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SECONDARY VALUES FOR BORON (CAS No. 7440-42-8)

A search was conducted for information on the chemical properties and toxicity of boron to human health and to fish and aquatic life using the following databases: ECOTOX (toxicity to fish and aquatic life), IRIS (Integrated Risk Information System; toxicity to human health), CHEMFATE (environmental fate), and ATSDR ToxFAQs (Agency for Toxic Substances and Disease Registry chemical fact sheets). A literature search was also conducted for journal articles containing fish and aquatic life data because ECOTOX did not contain any usable (for secondary values) data.

Fish and Aquatic Life Secondary Values

To derive 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 a search for information on the toxicity of boron to fish and other aquatic life, it was determined that data are available to meet only three out of the eight requirements. However, because data are available for a Daphnid species, it was possible to calculate a secondary acute value for boron.

Secondary acute values were calculated for cold water, warm water sportfish, warm water forage fish, limited forage fish and limited aquatic life designated water bodies. (Boron is not a bioaccumulative chemical of concern (BCC); therefore, it will not be necessary to automatically apply cold water criteria.)

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 three out of eight requirements met = 8.0
Lowest GMAV = 141,000 µg/L (*Daphnia magna*)

SAV = GMAV/SAF
= 141,000 µg/L / 8.0
= 17,625 µg/L

No chronic data are available for boron that meet acceptability requirements. Therefore, a secondary chronic value (SCV) may be calculated using default ratios only.

SACR (secondary acute-chronic ratio) = Geometric mean of three species mean acute-chronic ratios (SMACRs).

SACR = geometric mean of 18, 18, and 18 = 18

SCV = SAV/SACR
= **17,625 µg/L** /18
= 979.1667 µg/L

So, the secondary acute value is 18,000 µg/L and the secondary chronic value is 1,000 µg/L for boron in cold water designated waters.

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

The lowest GMAV in the cold water database is for an invertebrate (*Daphnia magna*). Because invertebrate species do not drop out of the database for Warm Water Sportfish, Warm Water Forage Fish, Limited Forage Fish, or Limited Aquatic Life designated waters, the secondary values will be the same for these water bodies as for cold water designated water bodies.

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

Species Name	Common Name	Duration/ Endpoint	Value µg/L	Reference #[a]	Source
1. At least one salmonid fish in the family Salmonidae, in the class Osteichthyes.					
Oncorhynchus tshawytscha	**Chinook salmon**	**96-h/LC50**	**725,000**	**1**	**Journal**
Oncorhynchus tshawytscha	**Chinook salmon**	**96-h/LC50**	**566,000**	**1**	**Journal**
Species Mean Acute Value (SMAV) = 640,585.67					
Oncorhynchus kisutch	**Coho salmon**	**96-h/LC50**	**447,000**	**1**	**Journal**
SMAV = 447,000					
Genus Mean Acute Value (GMAV) = 535,109.14					
2. At least one non-salmonid fish from another family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species.					
3. At least one planktonic crustacean (e.g., cladoceran, copepod).					
Daphnia magna	**water flea**	**48-h/LC50**	**141,000**	**2**	**Journal**
SMAV = 141,000					
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 decorus	**midge**	**48-h/LC50**	**1,376,000**	**2**	**Journal**
SMAV = 1,376,000					
6. At least one fish or amphibian from a family in the phylum Chordata not already represented in one of the other subdivisions.					

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]Hamilton, S.J. and K.J. Buhl. 1990. Acute toxicity of boron, molybdenum, and selenium to fry of Chinook salmon and Coho salmon. Archives of Environmental Contamination and Toxicology 19:366-373.

[2]Maier, K.J. and A.W. Knight. 1991. The toxicity of waterborne boron to *Daphnia magna* and *Chironomus decorus* and the effects of water hardness and sulfate on boron toxicity. Archives of Environmental Contamination and Toxicology 20:282-287.

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). Boron has not been classified as to its carcinogenicity. However, because an oral reference dose and a log octanol water partition coefficient are available, a human threshold secondary value can be calculated for boron.

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 **boron**, the K_{ow} = 1.6982, and log K_{ow} 0.23 = (Portsmouth Toxicity and Portsmouth Chemical-Specific Factors-- Non-Radionuclides).

$$f_{fd} = 1/\{1 + [(0.00000024\ Kg/L)(1.6982)]\}$$

$$= 1/1.0000$$

$$= \mathbf{1.0000}$$

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

Currently, there are no BAFs, BSAFs, or BCFs available for boron; therefore, the baseline BAF was calculated using the K_{ow} and a food chain multiplier (method d above).

Given boron's log K_{ow} of 0.23 (Kow of 1.6982), the FCMs (taken from table B-1 in GLI) are 1.005 for trophic level 3 (warm waters) and 1.000 trophic level 4 (cold waters).

a) Cold Water

Baseline BAF = (FCM)(Kow)

= (1.000)(1.6982)

= 1.6982

b) Warm Waters

Baseline BAF = (FCM)(Kow)

= (1.005)(1.6982)

= 1.7067

3) Calculation of the human health BAF

a) Cold Water

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

where

BAF^{HH}_{TL4} = Human health BAF for trophic level 4 (cold water)

baseline BAF = the baseline BAF (for cold waters) calculated in 2)

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

f_{fd} = fraction freely dissolved

BAF^{HH}_{TL4} = {[(1.6982)(0.044)] + 1} (1.0000)

= 1.0747

b) Warm Waters

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

where

BAF^{HH}_{TL3} = Human health BAF for trophic level 3 (warm waters)

baseline BAF = the baseline BAF (for warm waters) calculated in 2)

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

f_{fd} = fraction freely dissolved

BAF^{HH}_{TL3} = {[(1.7067)(0.013)] + 1} (1.0000)

= 1.0222

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; = 0.09 mg/Kg/day for boron (IRIS 2003))

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).

a) Public Water Supply/Cold Water

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

= [(0.09 mg/Kg/d)(70 Kg)(0.8)]/[**2** L/d + (0.02 Kg/d)(1.0747 L/Kg)]

= 2.4932 mg/L

= 2,493.2 µg/L

b) Public Water Supply/Warm Water Sportfish

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

= [(0.09 mg/Kg/d)(70 Kg)(0.8)]/[**2** L/d + (0.02 Kg/d)(1.0222 L/Kg)]

= 2.4946 mg/L

= 2,494.6 µg/L

c) Non-Public Water Supply/Cold Water

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

= [(0.09 mg/Kg/d)(70 Kg)(0.8)]/[**0.01** L/d + (0.02 Kg/d)(1.0747 L/Kg)]

= 160.0000 mg/L

= 160,000 µg/L

d) Non-Public Water Supply/Warm Waters (Warm Water Sportfish, Warm Water Forage Fish, and Limited Forage Fish designated waters)

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

= [(0.09 mg/Kg/d)(70 Kg)(0.8)]/[**0.01** L/d + (0.02 Kg/d)(1.0222 L/Kg)]

= 165.7895 mg/L

= 165,789.5 µg/L

e) Non-Public Water Supply/Limited Aquatic Life

Note: The Limited Aquatic Life classification applies to water bodies with no (or very few) fish present. Therefore, calculation of a human health threshold value for water bodies with this classification does not include a human health BAF since it is assumed that humans will not be exposed to boron through consumption of fish in these areas.

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

$= [(0.09\ mg/Kg/d)(70\ Kg)(0.8)]/[\mathbf{0.01}\ L/d + (0)]$

$= \mathbf{504.0000}\ mg/L$

$= \mathbf{504{,}000.0\ \mu g/L}$

Chemical	CAS #	Category	Type of Secondary Value	Water Body Classification	Value (µg/L)
Boron	7440-42-8	Fish and Aquatic	Acute	Cold, WWSF, WWFF, LFF, LAL	18,000
Boron	7440-42-8	Fish and Aquatic	Chronic	Cold, WWSF, WWFF, LFF, LAL	1,000
Boron	7440-42-8	Human Health	Human Threshold*	Public Water Supply/Cold	2,490
Boron	7440-42-8	Human Health	Human Threshold*	Public Water Supply/WWSF	2,490
Boron	7440-42-8	Human Health	Human Threshold*	Non-Public Water Supply/Cold	160,000
Boron	7440-42-8	Human Health	Human Threshold*	Non-Public Water Supply/WWSF, WWFF, LFF	166,000
Boron	7440-42-8	Human Health	Human Threshold*	Non-Public Water Supply/LAL	504,000

Cold = cold water designated water bodies
WWSF = warm water sportfish designated water bodies
WWFF = warm water forage fish designated water bodies
LFF = limited forage fish designated water bodies
LAL = limited aquatic life designated water bodies (includes wetlands)