENE (CAS # 91-20-3)

A search was conducted for information on the chemical properties and toxicity of naphthalene (to human health and to fish and aquatic life) using the following databases and search engines: ECOTOX (toxicity to fish and aquatic life), IRIS (Integrated Risk Information System; toxicity to human health), and CHEMFATE (environmental fate). This search yielded some information on naphthalene's properties, its biodegradation, and a significant amount of information on its toxicity.

FISH AND AQUATIC LIFE

To calculate an acute toxicity criterion for aquatic life, acute toxicity test results are required for at least one species in each of eight different families. Specific requirements and the data available to meet these requirements are found in Table 1. Following an extensive search, it was determined that data are available to meet only five out of the eight requirements. Because there are data available for *Daphnia magna*, it is possible to calculate secondary acute and chronic values for naphthalene.

Cold Water

To calculate a secondary acute value (SAV), the lowest genus mean acute value (GMAV) in the database is divided by the secondary acute factor (SAF; an adjustment factor corresponding to the number of satisfied requirements).

SAF for five out of eight requirements met = 6.1

Lowest GMAV = 2,100 µg/L (*Xenopus laevis*)

SAV = GMAV/SAF
= 2,100 µg/L /6.1
= 344.26 µg/L

There are currently no chronic data for naphthalene which meet suitability requirements. (MATC data are available for Coho salmon; however, the exposure duration was too short and the exposure was static rather than flow-through, as required.) Therefore, a secondary chronic value may be calculated only by using default acute-chronic ratios.

SACR = Geometric mean of 18, 18, and 18 = 18

SCV = SAV/SACR
= 344.26/18
= **19.12 µg/L**

Warm Water Sport Fish, Warm Water Forage Fish, Limited Forage Fish, and Limited Aquatic Life

Because the lowest GMAV in the cold water database is for an amphibian, secondary values calculated for cold water will also apply to all other water body use designations.

Table 1. Requirements for calculation of an acute toxicity criterion for protection of aquatic life for naphthalene, and corresponding acute toxicity data.

Species Name	Common Name	Duration/ Endpoint	Value µg/L	Reference #	Source
1. At least one salmonid fish in the family Salmonidae, in the class Osteichthyes.					
Oncorhynchus kisutch	**coho salmon**	**96-h/LC50**	**3,220**	**13**	**AQUIRE**
Oncorhynchus kisutch	**coho salmon**	**96-h/LC50**	**2,100**	**14**	**AQUIRE**
Oncorhynchus kisutch	**coho salmon**	**96-h/LC50**	**5,600**	**10**	**AQUIRE**
SMAV = 3,358.05					
Oncorhynchus mykiss	**rainbow trout**	**96-h/LC50**	**1,800**	**7**	**AQUIRE**
Oncorhynchus mykiss	**rainbow trout**	**96-h/LC50**	**6,100**	**7**	**AQUIRE**
Oncorhynchus mykiss	**rainbow trout**	**96-h/LC50**	**2,600**	**7**	**AQUIRE**
Oncorhynchus mykiss	**rainbow trout**	**96-h/LC50**	**4,400**	**7**	**AQUIRE**
Oncorhynchus mykiss	**rainbow trout**	**96-h/LC50**	**5,500**	**7**	**AQUIRE**
Oncorhynchus mykiss	**rainbow trout**	**96-h/LC50**	**4,500**	**7**	**AQUIRE**
Oncorhynchus mykiss	**rainbow trout**	**96-h/LC50**	**1,600**	**5**	**AQUIRE**
Oncorhynchus mykiss	**rainbow trout**	**96-h/LC50**	**2,250**	**2**	**AQUIRE**
SMAV = 3,207.11					
GMAV = 3,281.71					
2. At least one non-salmonid fish from another family in the class Osteichthyes, preferably a commercially or recreationally important warm water species.					
Pimephales promelas	**fathead minnow**	**96-h/LC50**	**6,080**	**9**	**AQUIRE**
Pimephales promelas	**fathead minnow**	**96-h/LC50**	**1,990**	**12**	**AQUIRE**
Pimephales promelas	**fathead minnow**	**96-h/LC50**	**6,140**	**8**	**AQUIRE**
Pimephales promelas	**fathead minnow**	**96-h/LC50**	**7,900**	**5**	**AQUIRE**
Pimephales promelas	**fathead minnow**	**96-h/LC50**	**4,900**	**2**	**AQUIRE**
SMAV = 4,917.56					

GMAV = 4,917.56

3. At least one planktonic crustacean (e.g., cladoceran, copepod).

Daphnia magna	**water flea**	**48-h/EC50**	**3,845**	**1**	**AQUIRE**
Daphnia magna	**water flea**	**48-h/EC50**	**16,662**	**1**	**AQUIRE**
Daphnia magna	**water flea**	**48-h/EC50**	**2,194**	**15**	**AQUIRE**
Daphnia magna	**water flea**	**48-h/EC50**	**1,600**	**11**	**AQUIRE**
Daphnia magna	**water flea**	**48-h/EC50**	**2,550**	**11**	**AQUIRE**

SMAV = 3,562.08

Daphnia pulex	**water flea**	**48-h/EC50**	**4,663**	**17**	**AQUIRE**

SMAV = 4,663

GMAV = 4,075.53

Diaptomus forbesi	**calanoid copepod**	**96-h/LC50**	**67,800**	**16**	**AQUIRE**

SMAV = 67,800

GMAV = 67,800

4. At least one benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish).

5. At least one insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge).

Chironomus tentans	**midge**	**48-h/LC50**	**2,810**	**12**	**AQUIRE**

SMAV = 2,810

GMAV = 2,810

Tanytarsus dissimilis	**midge**	**48-h/LC50**	**20,700**	**4**	**AQUIRE**
Tanytarsus dissimilis	**midge**	**48-h/LC50**	**12,600**	**4**	**AQUIRE**
Tanytarsus dissimilis	**midge**	**48-h/LC50**	**13,700**	**3**	**AQUIRE**
Tanytarsus dissimilis	**midge**	**48-h/LC50**	**12,200**	**3**	**AQUIRE**

SMAV = 14,449.58

GMAV = 14,449.58

6. At least one fish or amphibian from a family in the phylum Chordata not already represented in one of the other subdivisions.

Gambusia affinis	**western mosquitofish**	**96-h/LC50**	**150,000**	**18**	**AQUIRE**

SMAV = 150,000

GMAV = 150,000

Xenopus laevis	**clawed toad**	**96-h/LC50**	**2,100**	**6**	**AQUIRE**
Xenopus laevis	**clawed toad**	**96-h/LC50**	**2,100**	**6**	**AQUIRE**

SMAV = 2,100

GMAV = 2,100

7. At least one organism from a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca).

8. At least one organism from a family in any order of insect or any other phylum not already represented in subdivisions 1 through 7.

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[1]Abernethy, S. A.M. Bobra, W.Y. Shiu, P.G. Wells and D. MacKay. 1986. Acute lethal toxicity of hydrocarbons and chlorinated hydrocarbons to two planktonic crustaceans: The key role of organism-water partitioning. Aquatic Toxicology 8(3):163-174.

[2]Bergman, H.L. and A.D. Anderson. 1977. Effects of aqueous effluents from in situ fossil fuel processing technologies on aquatic systems. Contract No. EY-77-C-04-3913, University of Wyoming, Laramie, WY.

[3]Darville, R.G. 1982. The effects of naphthalene on the physiology and life cycle of *Chironomus attenuatus* and *Tanytarsus dissimilis*. Ph.D. Dissertation, Oklahoma State University, Stillwater, OK. 85 pages.

[4]Darville, R.G. and J.L. Wilhm. 1984. The effect of naphthalene on oxygen consumption and hemoglobin concentration in *Chironomus attenuatus* and on oxygen consumption and life cycle of *Tanytarsus dissimilis*. Environmental Toxicology and Chemistry 3(1):135-141.

[5]DeGraeve, G.M., R.G. Elder, D.C. Woods, and H.L. Bergman. 1982. Effects of naphthalene and benzene on fathead minnows and rainbow trout. Archives of Environmental Contamination and Toxicology 11(4):487-490.

[6]Edmisten, G.E. and J.A. Bantle. 1982. Use of *Xenopus laevis* larvae in 96-hour, flow-through toxicity tests with naphthalene. Bulletin of Environmental Contamination and Toxicology 29:392-399.

[7]Edsall, C.C. 1991. Acute toxicities to larval rainbow trout of representative compounds detected in Great Lakes fish. Bulletin of Environmental Contamination and Toxicology 46(2):173-178.
[8]Geiger, D.L., C.E. Northcott, D.J. Call and L.T. Brooke. 1985. Acute toxicities of organic chemicals to fathead minnows (*Pimephales promelas*), Vol. 2. Center for Lake Superior Environmental Studies, University of Wisconsin, Superior, WI:326.
[9]Holcombe, G.W., G.L. Phipps, M.L. Knuth and T. Felhaber. 1984. The acute toxicity of selected substituted phenols, benzenes and benzoic acid esters to fathead minnows, *Pimephales promelas*. Environ. Pollut. Ser. A Ecol. Biol. 35(4):367-381.
[10]Korn, S. and S. Rice. 1981. Sensitivity to, and accumulation and depuration of, aromatic petroleum components by early life stages of coho salmon (*Oncorhynchus kisutch*). Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 178:87-92.
[11]MacLean, M.M. and K.G. Doe. 1989. The comparative toxicity of crude and refined oils to *Daphnia magna* and *Artemia*… Environment Canada, EE-111, Dartmouth, Nova Scotia a:64.
[12]Millemann, R.E., W.J. Birge, J.A. Black, R.M. Cushman, K.L. Daniels, P.J. Franco, J.M. Giddings, et al. 1984. Comparative acute toxicity to aquatic organisms of components of coal-derived synthetic fuels. Transactions of the American Fisheries Society 113(1):74-85.
[13]Moles, A. 1980. Sensitivity of parasitized coho salmon fry to crude oil, toluene, and naphthalene. Transactions of the American Fisheries Society 109(3):293-297.
[14]Moles, A., S. Bates, S.D. Rice, and S. Korn. 1981. Reduced growth of coho salmon fry exposed to two petroleum components, toluene and naphthalene, in fresh water. Transactions of the American Fisheries Society 110(3):430-436.
[15]Munoz, M.J. and J.V. Tarazona. 1993. Synergistic effect of two- and four-component combinations of the polycyclic aromatic hydrocarbons: phenanthrene, anthracene, naphthalene, and… Bulletin of Environmental Contamination and Toxicology 50(3):363-368.
[16]Saha, M.K. and S.K. Konar. 1983. Acute toxicity of some petroleum pollutants to plankton and fish. Environment & Ecology 1(1):117-119.
[17]Smith, S.B., J.F. Savino and M.A. Blouin. 1988. Acute toxicity to *Daphnia pulex* of six classes of chemical compounds potentially hazardous to Great Lakes aquatic biota. Journal of Great Lakes Research 14(4):394-404.
[18]Wallen, I.E., W.C. Greer and R. Lasater. 1957. Toxicity to *Gambusia affinis* of certain pure chemicals in turbid waters. Sewage and Industrial Wastes 29(6):695-711.

HUMAN HEALTH

To calculate a criteria or secondary value for the protection of human health, it is first necessary to determine if the substance has been shown to be carcinogenic (which will result in the calculation of a human cancer criteria or secondary value) or not (which will result in the calculation of a human threshold criteria or secondary value). Naphthalene is currently classified as a class C carcinogen (possible human carcinogen) in EPA's IRIS database. No cancer slope factor is available because of a lack of chronic oral studies. However, an oral reference dose (RfD) is listed in the IRIS database. Therefore, it is possible to calculate a human threshold secondary value for naphthalene for the protection of human health.

There are several steps to calculating a human threshold secondary value: 1) calculation of the fraction of freely dissolved chemical; 2) calculation of the "baseline BAF"; 3) calculation of the "human health BAF"; and 4) calculation of the human threshold secondary value.

1) Calculation of the freely-dissolved fraction = f_{fd}

Given a standard dissolved organic carbon (DOC) concentration of 0.000002 Kg/L and a particulate organic carbon (POC) concentration of 0.00000004 Kg/L in water, the equation

$$f_{fd} = 1/\{1 + [(DOC)(K_{ow})/10] + [(POC)(K_{ow})]\}$$

can be reduced to:

$$= 1/\{1 + [(0.00000024\ Kg/L)(K_{ow})]\}$$

For naphthalene, the K_{ow} = 1995, and log K_{ow} = 3.30 (CHEMFATE database).

$$f_{fd} = 1/\{1 + [(0.00000024\ Kg/L)(1995)]\}$$

$$= 1/1.000479$$

$$= \mathbf{0.9995}$$

2) Calculation of the baseline BAF

The baseline BAF is calculated according to the equations contained in 40 CFR part 132 (Final Water Quality Guidance for the Great Lakes System), Appendix B, using BAF data that was collected in one of four ways (listed in order of most preferred to least preferred):

- -a measured BAF from a field study
- -a predicted BAF based on field-measured BSAFs
- -a predicted BAF using a laboratory-measured bioconcentration factor (BCF) and a food chain multiplier (FCM)
- -a predicted BAF using a K_{ow} and a FCM

A baseline BAF was calculated for naphthalene using a K_{ow} and a food chain multiplier (FCM).

FCM = food chain multiplier, from Table B-1, in 40 CFR Part 132

For discharges into water classified as warm water, the FCM will be for trophic level 3. For discharges into water classified as cold water, the FCM will be for trophic level 4. Given naphthalene's log Kow of 3.30, the FCM for trophic level 3 from the table is 1.053, and for trophic level 4, 1.012.

The anti-log of 3.30 = 1995

Warm Water Baseline BAF = (FCM)(K_{ow})

= (1.053)(1995)

= 2,100.7350

Cold Water Baseline BAF = (FCM)(Kow)

= (1.012)(1995)

= 2,018.9400

3) Calculation of the human health BAF

For Warm Water:

BAF^{HH}_{TL3} = {[(baseline BAF)(0.013)] + 1} (f_{fd})

where

baseline BAF = the baseline BAF calculated in 2)

0.013 = fraction lipid value for warm water fish and aquatic life communities

f_{fd} = fraction freely dissolved

BAF^{HH}_{TL3} = {[(baseline BAF)(0.013)] + 1} (f_{fd})

= {[(2,100.7350)(0.013)] + 1} (0.9995)

= 28.2954

For Cold Water:

BAF^{HH}_{TL4} = {[(baseline BAF)(0.044)] + 1} (f_{fd})

where

baseline BAF = the baseline BAF calculated in 2)

0.044 = fraction lipid value for cold water fish and aquatic life communities

f_{fd} = fraction freely dissolved

BAF^{HH}_{TL4} = {[(baseline BAF)(0.044)] + 1} (f_{fd})

= {[(2,018.9400)(0.044)] + 1} (0.9995)

= 89.7884

4) Calculation of the human threshold secondary value

Human Threshold Secondary Value = [(ADE)(70 Kg)(RSC)]/[W_H + (F_H)(BAF)]

where

ADE = acceptable daily exposure (= oral reference dose, or RfD; = 0.02 mg/Kg/day for naphthalene (IRIS 1998))

70 Kg = average weight of an adult

RSC = relative source contribution to account for other routes of exposure (= 0.8 in the absence of other data)

W_H = average per capita daily water consumption (= 2 L/d for public water supplies, and 0.01 L/d for non-public water supplies)

F_H = average consumption of sport-caught fish in Wisconsin (= 0.02 Kg/d)

BAF = human health BAF calculated in 3).

Warm Waters, Public Water Supply

Human Threshold Secondary Value = $[(ADE)(70\ Kg)(RSC)/[W_H + (F_H)(BAF)]$

= [0.02 mg/Kg/d)(70 Kg)(0.8)]/[2 L/d + (0.02 Kg/d)(28.2954)]

= 1.1200/2.5659

= 0.4365 mg/L

= 436.5 μg/L

Cold Water, Public Water Supply

Human Threshold Secondary Value = $[(ADE)(70\ Kg)(RSC)/[W_H + (F_H)(BAF)]$

= [0.02 mg/Kg/d)(70 Kg)(0.8)]/[2 L/d + (0.02 Kg/d)(89.7884)]

= 1.1200/3.7958

= 0.2951 mg/L

= 295.1 μg/L

Warm waters, Non-Public Water Supply

Human Threshold Secondary Value = $[(ADE)(70\ Kg)(RSC)]/[W_H + (F_H)(BAF)]$

= [(0.02 mg/Kg/d)(70 Kg)(0.8)]/[0.01 L/d + (0.02 Kg/d)(28.2954 L/Kg)]

= 1.1200/0.5759

= 1.94478 mg/L

= 1,944.78 μg/L

Cold Water, Non-Public Water Supply

Human Threshold Secondary Value = $[(ADE)(70\ Kg)(RSC)]/[W_H + (F_H)(BAF)]$

= [(0.02 mg/Kg/d)(70 Kg)(0.8)]/[0.01 L/d + (0.02 Kg/d)(89.7884 L/Kg)]

= 1.1200/1.8058

= 0.6202 mg/L

= 620.2 μg/L

Limited Aquatic Life, Non-Public Water Supply

Human Threshold Secondary Value = $[(ADE)(70\ Kg)(RSC)]/[W_H + (F_H)(BAF)]$

= [(0.02 mg/Kg/d)(70 Kg)(0.8)]/[0.01 L/d + (0.02 Kg/d)(0 L/Kg)]

= 1.1200/0.01

= 112.00 mg/L

= 112,000 μg/L