Chemical Category: POLYNUCLEAR AROMATIC HYDROCARBON (high molecular weight)

Chemical Name (Common Synonyms): BENZO(B)FLUORANTHENE **CASRN:** 205-99-2

Chemical Characteristics

Solubility in Water: 0.0012 mg/L [1]

Half-Life: 360 days - 1.67 yrs based on aerobic soil die-away test data [2]

Log K_{ow}: 6.20 [3]

Log K_{oc}: 6.09 L/kg organic carbon

Human Health

Oral RfD: No data [4]

Confidence: —

Critical Effect: —

Oral Slope Factor (Reference): No data [4]

Carcinogenic Classification: No data [4]

Wildlife

Partitioning Factors: Partitioning factors for benzo(b)fluoranthene in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for benzo(b)fluoranthene in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: Partitioning factors for benzo(b)fluoranthene in aquatic organisms were not found in the literature.

Food Chain Multipliers: Food chain multipliers for benzo(b)fluoranthene in aquatic organisms were not found in the literature.

Toxicity/Bioaccumulation Assessment Profile

The acute toxicity of hydrocarbons, including benzo(b)fluoranthene, to both fresh and salt water crustaceans is largely nonselective, i.e., it is not primarily influenced by molecular structure, but is rather controlled by organism-water partitioning which, for nonpolar organic chemicals, is in turn a reflection of aqueous solubility. The toxic effect is believed to occur at a relatively constant concentration within the organism [5].

Bioavailability of sediment-associated polynuclear aromatic hydrocarbons (PAHs), e.g., benzo(b)fluoranthene, has been observed to decline with increased contact time [6]. The majority of investigations have shown that aquatic organisms are able to release PAHs from their tissues rapidly when they were returned to a clean environment. The apparent effects threshold concentration of 4,500 ng/g was established for benzo(b)fluoranthene based on effects observed in the marine amphipod *Rhepoxynius abronius* [7].

Bioaccumulation of low- molecular-weight PAHs from sediments by *Rhepoxynius abronius* (amphipod) and *Armandia brevis* (polychaete) was similar, however, a large difference in tissue concentration between these two species was measured for high-molecular-weight PAHs including benzo(b)fluoranthene [8]. Meador et al. [8] concluded that the low-molecular-weight PAHs were available to both species from interstitial water, while sediment ingestion was a much more important uptake route for the high-molecular-weight PAHs. The authors also indicated that bioavailability of the high-molecular-weight PAHs to amphipods was significantly reduced due to their partitioning to dissolved organic carbon.

Summary of Biological Effects Tissue Concentrations for Benzo(b)fluoranthene

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Invertebrates									
Crassostrea virginica, Oyster	18 ng/g		18 ng/g					[9]	F
	2.9 ng/g		27 ng/g					[9]	F
	9.9 ng/g		40 ng/g					[9]	F
Diporeia spp, Amphipod	27 nmol/g		321 nmol/g					[6]	L

1 Concentration units based on wet weight unless otherwise noted.
2 BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
3 L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.

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Chemical Category: POLYNUCLEAR AROMATIC HYDROCARBON (high molecular weight)

Chemical Name (Common Synonyms): BENZO(G,H,I)PERYLENE **CASRN:** 191-24-2

Chemical Characteristics

Solubility in Water: Insoluble in water [1]

Half-Life: 590 d - 650 days based on aerobic soil die-away test data at 30°. [2]

Log K_{ow}: 6.70 [3]

Log K_{oc}: 6.59 L/kg organic carbon

Human Health

Oral RfD: No data [4]

Confidence: —

Critical Effect: —

Oral Slope Factor (Reference): No data [4]

Carcinogenic Classification: No data [4]

Wildlife

Partitioning Factors: Partitioning factors for benzo(g,h,i)perylene in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for benzo(g,h,i)perylene in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: Partitioning factors for benzo(g,h,i)perylene in aquatic organisms were not found in the literature.

Food Chain Multipliers: An ecotoxicological in situ study conducted at the Baltic Sea, showed that the tissue residue concentration of benzo(g,h,i)perylene decreased with increasing trophic level [5]. The relatively high theoretical flux through the food chain was not possible to detect.

Toxicity/Bioaccumulation Assessment Profile

The acute toxicity of hydrocarbons, including benzo(g,h,i)perylene, to both fresh and salt water crustaceans is largely nonselective, i.e., it is not primarily influenced by molecular structure, but is rather controlled by organism-water partitioning which, for nonpolar organic chemicals, is in turn a reflection of aqueous solubility. The toxic effect is believed to occur at a relatively constant concentration within the organism [5].

The majority of investigations have shown that aquatic organisms are able to release polynuclear aromatic hydrocarbons (PAHs), e.g., benzo(g,h,i)perylene, from their tissues rapidly when they were returned to clean environment. Tanacredl and Cardenas [6] reported that *Mercenaria mercenaria* exposed to PAHs accumulated them to high levels in their tissues and failed to release them when returned to clean seawater over the 45-day depuration period. Unlike other marine organisms, this “sequestering” in molluscs may support the apparent inability to metaboilize PAHs to more water soluble and thus easily secreted polar metabolites.

Bioaccumulation of low-molecular-weight PAHs from sediments by *Rhepoxynius abronius* (amphipod) and *Armandia brevis* (polychaete) was similar; however, a large difference in tissue concentration between these two species was measured for high-molecular-weight PAHs including benzo(g,h,i)perylene [7]. Meador et al. [7] concluded that the low-molecular-weight PAHs were available to both species from interstitial water, while sediment ingestion was a much more important uptake route for the high-molecular-weight PAHs. The authors also indicated that bioavailability of the high-molecular-weight PAHs to amphipods was significantly reduced due to their partitioning to dissolved organic carbon.

Summary of Biological Effects Tissue Concentrations for Benzo(g,h,i)perylene									
Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Invertebrates									
Mytilus edulis, Mussels			13 ng/g					[8]	F
Crassostrea virginica, Oyster	0.4 ng/g		10 ng/g					[10]	
	122.1 ng/g		16 ng/g					[10]	F
	31.1 ng/g		27 ng/g					[10]	F
	75.1 ng/g		12 ng/g					[10]	F
	5.4 ng/g		14 ng/g					[10]	F
	5.7 ng/g		18 ng/g					[10]	F
	6.2 ng/g		10 ng/g					[10]	F
	6.7 ng/g		10 ng/g					[10]	F
	0.4 ng/g		10 ng/g					[10]	F
	16.1 ng/g		16 ng/g					[10]	F
Pontoporeia hoyi, Amphipod	400 ng/g	5 ng/mL	BDL					[9]	L
Fishes									
Cyprinus carpio, Common carp			29.6 mg/kg (liver)[4]	Physiological, NOED				[11]	L; no significant increase in EROD enzyme and P450 1a protein content

Summary of Biological Effects Tissue Concentrations for Benzo(g,h,i)perylene

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Wildlife									
Somateria mollissima, Eider duck			2 ng/g					[8]	F

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
[4] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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Chemical Category: POLYNUCLEAR AROMATIC HYDROCARBON (high molecular weight)

Chemical Name (Common Synonyms): BENZO(K)FLUORANTHENE **CASRN:** 207-08-9

Chemical Characteristics

Solubility in Water: Insoluble in water [1]

Half-Life: 2.49 yrs - 5.86 yrs based on aerobic soil die-away test data [2]

Log K_{ow}: 6.20 [3]

Log K_{oc}: 6.09 L/kg organic carbon

Human Health

Oral RfD: No data [4]

Confidence: —

Critical Effect: —

Oral Slope Factor (Reference): Not available [4]

Carcinogenic Classification: B2 [4]

Wildlife

Partitioning Factors: Partitioning factors for benzo(k)fluoranthene in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for benzo(k)fluoranthene in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: The only partitioning factors for benzo(k)fluoranthene in aquatic organisms found in the literature were log BAFs of -0.68 to 0.01 for the clam *Macoma nasuta* [9].

Food Chain Multipliers: An ecotoxicological in situ study conducted at the Baltic Sea [5] showed that the tissue residue concentration of benzo(k)fluoranthene decreased with increasing trophic level. The relatively high theoretical flux through the food chain was not possible to detect.

Toxicity/Bioaccumulation Assessment Profile

The acute toxicity of hydrocarbons, including benzo(k)fluoranthene, to both fresh and salt water crustaceans is largely nonselective, i.e., it is not primarily influenced by molecular structure, but is rather controlled by organism-water partitioning which, for nonpolar organic chemicals, is in turn a reflection of aqueous solubility. The toxic effect is believed to occur at a relatively constant concentration within the organism [6].

The majority of investigations have shown that aquatic organisms are able to release polynuclear aromatic hydrocarbons (PAHs), e.g., benzo(k)fluoranthene, from their tissues rapidly when they were returned to clean environment. The apparent effects threshold concentration of 4500 ng/g for benzo(k)fluoranthene was established based on effects observed in the marine amphipod *Rhepoxynius abronius* [7].

Bioaccumulation of low-molecular-weight PAHs from sediments by *Rhepoxynius abronius* (amphipod) and *Armandia brevis* (polychaete) was similar, however, a large difference in tissue concentration between these two species was measured for high-molecular-weight PAHs including benzo(k)fluoranthene [8]. Meador et al. [8] concluded that the low-molecular-weight PAHs were available to both species from interstitial water, while sediment ingestion was a much more important uptake route for the high-molecular-weight PAHs. The authors also indicated that bioavailability of the high-molecular-weight PAHs to amphipods was significantly reduced due to their partitioning to dissolved organic carbon.

Summary of Biological Effects Tissue Concentrations for Benzo(k)fluoranthene

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
Invertebrates									
Mytilus edulis, Blue mussel			44 ng/g					[5]	F
Crassostrea virginica, Eastern oyster	1.5 ng/g		14 ng/g					[10]	F
	36 ng/g		85 ng/g					[10]	F
	59.6 ng/g		65 ng/g					[10]	F
	127.5 ng/g		61 ng/g						
Macoma nasuta, Clam	14.1 ng/g		92 ng/g			0.009 or 0.01		[9]	F
	17 ng/g		24 ng/g			-0.66		[9]	F
	121 ng/g		59 ng/g			-0.48		[9]	F
	156 ng/g		87 ng/g			-0.39		[9]	F
	390 ng/g		128 ng/g			-0.51		[9]	F
	610 ng/g		96 ng/g			-0.68		[9]	F
Wildlife									
Somateria mollissima, Eider duck			4.3 ng/g					[5]	F

1 Concentration units based on wet weight unless otherwise noted.
2 BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
3 L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
4 This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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Chemical Category: METAL (Divalent)

Chemical Name (Common Synonyms): CADMIUM **CASRN:** 7440-43-9

Chemical Characteristics

Solubility in Water: Insoluble [1]

Half-Life: Not applicable, stable [1]

Log K_{ow}: –

Log K_{oc}: –

Human Health

Oral RfD: 5 x 10^{-4} mg/kg-day [2]

Confidence: High, uncertainty factor = 10

Critical Effect: Significant proteinuria, presence of protein in urine

Oral Slope Factor: Not available [2]

Carcinogenic Classification: B1 [2]

Wildlife

Partitioning Factors: Partitioning factors for cadmium in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for cadmium in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: Cadmium in the water column can partition to dissolved and particulate organic carbon. The more important issues related to water column concentrations of cadmium are water hardness (i.e., calcium concentration), pH, and metal speciation since the divalent cadmium ion is believed to be responsible for observed biological effects. Cadmium speciation yields primarily the divalent form of the metal, Cd^{+2}, between pH values of 4.0 and 7.0 [3]. In addition, the concentration of acid-volatile sulfides is known to be an important factor controlling the toxicity and bioaccumulation of cadmium in sediments.

Food Chain Multipliers: Most studies reviewed contained data which suggest that cadmium is not a highly mobile element in aquatic food webs, and there appears to be little evidence to support the general occurrence of biomagnification of cadmium within marine or freshwater food webs [4,5,6,7].

Toxicity/Bioaccumulation Assessment Profile

Cadmium does not appear to be a highly mobile element under typical conditions in most aquatic habitats [4]. Additional studies reviewed by Kay [4] indicated that no maternal transfer of cadmium was observed in zebrafish and that the cadmium content of bird eggs did not appear to be a good indicator of environmental exposure to cadmium. Tissue residue-toxicity relationships can also be variable because organisms might sequester metal in various forms that can be analytically measurable as tissue residue but might actually be stored in unavailable forms within the organism as a form of detoxification [8]. Whole body residues might also not be indicative of effects concentrations at the organ level because concentrations in target organs, such as the kidneys and liver, may be 20 times higher than whole body residues [9]. The application of "clean" chemical analytical and sample preparation techniques is also critical in the measurement of metal tissue residues. After evaluating the effects of sample preparation techniques on measured concentrations of metals in the edible tissue of fish, Schmitt and Finger [10] concluded that there was little direct value in measuring copper, zinc, iron, or manganese tissue residues in fish because they do not bioaccumulate to any appreciable extent. Cadmium and lead were the only ones found to be of potential concern in edible fish tissue based on the results from Schmitt and Finger's study of "clean" chemical techniques, although Wiener and Stokes [11] suggested that cadmium did not generally accumulate to any appreciable extent in the edible muscle tissue of fish.

Rule and Alden [26] studied the relationship between uptake of cadmium and copper from the sediment by the blue mussel (*Mytilus edulis*), grass shrimp (*Palaemonetes pugio*), and hard clam (*Mercenaria mercenaria*). The uptake of cadmium by the blue mussel significantly increased as a function of increasing cadmium concentration in sediment. However, the uptake of cadmium increased when copper was added to the sediments. The uptake of cadmium by the grass shrimp exhibited a pattern similar to that of the mussel, while the uptake of cadmium by the hard clam was low compared to the other two species and related only to the cadmium concentration in sediment.

The experiments performed by Meador [28] revealed that the response of the amphipods *Rhepoxynius abronius* and *Eohaustorius estuarius* to cadium decreased two- to threefold for animals held in the laboratory for several weeks compared to organisms recently collected from the field.

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Plants									
Scenedesmus obliquus, Freshwater colonial green algae			2,340 mg/kg (whole body)[5]	Growth, LOED				[31]	L; significant inhibition of growth (27% reduction from control)
			658 mg/kg (whole body)[5]	Growth, LOED				[31]	L; 39% reduction in population growth from controls
			3,030 mg/kg (whole body)[5]	Growth, NOED				[31]	L; no significant inhibition of growth
Eichhornia crassipes, Water hyacinth			11.4 mg/kg (leaf)[5]	Growth, LOED				[47]	F; reduced growth rate, chlorosis
			262 mg/kg (root)[5]	Growth, LOED				[47]	F; reduced growth rate, chlorosis
			49.6 mg/kg (stem)[5]	Growth, LOED				[47]	F; reduced growth rate, chlorosis

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			11.4 mg/kg (leaf)[5]	Morphology, LOED				[47]	F; chlorosis, browning, necrosis, waterlogging of tissues
			262 mg/kg (root)[5]	Morphology, LOED				[47]	F; chlorosis, browning, necrosis, waterlogging of tissues
			49.6 mg/kg (stem)[5]	Morphology, LOED				[47]	F; chlorosis, browning, necrosis, waterlogging of tissues
			20.8 mg/kg (leaf)[5]	Growth, NA				[47]	F; reduced growth rate, chlorosis
			45.8 mg/kg (leaf)[5]	Growth, NA				[47]	F; reduced growth rate, chlorosis
			578 mg/kg (root)[5]	Growth, NA				[47]	F; reduced growth rate, chlorosis
			1,300 mg/kg (root)[5]	Growth, NA				[47]	F; reduced growth rate, chlorosis

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			84.8 mg/kg (stem)[5]	Growth, NA				[47]	F; reduced growth rate, chlorosis
			159 mg/kg (stem)[5]	Growth, NA				[47]	F; reduced growth rate, chlorosis
			20.8 mg/kg (leaf)[5]	Morphology, NA				[47]	F; chlorosis, browning, necrosis, waterlogging of tissues
			45.8 mg/kg (leaf)[5]	Morphology, NA				[47]	F; chlorosis, browning, necrosis, waterlogging of tissues
			578 mg/kg (root)[5]	Morphology, NA				[47]	F; chlorosis, browning, necrosis, waterlogging of tissues
			1,300 mg/kg (root)[5]	Morphology, NA				[47]	F; chlorosis, browning, necrosis, waterlogging of tissues

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			84.8 mg/kg (stem)[5]	Morphology, NA				[47]	F; chlorosis, browning, necrosis, waterlogging of tissues
			159 mg/kg (stem)[5]	Morphology, NA				[47]	F; chlorosis, browning, necrosis, waterlogging of tissues
			8 mg/kg (leaf)[5]	Growth, NOED				[47]	F; no effect on growth
			142 mg/kg (root)[5]	Growth, NOED				[47]	F; no effect on growth
			27.8 mg/kg (stem)[5]	Growth, NOED				[47]	F; no effect on growth
			8 mg/kg (leaf)[5]	Morphology, NOED				[47]	F; no effect on plant appearance
			142 mg/kg (root)[5]	Morphology, NOED				[47]	F; no effect on plant appearance
			27.8 mg/kg (stem)[5]	Morphology, NOED				[47]	F; no effect on plant appearance

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Invertebrates									
Lumbriculus variegatus, Oligochaete			670 mg/kg (whole body)[5]	Mortality, LOED				[32]	L; 40% mortality
			310 mg/kg (whole body)[5]	Mortality, NOED				[32]	L; no effect on mortality
Najas quadulepensis, Southern naiad			10.3 mg/kg (whole body)[5]	Development, LOED				[35]	L; reductions in chlorophyll and stolon development
Neanthes arenaceodentata, Polychaete			67 mg/kg (whole body)[5]	Reproduction, ED100				[46]	L; reproductive failure
			67 mg/kg (whole body)[5]	Behavior, LOED				[46]	L; reduced tube building, sluggish behavior
			4.5 mg/kg (whole body)[5]	Behavior, NOED				[46]	L; no effect on behavior
			0.22 mg/kg (whole body)[5]	Behavior, NOED				[46]	L; no effect on behavior
			0.028 mg/kg (whole body)[5]	Behavior, NOED				[46]	L; no effect on behavior

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			0.0028 mg/kg (whole body)[5]	Behavior, NOED				[46]	L; no effect on behavior
			67 mg/kg (whole body[5]	Mortality, NOED				[46]	L; no effect on survival
			4.5 mg/kg (whole body)[5]	Mortality, NOED				[46]	L; no effect on survival
			0.22 mg/kg (whole body)[5]	Mortality, NOED				[46]	L; no effect on survival
			0.028 mg/kg (whole body)[5]	Mortality, NOED				[46]	L; no effect on survival
			0.0028 mg/kg (whole body)[5]	Mortality, NOED				[46]	L; no effect on survival
			4.5 mg/kg (whole body)[5]	Reproduction, NOED				[46]	L; no effect on reproduction
			0.22 mg/kg (whole body)[5]	Reproduction, NOED				[46]	L; no effect on reproduction
			0.028 mg/kg (whole body)[5]	Reproduction, NOED				[46]	L; no effect on reproduction
			0.0028 mg/kg (whole body)[5]	Reproduction, NOED				[46]	L; no effect on reproduction

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Neanthes virens, Polychaete - Sandworm			106 mg/kg (whole body)[5]	Behavior, LOED				[33]	L; lethargy
			78 mg/kg (whole body)[5]	Physiological, LOED				[33]	L; total glycogen reduced, increase in ascorbic acid
			290 mg/kg (whole body)[5]	Physiological, LOED				[33]	L; increase in ascorbic acid content
Helisoma sp., Snail			625 mg/kg (whole body)[5]	Mortality, ED50				[32]	L; 50% mortality
			300 mg/kg (whole body)[5]	Mortality, NOED				[32]	L; no effect on mortality
			460 mg/kg (whole body)[5]	Mortality, NOED				[32]	L; no effect on mortality
Dreissena polymorpha, Zebra mussel			Day 27: 539-598 µg/g 0.96-1.06 mmol/kg	50% mortality				[19]	L
Mytilus edulis, Blue mussel			30 mg/kg (whole body)[5]	Growth, NOED				[53]	L

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			30 mg/kg (whole body)[5]	Mortality, NOED				[53]	L; highest body burden reported
			6.45 mg/kg (whole body)[5]	Mortality, NOED				[26]	L; estimated wet weight
			4.22 mg/kg (whole body)[5]	Mortality, NA				[60]	L; decreased anoxic survival time (Control 10.7 days)
			8.06 mg/kg (whole body)[5]	Mortality, NA				[60]	L; decreased anoxic survival time (Control 10.7 days)
			3.74 mg/kg (whole body)[5]	Mortality, NA				[60]	L; decreased anoxic survival time (Control 13 days)
			8.06 mg/kg (whole body)[5]	Mortality, NA				[60]	L; decreased anoxic survival time (Control 10.7 days)
			8.06 mg/kg (whole body)[5]	Physiological, NOED				[60]	L; no significant changes in adenylate energy charge or glycogen content

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Mytilus galloprovincialis, Mussel			0.57-0.92 mg/kg				0.416	[27]	F
Crassostrea virginica, Oyster			18.2 mg/kg (whole body)[5]	Reproduction, NOED				[62]	L; no reduced viability of gametes after exposure of adults in 21 ppt seawater
			54 mg/kg (whole body)[5]	Reproduction, NOED				[62]	L; 24% reduction in viability of gametes after exposure of adults in 21 ppt seawater
Daphnia magna, Cladoceran			Day 21: 2.36 µg/g	LOEC				[20]	F
			Week 20: 17.4 µg/g	LOEC				[17]	L
			Day 21: 2.0 mmol/kg	10% mortality				[21]	L

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Daphnia magna, Cladoceran			1.7 mg/kg (whole body)[5]	Reproduction, ED10				[21]	L; 10% reduction in number of offspring
			221 mg/kg (whole body)[5]	Mortality, ED50				[21]	L; lethal body burden after 21-day exposure
Daphnia galeata mendotae, Cladoceran			10.3 mg/kg (whole body) [5]	Growth, LOED				[48]	L; increased weight of individual animals
			3.5 mg/kg (whole body)	Mortality, LOED				[48]	L; reduced longevity, increased prenatal mortality
			5.7 mg/kg (whole body) [5]	Mortality, NA				[48]	L; reduced longevity, increased prenatal mortality
			8.6 mg/kg (whole body)[5]	Mortality, NA				[48]	L; reduced longevity, increased prenatal mortality

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			10.3 mg/kg (whole body)[5]	Mortality, NA				[48]	L; reduced longevity, increased prenatal mortality
			3.5 mg/kg (whole body)[5]	Growth, NOED				[48]	L; no effect on individual weight
			5.7 mg/kg (whole body)[5]	Growth, NOED				[48]	L; no effect on individual weight
			8.6 mg/kg (whole body)[5]	Growth, NOED				[48]	L; no effect on individual weight
Folsomia candida, Cladoceran			60 µg/g	LOEC				[22]	F
Gammarus fossarum, Amphipod			Day 14: 60-70 µg/g	50% mortality				[18]	L
Moina macrocopa, Cladoceran			16.4 mg/kg (whole body)[5]	Reproduction, ED100				[42]	L; no reproduction after 12 days
			16.4 mg/kg (whole body)[5]	Growth, LOED				[42]	L; reduced growth

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			16.4 mg/kg (whole body)[5]	Mortality, LOED				[42]	L; reduced survival
			10.6 mg/kg (whole body)[5]	Reproduction, LOED				[42]	L; reduced brood size
			10.6 mg/kg (whole body)[5]	Mortality, NOED				[42]	L; no effect on survival
			8 mg/kg (whole body)[5]	Reproduction, NOED				[42]	L; no effect on brood size
Hyallela azteca, Amphipod			Week 6: 15.2 µg/g	LOAEC				[17]	L
Pontoporeia affinis, Amphipod (juveniles, 105-460 d)			Day 460: 80-90 µg/g (0.14 mmol/kg)	LOEC				[16]	L
Pontoporeia affinis, Amphipod			11 mg/kg (whole body)[5]	Mortality, LOED				[58]	L
			6 mg/kg (whole body)[5]	Reproduction, LOED				[58]	L; percent malformed eggs
			6 mg/kg (whole body)[5]	Mortality, NOED				[58]	L

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			3 mg/kg (whole body)[5]	Reproduction, NOED				[58]	L; Percent malformed eggs
			2 mg/kg (whole body)[5]	Mortality, NOED				[59]	L; body burden estimated from graph
			10 mg/kg (whole body)[5]	Mortality, NOED				[59]	L; body burden estimated from graph
Balanus crenatus, Barnacle			52 mg/kg (whole body)[5]	Behavior, NOED				[55]	L; regulation of metals endpoint - summer experiment
Mysidopsis bahia, Mysid			1.29 mg/kg (whole body)[5]	Growth, LOED				[34]	L; reduction in growth, mean dry weight of animals
			1.29 mg/kg (whole body)[5]	Physiological, LOED				[34]	L; altered O:N ratio, shift towards lipid utilization with increasing cadmium concentration

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			2.38 mg/kg (whole body)[5]	Growth, NA				[34]	L; reduction in growth, mean dry weight of animals
			4.36 mg/kg (whole body)[5]	Growth, NA				[34]	L; reduction in growth, mean dry weight of animals
			2.38 mg/kg (whole body)[5]	Physiological, NA				[34]	L; altered O:N ratio, shift towards lipid utilization with increasing cadmium concentration
			4.36 mg/kg (whole body)[5]	Physiological, NA				[34]	L; altered O:N ratio, shift towards lipid utilization with increasing cadmium concentration
Oniscus asellus, Isopod			Day 91: 8.15 mmol/kg	 50% mortality				[23]	F
Porcellio scaber, Isopod			Day 63: 5.40 mmol/kg 3.77 mmol/kg	 50% mortality 50% mortality				[23]	F

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Palaemonetes pugio, Grass shrimp			0.9 mg/kg (whole body)[5]	Mortality, NOED				[26]	L; estimated wet weight
			2.6 mg/kg (whole body)[5]	Mortality, NA				[61]	L; 20% increased mortality over control in 5 ppt water; no statistical analysis
			5.8 mg/kg (whole body)[5]	Mortality, NA				[61]	L; 22% increased mortality over control in 5 ppt water; no statistical analysis
			7 mg/kg (whole body)[5]	Mortality, NA				[61]	L; 25% increased mortality over control in 5 ppt water; no statistical analysis
Palaemonetes pugio, Grass shrimp			Day 21: 4.0 µg/g	25% mortality				[14]	L

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Callianassa australiensis, Mole shrimp			Day 14: 4.8 µg/g	50% mortality				[15]	L
Cambarus latimanus, Crayfish			14.9 mg/kg (whole body)[5]	Growth, NOED				[13]	L; no significant difference from control growth at lowest test concentration
			14.9 mg/kg (whole body)[5]	Mortality, NOED				[13]	L; no significant difference from control mortality
			14.9 mg/kg (whole body)[5]	Physiological, NOED				[13]	L; no significant difference from control temperature sensitivity at lowest test concentration
Cambarus latimanus, Crayfish			Month 5: 4.4 µg/g	LOEC				[13]	L

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Orconectes virilis, Crayfish			Day 14: 5.6 µg/g	25% mortality				[12]	L
Orconectes propinquus, Crayfish			534 mg/kg (whole body)[5]	Mortality, NOED				[39]	L; 7% mortality after 190.5 hours, probably not significant
Chironomus gr. thummi, Midge			0.156 mg/kg (whole body)[5]	Morphology, NOED				[45]	F; 4th instar larvae
Glyptotendipes pallens, Midge			20 mg/kg (whole body)[5]	Behavior, LOED				[44]	L; modified feeding behavior, reduced net spinning activity
			20 mg/kg (whole body)[5]	Growth, LOED				[44]	L; reduced biomass
			30 mg/kg (whole body)[5]	Behavior, NA				[44]	L; modified feeding behavior, reduced net spinning activity
			50 mg/kg (whole body)[5]	Behavior, NA				[44]	L; lethargy

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			72 mg/kg (whole body)[5]	Behavior, NA				[44]	L; lethargy
			138 mg/kg (whole body)[5]	Behavior, NA				[44]	L; lethargy
			30 mg/kg (whole body)[5]	Growth, NA				[44]	L; reduced biomass
			50 mg/kg (whole body)[5]	Growth, NA				[44]	L; reduced biomass
			72 mg/kg (whole body)[5]	Growth, NA				[44]	L; reduced biomass
			138 mg/kg (whole body)[5]	Growth, NA				[44]	L; reduced biomass
			10 mg/kg (whole body)[5]	Behavior, NOED				[44]	L; no effect on feeding behavior or activity level
			18 mg/kg (whole body)[5]	Behavior, NOED				[44]	L; no effect on feeding behavior or activity level
			10 mg/kg (whole body)[5]	Growth, NOED				[44]	L; no effect on biomass
			18 mg/kg (whole body)[5]	Growth, NOED				[44]	L; no effect on biomass

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			10 mg/kg (whole body)[5]	Mortality, NOED				[44]	L; no effect on mortality in 96 hours
			18 mg/kg (whole body)[5]	Mortality, NOED				[44]	L; no effect on mortality in 96 hours
			20 mg/kg (whole body)[5]	Mortality, NOED				[44]	L; no effect on mortality in 96 hours
			30 mg/kg (whole body)[5]	Mortality, NOED				[44]	L; no effect on mortality in 96 hours
			50 mg/kg (whole body)[5]	Mortality, NOED				[44]	L; no effect on mortality in 96 hours
			72 mg/kg (whole body)[5]	Mortality, NOED				[44]	L; no effect on mortality in 96 hours
			138 mg/kg (whole body)[5]	Mortality, NOED				[44]	L; no effect on mortality in 96 hours
Orchesella cincta, Springtail			Day 49: 0.07 mmol/kg	50% mortality				[23]	F
Tomocerus minor, Springtail			Day 63: 0.13 mmol/kg	50% mortality				[23]	F

Summary of Biological Effects Tissue Concentrations for Cadmium

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
Platynothrus peltifer, Oribatid mite			Day 63: 0.42 mmol/kg	50% mortality				[23]	F
Classenia sabulosa, Stonefly	<0.3 µg/g 3.5 µg/g 6.6 µg/g		0.1 µg/g ND 1.4 µg/g					[24]	F
Hesperoperla pacifica, Stonefly	<0.3 µg/g 3.5 µg/g 6.6 µg/g		0.2 µg/g ND 1.0 µg/g					[24]	F
Isogenoides sp., Stonefly	<0.3 µg/g 3.5 µg/g 6.6 µg/g		<0.4 µg/g 1.4 µg/g 1.8 µg/g					[24]	F
Pteronarcys californica, Stonefly	<0.3 µg/g 3.5 µg/g 6.6 µg/g		0.1 µg/g ND 1.0 µg/g					[24]	F
Hydropsyche sp., Caddisfly			9.8 mg/kg (whole body)[5]	Mortality, LOED				[38]	L; mortality in one day
			17.4 mg/kg (whole body)[5]	Mortality, LOED				[38]	L; mortality in two days
			29.8 mg/kg (whole body)[5]	Mortality, LOED				[38]	L; mortality in four days

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			0.118 mg/kg (whole body)[5]	Mortality, LOED				[38]	L; mortality in one day
			0.0934 mg/kg (whole body)[5]	Mortality, LOED				[38]	L; mortality in two days
			16 mg/kg (whole body)[5]	Mortality, NOED				[38]	L; no effect on mortality in one day
			24.8 mg/kg (whole body)[5]	Mortality, NOED				[38]	L; no effect on mortality in one day
			41.8 mg/kg (whole body)[5]	Mortality, NOED				[38]	L; no effect on mortality in one day
			0.202 mg/kg (whole body)[5]	Mortality, NOED				[38]	L; no effect on mortality in one day
			0.284 mg/kg (whole body)[5]	Mortality, NOED				[38]	L; no effect on mortality in one day
Hydropsyche spp., Caddisfly	<0.3 µg/g 3.5 µg/g 6.6 µg/g		0.2 µg/g 2.2 µg/g 2.8 µg/g					[24]	F
Arctopsyche grandis, Caddisfly	<0.3 µg/g 3.5 µg/g 6.6 µg/g		0.2 µg/g ND[4] 1.4 µg/g					[24]	F

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Asterias rubens, Starfish			0.03 mg/kg (gonad)[5]	Development, LOED				[37]	combined, estimated wet weight adult males
			0.14 mg/kg (gonad)[5]	Development, LOED				[37]	combined, estimated wet weight adult females
Fishes									
Oncorhynchus mykiss, Rainbow trout			16.4 mg/kg (whole body)[5]	Mortality, ED100				[29]	L; complete mortality of alevins within 10 hours
			101 mg/kg (whole body)[5]	Mortality, ED100				[29]	L; complete mortality of eggs within 32 hours
			0.84 mg/kg (whole body)[5]	Mortality, ED100				[29]	L; complete mortality of alevins within 320 hours
			0.71 mg/kg (whole body)[5]	Behavior, LOED				[29]	L; erratic swimming
			0.21 mg/kg (whole body)[5]	Morphology, LOED				[29]	L; deformed vertebrae, blood clots in fins

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.21 mg/kg (whole body)[5]	Mortality, LOED				[29]	L; hatching alevins unable to break free from egg membrane, died
			10 mg/kg (whole body)[5]	Physiological, LOED				[30]	L; induction of metallothionein
			0.0599 mg/kg (whole body)[5]	Mortality, NOED				[41]	L; no effect on mortality
			6.4 mg/kg (whole body)[5]	Mortality, ED50				[51]	L; hardness: 279 mg/L $CaCO_3$
			3.74 mg/kg (whole body)[5]	Mortality, ED50				[51]	L; Hardness: 279 Mg/L $CaCO_3$
			4 mg/kg (whole body)[5]	Mortality, ED50				[51]	L; hardness: 70 mg/L $CaCO_3$
			2.2 mg/kg (whole body)[5]	Mortality, ED50				[51]	L; hardness: 70 mg/L $CaCO_3$

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Salmo salar, Atlantic Salmon			0.26 mg/kg (yolk sac/stomach)[5]	Growth, LOED				[52]	L; yolk sac/stomach weight - graph and table interpretation
			0.26 mg/kg (yolk sac/stomach)[5]	Mortality, LOED				[52]	L; yolk sac/stomach weight - graph and table interpretation
			0.05 mg/kg (yolk sac/stomach)[5]	Growth, NOED				[52]	L; yolk sac/stomach weight - graph and table interpretation
			0.05 mg/kg (yolk sac/stomach)[5]	Mortality, NOED				[52]	L; yolk sac/stomach weight - graph and table interpretation
Salvelinus fontinalis, Brook trout		3.4 µg/g	Week 38: 10 µg/g, kidney 2 µg/g, liver					[25]	L

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Salvelinus fontinalis, Brook Trout			0.175 mg/kg (liver)[5]	Mortality, LOED				[40]	L; significant mortality in 10.5 µg/L at 15 days and 1.91 µg/L at 7 days, but no body burdens measured
			0.232 mg/kg (liver)[5]	Growth, NA				[40]	L; no significant effect on growth
			0.203 mg/kg (liver)[5]	Mortality, NOED				[40]	L
			144 mg/kg (whole body)[5]	Mortality, LOED				[40]	L; significantly reduced survival at lowest test concentration, exp_conc = <3.6

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.742 mg/kg (liver)[5]	Physiological, LOED				[40]	L; significantly increased metallothionein in whole body tissues at lowest test concentration; no correlation between metallothionein concentration and mortality or whole body tissue residues, exp_conc = < 3.6
			144 mg/kg (whole body)[5]	Physiological, LOED				[40]	L; significantly increased metallothionein in whole body tissues at lowest test concentration; no correlation between metallothionein and mortality or whole body tissue residues, exp_conc = < 3.6

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Jordanella floridae, American flagfish			0.4 mg/kg (whole body)[5]	Mortality, LOED				[56]	L; body burden estimated from graph, fish initially exposed as embryos
			0.4 mg/kg (whole body)[5]	Mortality, LOED				[56]	L; body burden estimated from graph, fish not exposed as embryos
			6 mg/kg (whole body)[5]	Growth, NOED				[56]	L; body burden estimated from graph
			0.4 mg/kg (whole body)[5]	Mortality, NOED				[56]	L; body burden estimated from graph, fish not exposed as embryos
			0.09 mg/kg (whole body)[5]	Mortality, NOED				[56]	L; body burden estimated from graph, fish initially exposed as embryos
			6 mg/kg (whole body)[5]	Reproduction, NOED				[56]	L; body burden estimated from graph

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			20 mg/kg (whole body)[5]	Growth, LOED				[57]	L; total length of females
			10 mg/kg (whole body)[5]	Growth, NOED				[57]	L; total length of females
			35 mg/kg (whole body)[5]	Mortality, NOED				[57]	L
Poecilia reticulata, Guppy			8 mg/kg (whole body)[5]	Mortality, ED50				[43]	L; 50% reduction in survival
			0.5 mg/kg (whole body)[5]	Growth, LOED				[43]	L; reduction in body length within 10 days
			1.2 mg/kg (whole body)[5]	Mortality, LOED				[43]	L; 14% reduction in survival
			0.8 mg/kg (whole body)[5]	Growth, NA				[43]	L; reduction in body length within 10 days
Cyprinodon variegatus, Sheepshead minnow			0.9 mg/kg (whole body)[5]	Development, LOED				[49]	L; decreased time to hatch

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Platichthys flesus, European flounder			17.2 mg/kg (kidney)[5]	Biochemical, LOED				[54]	L; females - Cd + estradiol injection: RNA:DNA ratio
			21.6 mg/kg (liver)[5]	Biochemical, LOED				[54]	L; females - Cd + estradiol injection: RNA:DNA ratio
			1.82 mg/kg (ovary)[5]	Biochemical, LOED				[54]	L; females - Cd + estradiol injection: RNA:DNA ratio
			33.2 mg/kg (kidney)[5]	Biochemical, NOED				[54]	L; males - Cd + estradiol injection: RNA:DNA ratio
			43.8 mg/kg (liver)[5]	Biochemical, NOED				[54]	L; males - Cd + estradiol injection: RNA:DNA ratio

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			4.66 mg/kg (ovary)[5]	Biochemical, NOED				[54]	L; males - Cd + estradiol injection: RNA:DNA ratio
			17.2 mg/kg (kidney)[5]	Mortality, NOED				[54]	L; females - Cd + estradiol injection: survival
			33.2 mg/kg (kidney)[5]	Mortality, NOED				[54]	L; males - Cd + estradiol injection: survival
			43.8 mg/kg (liver)[5]	Mortality, NOED				[54]	L; males - Cd + estradiol injection: survival
			21.6 mg/kg (liver)[5]	Mortality, NOED				[54]	L; females - Cd + estradiol injection: survival
			4.66 mg/kg (ovary)[5]	Mortality, NOED				[54]	L; males - Cd + estradiol injection: survival
			1.82 mg/kg (ovary)[5]	Mortality, NOED				[54]	L; females - Cd + estradiol injection: survival

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Pleuronectes americanus, Winter flounder			1 mg/kg (whole body)[5]	Physiological, LOED				[36]	L; induction of metallothionein
Wildlife									
Ambystoma gracile, Salamander			140 mg/kg (whole body)[5]	Behavior, LOED				[50]	L; significant reduction in regurgitation/ food retention
			6.28 mg/kg (whole body)[5]	Growth, LOED				[50]	L; significant reduction in both length and weight
			4.7 mg/kg (whole body)[5]	Growth, LOED				[50]	L; significant reduction in both length and weight
			71.7 mg/kg (whole body)[5]	Behavior, NOED				[50]	L; no significant increase in regurgitation/ food retention

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			43.5 mg/kg (whole body)[5]	Growth, NOED				[50]	L; no significant reduction in length or weight at highest test concentration
			3.75 mg/kg (whole body)[5]	Growth, NOED				[50]	L; no significant reduction in length or weight
			145 mg/kg (whole body)[5]	Growth, NOED				[50]	L; no significant reduction in length or weight at highest test concentration
			1.62 mg/kg (whole body)[5]	Growth, NOED				[50]	L; no significant reduction in length or weight
			43.5 mg/kg (whole body)[5]	Mortality, NOED				[50]	L; no significant increase in mortality at highest test concentration

Summary of Biological Effects Tissue Concentrations for Cadmium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			145 mg/kg (whole body)[5]	Mortality, NOED				[50]	L; no significant increase in mortality at highest test concentration
			4.13 mg/kg (whole body)[5]	Mortality, NOED				[50]	L; no significant increase in mortality at highest test concentration

1 Concentration units based on wet weight unless otherwise noted.
2 BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
3 L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
4 ND = not detected.
5 This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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Chemical Category: PESTICIDE (ORGANOCHLORINE)

Chemical Name (Common Synonyms): CHLORDANE **CASRN:** 57-74-9

Chemical Characteristics

Solubility in Water: 0.1 mg/L at 20 - 30°C [1]

Half-Life: 283 days - 3.8 yrs based on unacclimated aerobic river die-away test and reported soil grab sample data [2]

Log K_{ow}: 6.32 [3]

Log K_{oc}: 6.21 L/kg organic carbon

Human Health

Oral RfD: 6×10^{-5} mg/kg/day [4]

Confidence: Low, uncertainty factor = 1000

Critical Effect: Regional liver hypertrophy in female rats; hepatocellular carcinomas in mice

Oral Slope Factor: $1.3 \times 10^{+0}$ per (mg/kg)/day [4]

Carcinogenic Classification: B2 [4]

Wildlife

Partitioning Factors: Partitioning factors for chlordane in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for chlordane in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: The major components of technical chlordane include gamma chlordane (24 percent), alpha chlordane (19 percent), and *trans*-nonachlor (7 percent). Alpha chlordane is environmentally more stable and therefore more persistent than gamma chlordane. Oxychlordane is an epoxide metabolite formed in mammalian liver. It is persistent and much more toxic than its parent chemicals [5].

Food Chain Multipliers: In a marine ecosystem the chlordane compounds (nonachlor and oxychlordane) increased significantly with trophic levels from zooplankton to marine mammals [6]. Although the results of the study reported by Kawano et al. [6] indicated a small difference in the chlordane composition in zooplankton from the North Pacific, Bering Sea, and Antarctic, they also revealed a significant difference in chlordane composition between Dall's porpoise and the Weddell seal. *Trans*-chlordane was present in the seal but not in the porpoise, and the percentage composition of oxychlordane in the seal was larger than that in the porpoise. Furthermore, the compositional percentage of oxychlordane in the Adelie penguin and thick-billed murre was much higher than that in the other organisms. Marine mammals and seabirds accumulated chlordane via food. Biomagnification of total chlordanes through the food chain is strongly evident in marine mammals. Chlordanes are concentrated gradually from zooplankton, through squid and fish, to porpoises and dolphins [7,8]. Chlordane residues in marine mammals are positively correlated with lipid content and not with the age of the animal [9]. Food chain multipliers (FCMs) for *cis*- or *trans*-chlordane for trophic level 3 aquatic organisms were 21.7 (all benthic food web), 1.6 (all pelagic food web), and 13.2 (benthic and pelagic food web). FCMs for trophic level 4 aquatic organisms were 49.5 (all benthic food web), 3.5 (all pelagic food web), and 23.3 (benthic and pelagic food web) [26].

Toxicity/Bioaccumulation Assessment Profile

Chlordane adversely affected sensitive species of fish and aquatic invertebrates at concentrations of 0.2 to 2.0 µg/L. Specifically, survival of shrimp and crabs was reduced at water concentrations of 0.2 to 2.0 µg/L, while survival of freshwater and marine fishes was reduced between 1.7 and 3.0 µg/L. Generally, the uptake of chlordane by aquatic organisms is high, ranging from 216.8 µg organic carbon cleared per gram organism per hour for *Diporeia* spp. to 358 µg organic carbon cleared per gram organism per hour for *Chironomus riparius* [10]. Accumulation of chlordane by *Diporeia* spp., *C. riparius,* or *Lumbriculus variegatus* from whole sediment exposures was greater than that from the elutriate or pore water. Neither species was able to metabolize chlordane. A study by Wilcock et al. [11] has shown that the bivalve *Macomona liliana* can accumulate chlordane bound to sediment at depths below 2 cm. Animals constantly exposed to contaminated sediment accumulated more (5,728 ppb lipid) than those able to feed alternatively on contaminated and uncontaminated sediments (3,617 and 2,756 ppb). An in situ study of the uptake and elimination by adult intertidal benthic infauna of chlordane from contaminated sediment has shown large differences in accumulation between deposit- and suspension-feeding species [12]. In the case of surface feeders, these differences can be attributed to direct exposure to high initial concentration of chlordane in surficial sediments. The extract from the chlordane residues obtained from Lake Michigan lake trout was significantly more toxic (3 to 5 times) than the chlordane used in agricultural applications. Gooch et al. [13] suggested that the increased toxicity of these extracts was due to the presence of the stable metabolite heptachlor epoxide and oxychlordane. Chlordane is persistent in the environment; measurable residues in sediment were found 2.8 years after application to the overlying water column [5]. More than 80 percent of the fish sampled from the Kansas River had detectable chlordanes in their tissue [14]. Residues of *cis*-chlordane and *trans*-chlordane were the most abundant and persistent of the chlordane components measured in fish tissues in a U.S. study conducted aproximately 10 years after the termination of the agricultural use of chlordanes [15]. In birds, technical chlordane and its metabolite oxychlordane are frequently elevated in tissues with high lipid content. In northern gannets, the half-time persistence of *cis*-chlordane, *cis*-nonachlor, and oxychlordane was estimated at 11, 199, and 35 years [16].

Summary of Biological Effects Tissue Concentrations for Chlordane

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Invertebrates									
Lumbriculus variegatus, Oligochaete worm	125 ng/g		28,197 ng/g					[10]	F
	1,406 ng/g		23,031 ng/g[3]						
		BDL[4]	0.03 µ/kg					[17]	F
Crassostrea virginica, Eastern oyster			0.02 mg/kg (whole body)[5]	Growth, ED18				[22]	L; exposure media 65% heptachlor (technical grade)
			2.2 mg/kg (whole body)[5]	Growth, ED28				[22]	L; exposure media 65% heptachlor (technical grade)
			0.3 mg/kg (whole body)[5]	Growth, ED28					L; exposure media 65% heptachlor (technical grade)
			0.075 mg/kg (whole body)[5]	Growth, ED30				[22]	L; exposure media 65% heptachlor (technical grade)
			0.6 mg/kg (whole body)[5]	Growth, ED30				[22]	L; exposure media 65% heptachlor (technical grade)
			0.78 mg/kg (whole body)[5]	Growth, ED33				[22]	L; exposure media 65% heptachlor (technical grade)
			6.5 mg/kg (whole body)[5]	Growth, ED33				[22]	L; exposure media 65% heptachlor (technical grade)

Summary of Biological Effects Tissue Concentrations for Chlordane

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			1.9 mg/kg (whole body)[5]	Growth, ED78				[22]	L; exposure media 65% heptachlor (technical grade)
			14 mg/kg (whole body)[5]	Growth, ED78				[22]	L; exposure media 65% heptachlor (technical grade)
			5.6 mg/kg (whole body)[5]	Growth, ED95				[22]	L; exposure media 65% heptachlor (technical grade)
			47 mg/kg (whole body)[5]	Growth, ED95				[22]	L; exposure media 65% heptachlor (technical grade)
			0.022 mg/kg (whole body)[5]	Growth, NOED				[22]	L; exposure media 65% heptachlor (technical grade)
Crassostrea virginica, Eastern oyster			27 mg/kg (whole body)[5]	Growth, LOED				[23]	L; estimated LOED - no statistical summary in text
			11 mg/kg (whole body)[5]	Growth, NOED				[23]	L; estimated NOED - no statistical summary in text
Corbicula fluminea, Asian clam	21.7 µg/kg OC		2,400 µg/kg lipid				2.04	[21]	F; *trans*-chlordane; %lipid not reported; %sed OC = 2.30

Summary of Biological Effects Tissue Concentrations for Chlordane

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Gonatopsis borealis, Eight-armed squid			*cis*-chlordane: 15 (11-18) µg/kg *trans*-chlordane: 8.1 (6.3-9.9) µg/kg *cis*-nonachlor: 2.4 (2.2-2.8) µg/kg *trans*-nonachlor: 18 (14-20) µg/kg oxychlordane: 1.2 (0.8-1.60) µg/kg total chlordanes: 44 (35-52) µg/kg					[5]	F; lipid samples
Diporeia sp., Amphipod	493 ng/g 430 ng/g		23,729 ng/g 40,086 ng/g					[10]	F
Euphasia superba, Krill			*cis*-chlordane: 0.58 µg/kg *trans*-chlordane: 0.51 µg/kg *cis*-nonachlor: 0.22 µg/kg *trans*-nonachlor: 0.8 µg/kg oxychlordane: 0.1 µg/kg					[6]	F
Palaemonetes pugio, Grass shrimp			4.5 mg/kg (whole body)[5]	Mortality, LOED				[23]	L; estimated LOED - no statistical summary in text

Summary of Biological Effects Tissue Concentrations for Chlordane

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
			4.8 mg/kg (whole body)[5]	Mortality, NOED				[23]	L; estimated NOED - no statistical summary in text
Penaeus duorarum, Pink shrimp			1.7 mg/kg (whole body)[5]	Mortality, LOED				[23]	L; estimated LOED - no statistical summary in text
			0.71 mg/kg (whole body)[5]	Mortality, NOED				[23]	L; estimated NOED - no statistical summary in text
Homarus americanus, American lobster			*cis*-chlordane: 80-100 µg/kg, hepatopancreas *trans*-chlordane: 80-100 µg/kg, hepatopancreas *cis*-nonachlor: 30 µg/kg, hepatopancreas *trans*-nonachlor: (380-440) µg/kg, hepatopancreas					[5]	F
Chironomus riparius, Midge	1,663 ng/g 1,741 ng/g		16,224 ng/g 8,417 ng/g					[10]	F

Summary of Biological Effects Tissue Concentrations for Chlordane

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Fishes									
Oncorhynchus, Salmo, Salvelinus sp., Salmonids		0.000034 µg/L	19 µg/kg			5.75		[20]	F; *trans*-chlordane, % lipid = 11
	77.8 µg/kg OC		172.7 µg/kg lipid				2.22	[20]	F; *trans*-chlordane; %lipid = 11; %sed OC = 2.70
Salmonids							2.00	[25]	F; *trans*-chlordane
							4.77	[25]	F; *cis*-chlordane
Osmerus mordax, Smelt; *Oncorhynchus velinus,* Coho salmon	2.1 ng/g	34 pg/L	3.6 ng/g 19 ng/g					[18,20]	F; median BSAFs calculated in [18] from field data in [20]
Cyprinus carpio, Carp	2.5 ng/g		18 ng/g				46.3 33.4	[18,19]	F; median BSAFs calculated in [18] from field data in [19]
Cyprinus carpio, Carp	437.5 µg/kg OC		217.9 µg/kg lipid				0.498	[24]	F; *trans*-chlordane; %lipid = 7.8; %sed OC = 0.80
	145.3 µg/kg OC		110.7 µg/kg lipid				0.762	[24]	F; *trans*-chlordane; %lipid = 8.4; %sed OC = 1.79
	112.1 µg/kg OC		161.3 µg/kg lipid				1.439	[24]	F; *trans*-chlordane; %lipid = 9.3; %sed OC = 1.16

Summary of Biological Effects Tissue Concentrations for Chlordane

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Cyprinus carpio, Carp	212.5 µg/kg OC		294.9 µg/kg lipid				1.3878	[24]	F; *cis*-chlordane; %lipid = 7.8; %sed OC = 0.80
	128.5 µg/kg OC		190.5 µg/kg lipid				1.4825	[24]	F; *cis*-chlordane; %lipid = 8.4; %sed OC = 1.79
	86.21 µg/kg OC		258.1 µg/kg lipid				2.9939	[24]	F; *cis*-chlordane; %lipid = 9.3; %sed OC = 1.16
Catastomus commersoni, White sucker	437.5 µg/kg OC		132.5 µg/kg lipid				0.301	[24]	F; *trans*-chlordane; %lipid = 8.3; %sed OC = 0.8
	145.3 µg/kg OC		189.9 µg/kg lipid				1.307	[24]	F; *trans*-chlordane; %lipid = 7.9; %sed OC = 1.79
	112.1 µg/kg OC		266.7 µg/kg lipid				2.379	[24]	F; *trans*-chlordane; %lipid = 4.5; %sed OC = 1.16
Catastomus commersoni, White sucker	212.5 µg/kg OC		192.8 µg/kg lipid				0.9073	[24]	F; *cis*-chlordane; %lipid = 8.3; %sed OC = 0.8
	128.5 µg/kg OC		519 µg/kg lipid				4.0389	[24]	F; *cis*-chlordane; %lipid = 7.9; %sed OC = 1.79
	86.21 µg/kg OC		533.3 µg/kg lipid				6.1861	[24]	F; *cis*-chlordane; %lipid = 4.5; %sed OC = 1.16

Summary of Biological Effects Tissue Concentrations for Chlordane

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Cyprinodon variegatus, Sheepshead minnow			909 mg/kg (whole body)	Mortality, ED35				[22]	L; exposure media 65% heptachlor (technical grade)
			1.2 mg/kg (whole body)[5]	Mortality, ED35				[22]	L; exposure media 65% heptachlor (technical grade)
			0.019 mg/kg (whole body)[5]	Mortality, ED5				[22]	L; exposure media 65% heptachlor (technical grade)
			0.01 mg/kg (whole body)[5]	Mortality, ED5				[22]	L; exposure media 65% heptachlor (technical grade)
			17.5 mg/kg (whole body)[5]	Mortality, ED50				[22]	L; exposure media 65% heptachlor (technical grade)
			2 mg/kg (whole body)[5]	Mortality, ED50				[22]	L; exposure media 65% heptachlor (technical grade)
			3.9 mg/kg (whole body)[5]	Mortality, ED60				[22]	L; exposure media 65% heptachlor (technical grade)
			32 mg/kg (whole body)[5]	Mortality, ED60				[22]	L; exposure media 65% heptachlor (technical grade)
			47 mg/kg (whole body)[5]	Mortality, ED85				[22]	L; exposure media 65% heptachlor (technical grade)
			6.1 mg/kg (whole body)[5]	Mortality, ED85				[22]	L; exposure media 65% heptachlor (technical grade)

Summary of Biological Effects Tissue Concentrations for Chlordane

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
Cyprinodon variegatus, Sheepshead minnow			281 mg/kg (whole body)[5]	Mortality, LOED				[23]	L; estimated LOED - no statistical summary in text
			3.18 mg/kg (whole body)[5]	Mortality, LOED				[23]	L
			3.18 mg/kg (whole body)[5]	Reproduction, LOED				[23]	L; hatching success of fry from exposed parents
			0.6 mg/kg (whole body)[5]	Mortality, NOED				[23]	L; estimated NOED - no statistical summary in text
			87 mg/kg (whole body)[5]	Mortality, NOED				[23]	L; estimated NOED - no statistical summary in text
			1.38 mg/kg (whole body)[5]	Mortality, NOED				[23]	L
			1.38 mg/kg (whole body)[5]	Reproduction, NOED				[23]	L; hatching success of fry from exposed parents
Lagodon rhomboides, Pinfish			16.6 mg/kg (whole body)[5]	Mortality, LOED				[23]	L; estimated LOED - no statistical summary in text
Leiostomus xanthurus, Spot			0.16 mg/kg (whole body)[5]	Mortality, ED25				[22]	L; exposure media 65% heptachlor (technical grade)

Summary of Biological Effects Tissue Concentrations for Chlordane

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.55 mg/kg (whole body)[5]	Mortality, ED25				[22]	L; exposure media 65% heptachlor (technical grade)
			0.89 mg/kg (whole body)[5]	Mortality, ED35				[22]	L; exposure media 65% heptachlor (technical grade)
			0.22 mg/kg (whole body)[5]	Mortality, ED35				[22]	L; exposure media 65% heptachlor (technical grade)
			3.3 mg/kg (whole body)[5]	Mortality, ED40				[22]	L; exposure media 65% heptachlor (technical grade)
			0.94 mg/kg (whole body)[5]	Mortality, ED40				[22]	L; exposure media 65% heptachlor (technical grade)
			1.6 mg/kg (whole body)[5]	Mortality, ED70				[22]	L; exposure media 65% heptachlor (technical grade)
			7.1 mg/kg (whole body)[5]	Mortality, ED70				[22]	L; exposure media 65% heptachlor (technical grade)
			0.7 mg/kg (whole body)[5]	Mortality, ED85				[22]	L; exposure media 65% heptachlor (technical grade)
			3.5 mg/kg (whole body)[5]	Mortality, ED85				[22]	L; exposure media 65% heptachlor (technical grade)
			0.01 mg/kg (whole body)[5]	Mortality, NOED				[22]	L; exposure media 65% heptachlor (technical grade)

Summary of Biological Effects Tissue Concentrations for Chlordane

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.01 mg/kg (whole body)[5]	Mortality, NOED				[22]	L; exposure media 65% heptachlor (technical grade)
			0.01 mg/kg (whole body)[5]	Mortality, NOED				[22]	L; exposure media 65% heptachlor (technical grade)
			0.01 mg/kg (whole body)[5]	Mortality, NOED				[22]	L; exposure media 65% heptachlor (technical grade)
Cottus cognatus, Slimy sculpin	2.1 ng/g	34 g/L	30 µg/kg			5.95	2.47	[18,20]	F; *trans*-chlordane, % lipid = 8
	77.8 µg/kg OC		375 µg/kg lipid				4.821	[20]	F; *trans*-chlordane; %lipid = 8; %sed OC = 2.70
Pimelodus albicans, Oligosarcus jenynsi, Prochilodus platensis	3.4 ng/g	0.8 ng/L	2.9 µg/g				20	[18,21]	F; median BSAFs calculated in [18] from field data in [21]
Prochilodus platensis, Curimata	20 µg/kg OC		4,600 µg/kg lipid				230	[21]	F; *trans*-chlordane; %lipid not reported; %sed OC = 1
Pimelodus albicans, Mandi	20 µg/kg OC		1,000 µg/kg lipid				50	[21]	F; *trans*-chlordane; %lipid not reported; %sed OC = 1

Summary of Biological Effects Tissue Concentrations for Chlordane

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Wildlife									
Ducks							0.83 19.5	[18,19]	F; median BSAFs calculated in [18] from field data in [19]

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
[4] BDL = Below detection limit.
[5] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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Chemical Category: PESTICIDE (ORGANOPHOSPHATE)

Chemical Name (Common Synonyms): CHLORPYRIFOS **CASRN:** 2921-88-2

Chemical Characteristics

Solubility in Water: 0.7 ppm at 20°C [1]

Half-Life: No data [2]

Log K_{ow}: 5.26 [3]

Log K_{oc}: 5.17 L/kg organic carbon

Human Health

Oral RfD: 3 x 10^{-3} mg/kg/day [4]

Confidence: Medium, uncertainty factor =10[4]

Critical Effect: Decreased plasma cholinesterase activity after 9 days of 20-day human feeding study

Oral Slope Factor): No data [4]

Carcinogenic Classification: No data [4], D[5]

Wildlife

Partitioning Factors: Partitioning factors for chlorpyrifos in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for chlorpyrifos in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: The only partitioning factors for chlorpyrifos in aquatic organisms found in the literature were log BCF of 3.23 for an isopod [14].

Food Chain Multipliers: Food chain multipliers for chlorpyrifos in aquatic organisms were not found in the literature.

Toxicity/Bioaccumulation Assessment Profile

Chlorpyrifos or Dursban is an organophosphorus insecticide which is used to control both adult and larval mosquitoes [6]. It is more toxic to nontarget organisms like cladocerans, amphipods, and other organisms than to mosquito larvae, however. The increase of chlorpyrifos concentration in water proportionally increased the bioconcentration factor in fish [7]. A low recovery (20 percent or lower) of chlorpyrifos from C-18 columns was attributed to its high binding affinity [8]. Also, acidic or basic conditions were not effective in reducing its concentration in water [9]. Because of the binding capacity and the high K_{ow}, chlorpyrifos does not remain in aqueous solution or suspension but is bound to the organic and clay fractions of sediments. The time for sediment-associated pesticides to degrade and reach nontoxic states is much greater than for aqueous phases [10]. The responses to chlorpyrifos from single-species tests were compared to responses observed in a field mesocosm [11]. The EC50 for seven species in the mesocosms ranged from 0.1 to 3.4 µg/L and were within the same order of magnitude as the laboratory data. Toxicity to the most sensitive test species, *D. magna* , at 1 µg/L was representative of sensitive indigenous species.

The results of toxicity tests exposing *Chironomus tentans* to sediments with differing organic carbon content spiked with chlorpyrifos revealed that an organic carbon partitioning model can be reasonably used to predict the toxicity of chlorpyrifos to benthic macroinvertebrates [12]. The TOC-normalized, solid-phase concentration of chlorpyrifos was no better predictor of the toxicity of the pesticide to *C. tentans* than the sediment dry-weight concentration of chlorpyrifos. The effects based on predicted pore-water concentrations were accurate to within a factor of two of expected effects based on water-only toxicity tests with the midge.

Distinct pulses of pesticides, including chlorpyrifos, were detected in the San Joaquin River and in the Sacramento River following rainfall events [13]. The results of short-term chronic tests with *Ceriodaphnia dubia* indicated that Sacramento River water at Rio Vista was acutely toxic for three consecutive days, while San Joaquin River water at Vernalis was toxic for 12 consecutive days.

Summary of Biological Effects Tissue Concentrations for Chlorpyrifos

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Invertebrates									
Mytilus galloprovincialis, Mediterranean mussel			42 mg/kg (whole body)[4]	Mortality, ED50				[19]	L; estimated from table 4
			4 mg/kg (whole body)[4]	Morphology, LOED				[19]	L; presence of functional byssus
			1.9 mg/kg (whole body)[4]	Morphology, NOED				[19]	
			4 mg/kg (whole body)[4]	Mortality, NOED				[19]	L; estimated from table 4
Asellus aquaticus, Isopod		0.7 µg/L 5.0 µg/L	140,000 µg/kg 260,000 µg/kg		3.23			[14]	F
Fishes									
Pimephales promelas, Fathead minnow			2 mg/kg (whole body)[4]	Growth, LOED				[21]	L; significant reduction in growth
			4.5 mg/kg (whole body)[4]	Morphology, LOED				[21]	L; body constriction behind opercula, shortening of caudal peduncle
			4.5 mg/kg (whole body)[4]	Mortality, LOED				[21]	L; significant reduction in survival

Summary of Biological Effects Tissue Concentrations for Chlorpyrifos

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			0.45 mg/kg (whole body)[4]	Physiological, LOED				[21]	L; inhibition of acetylcholinesterase (ACHE) activity
			4.5 mg/kg (whole body)[4]	Growth, NA				[21]	L; significant reduction in growth
			4.5 mg/kg (whole body)[4]	Physiological, NA				[21]	L; inhibition of acetylcholinesterase (ACHE) activity
			2 mg/kg (whole body)[4]	Physiological, NA				[21]	L; inhibition of acetylcholinesterase (ACHE) activity
			1.1 mg/kg (whole body)[4]	Physiological, NA				[21]	L; inhibition of acetylcholinesterase (ACHE) activity
			1.1 mg/kg (whole body)[4]	Growth, NOED				[21]	L; no effect on growth
			0.45 mg/kg (whole body)[4]	Growth, NOED				[21]	L; no effect on growth
			0.2 mg/kg (whole body)[4]	Growth, NOED				[21]	L; no effect on growth
			2 mg/kg (whole body)[4]	Morphology, NOED				[21]	L; no effect on appearance or development
			1.1 mg/kg (whole body)[4]	Morphology, NOED				[21]	L; no effect on appearance or development

Summary of Biological Effects Tissue Concentrations for Chlorpyrifos

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			0.45 mg/kg (whole body)[4]	Morphology, NOED				[21]	L; no effect on appearance or development
			0.2 mg/kg (whole body)[4]	Morphology, NOED				[21]	L; no effect on appearance or development
			2 mg/kg (whole body)[4]	Mortality, NOED				[21]	L; no effect on survival
			1.1 mg/kg (whole body)[4]	Mortality, NOED				[21]	L; no effect on survival
			0.45 mg/kg (whole body)[4]	Mortality, NOED				[21]	L; no effect on survival
			0.2 mg/kg (whole body)[4]	Mortality, NOED				[21]	L; no effect on survival
			0.2 mg/kg (whole body)[4]	Physiological, NOED				[21]	L; inhibition of acetylcholinesterase (ACHE) activity
Gambusia affinis, Mosquito fish			0.0352 mg/kg (whole body)[4]	Mortality, NOED				[22]	L; no effect on survivorship after 3 days
Poecilia reticulata, Guppy		0.9 µg/L 1.9 µg/L 3.9 µg/L 10 µg/L 19 µg/L 37 µg/L	6 µg/g lipid 33 µg/g lipid 66 µg/g lipid 350 µg/g lipid 710 µg/g lipid 2,100 µg/g lipid					[15]	L

Summary of Biological Effects Tissue Concentrations for Chlorpyrifos

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Poecilia reticulata, Guppy			2,810 mg/kg (whole body)[4]	Mortality, ED100				[18]	L; lifestage: 2-3 months
Gasterosteus aculeatus, Three-spined stickleback		0.12 µg/L 0.46 µg/L 1.0 µg/L	8.1 µg/g lipid 31.2 µg/g lipid 125 µg/g lipid					[16]	L
Cyprinodon variegatus, Sheepshead minnow		series 1 0.78µg/L 1.7 µg/L 3.0 µg/L 6.8 µg/L	 0.033 µg/g 0.22 µg/g 0.45 µg/g 4.8 µg/g					[17]	L (low feeding: 20 *Artemia*/fish/ feeding)
Cyprinodon variegatus, Sheepshead minnow		series 1 0.78µg/L 1.7 µg/L 3.0 µg/L 6.8 µg/L	 0.054 µg/g 0.12 µg/g 0.78 µg/g 2.9 µg/g					[17]	L (medium feeding: 110 *Artemia*/fish/ feeding)
		series 1 0.78µg/L 1.7 µg/L 3.0 µg/L 6.8 µg/L	 0.66 µg/g 0.19 µg/g 2.9 µg/g 7.3 µg/g					[17]	L (high feeding: 550 *Artemia*/ fish/feeding)
		series 2 3.1 µg/L 7.2 µg/L 14 µg/L 26 µg/L 52 µg/L	 0.67 µg/g 1.8 µg/g 4.3 µg/g 17 µg/g 34 µg/g					[17]	L (low feeding: 20 *Artemia*/fish/ feeding)

Summary of Biological Effects Tissue Concentrations for Chlorpyrifos

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
		series 2 3.1 µg/L 7.2 µg/L 14 µg/L 26 µg/L 52 µg/L	 0.82 µg/g 2.9 µg/g 5.5 µg/g 15.9 µg/g 52 µg/g					[17]	L (medium feeding: 110 *Artemia*/fish/ feeding)
		series 2 3.1 µg/L 7.2 µg/L 14 µg/L 26 µg/L 52 µg/L	 2.2 µg/g 5.3 µg/g 13.9 µg/g 37 µg/g 95 µg/g					[17]	L (high feeding: 550 *Artemia*/ fish/feeding)
Leuresthes tenuis, California grunion			0.21 mg/kg (whole body)[4]	Behavior, LOED				[23]	L; reduced activity
			0.038 mg/kg (whole body)[4]	Growth, LOED				[23]	L; significant reduction in weight of fry
			0.21 mg/kg (whole body)[4]	Growth, LOED				[23]	L; significant reduction in mean fish weight
			0.21 mg/kg (whole body)[4]	Morphology, LOED				[23]	L; fish appeared darker, abnormal lateral flexure of the back
			0.58 mg/kg (whole body)[4]	Mortality, LOED				[23]	L; nearly 40% reduction in fry survival
			0.39 mg/kg (whole body)[4]	Mortality, LOED				[23]	L; 38% reduction in fry survival

Summary of Biological Effects Tissue Concentrations for Chlorpyrifos

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.58 mg/kg (whole body)[4]	Growth, NA				[23]	L; significant reduction in weight of fry
			0.15 mg/kg (whole body)[4]	Behavior, NOED				[23]	L; no effect on behavior
			0.015 mg/kg (whole body)[4]	Growth, NOED				[23]	L; no effect on weight of fry
			0.15 mg/kg (whole body)[4]	Growth, NOED				[23]	L; no effect on growth
			0.15 mg/kg (whole body)[4]	Morphology, NOED				[23]	L; no effect on morphology
			0.015 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on fry mortality
			0.15 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on fry survival
			0.038 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on fry mortality
			0.21 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on fry survival
Opsanus beta, Gulf toadfish			770 mg/kg (whole body)[4]	Development, ED25				[20]	L; delayed development of 25% of sac fry
			12 mg/kg (whole body)[4]	Growth, ED25				[20]	L; 25% reduction in average weight of fry
			175 mg/kg (whole body)[4]	Growth, ED50				[20]	L; 50% reduction in average weight of fry

Summary of Biological Effects Tissue Concentrations for Chlorpyrifos

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			770 mg/kg (whole body)[4]	Behavior, LOED				[20]	L; hyperactivity, hyperventilation
			0.95 mg/kg (whole body)[4]	Growth, LOED				[20]	L; 9% reduction in fry weight
			770 mg/kg (whole body)[4]	Mortality, LOED				[20]	L; significant increase in fry mortality
			2.2 mg/kg (whole body)[4]	Growth, NA				[20]	L; 19% reduction in fry weight
			4.7 mg/kg (whole body)[4]	Growth, NA				[20]	L; 21% reduction in fry weight
			15 mg/kg (whole body)[4]	Growth, NA				[20]	L; 37% reduction in fry weight
			30 mg/kg (whole body)[4]	Growth, NA				[20]	L; 42% reduction in fry weight
			9.9 mg/kg (whole body)[4]	Growth, NA				[20]	L; 21% reduction in average weight of fry
			45 mg/kg (whole body)[4]	Growth, NA				[20]	L; 35% reduction in average weight of fry
			770 mg/kg (whole body)[4]	Growth, NA				[20]	L; 62% reduction in average weight of fry
			0.14 mg/kg (whole body)[4]	Growth, NOED				[20]	L; no effect on growth
			12 mg/kg (whole body)[4]	Mortality, NOED				[20]	L; no effect on fry mortality
			9.9 mg/kg (whole body)[4]	Mortality, NOED				[20]	L; no effect on fry mortality

Summary of Biological Effects Tissue Concentrations for Chlorpyrifos

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			45 mg/kg (whole body)[4]	Mortality, NOED				[20]	L; no effect on fry mortality
			175 mg/kg (whole body)[4]	Mortality, NOED				[20]	L; no effect on fry mortality

1 Concentration units based on wet weight unless otherwise noted.

2 BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.

3 L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.

4 This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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Chemical Category: METAL

Chemical Name (Common Synonyms): CHROMIUM (hexavalent) **CASRN:** 18540-29-9

Chemical Characteristics

Solubility in Water: Insoluble [1]

Half-Life: Not applicable, stable [1]

Log K_{ow}: –

Log K_{oc}: –

Human Health

Oral RfD: 5 x 10^{-3} mg/kg/day [2]

Confidence: Low, uncertainty factor = 500

Critical Effect: No effects observed (Currently under review by RfD/RfC Work Group)

Oral Slope Factor: Not available [2]

Carcinogenic Classification: A [2]

Wildlife

Partitioning Factors: Partitioning factors for chromium in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for chromium in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: In aqueous solutions, within a pH range of 6 to 8, hexavalent chromium is distributed between two species: monovalent hydrochromate anion and divalent chromate anion. Hexavalent chromium may account for 75 to 85 percent of the dissolved chromium while trivalent chromium is generally below detection limits in most oxic surface waters [3]. In some surface waters, as much as 10 to 15 percent of the dissolved chromium may be present in the colloidal/organic form. A log BCF of 2.74 was reported for *Daphia magna* [9].

Food Chain Multipliers: Little evidence exists for the bioaccumulation/biomagnification of chromium in aquatic food webs, although sediments frequently contain elevated concentrations of trivalent chromium [4].

Toxicity/Bioaccumulation Assessment Profile

Chromium appears to have limited mobility under typical conditions in most aquatic habitats because the trivalent form tends to bind to sediments. Plants can, however, bioaccumulate and reduce chromium.

Tissue residue-toxicity relationships can also be variable because organisms might sequester metal in various forms that might be analytically measurable as tissue residue but are actually stored in unavailable forms within the organism as a form of detoxification [5]. Whole body residues might also not be indicative of effects concentrations at the organ level because concentrations in target organs, such as the kidneys and liver, may be 20 times more than whole body residues [6]. The application of "clean" chemical analytical and sample preparation techniques is critical for the accurate measurement of metal tissue residues [7]. Accumulation of hexavalent chromium in the gills of rainbow trout was significantly higher at pH 6.5 than at 8.1 and is directly coupled with oxygen transfer, irrespective of exposure time or concentration [8]. The authors of that study suggested that chromium uptake might be related to the $HCr0_4$ to $Cr0_4$ ratio, whereby the monovalent hydrochromate anion is taken up more readily by the gill tissue.

Summary of Biological Effects Tissue Concentrations for Chromium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Invertebrates									
Mytilus galloprovincialis, Mussel			0.73-1.04 mg/kg				0.018	[13]	F
Daphnia magna, Cladoceran			Day 21: 1.1 mmol/kg	10% mortality	2.74			[9]	F
Xantho hydrophilus, Mud crab		1 µg/L	0.2 µg/g (whole body) 0.2 µg/g (hepatopancreas) 0.4 µg/g (gill) 0.05 µg/g (muscle)					[12]	F
Fishes									
Oncorhynchus mykiss (*Salmo gairdneri*), Rainbow trout		2.5 mg/L	Day 22: 171 µg/g (skin) 187 µg/g (muscle) 132 µg/g (gastro-intestinal) 49.8 µg/g (bone) 75.4 µg/g (kidney) 77.2 µg/g (blood) 41.4 µg/g (gill) 16.9 µg/g (fat) 27.3 µg/g (liver)					[10]	L
		10.0 µg/L 1.3 µg/L	133.6 µg/g 16.6 µg/g					[11]	L

Summary of Biological Effects Tissue Concentrations for Chromium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Oncorhynchus mykiss Salmo gairdneri), Rainbow trout		2.0 mg/L	2.0 µg/g (whole body) 31.7 µg/g (gill) 6.2 µg/g (digestive tract) 2.0 µg/g (liver) 6.7 µg/g (kidney)	100% survival				[8]	L; pH = 6.5
		2.0 mg/L	0.9 µg/g (whole body) 5.1 µg/g (gill) 7.4 µg/g (digestive tract) 3.4 µg/g (liver) 8.5 µg/g (kidney)	100% survival				[8]	L; pH = 7.8
		5.0 mg/L	5.5 µg/g (whole body) 51.8 µg/g (gill) 9.5 µg/g (digestive tract) 3.8 µg/g (liver) 10.7 µg/g (kidney)	100% survival				[8]	L; pH = 6.5
		5.0 mg/L	2.3 µg/g (whole body) 10.6 µg/g (gill) 11.2 µg/g (digestive tract) 5.1 µg/g (liver) 12.2 µg/g (kidney)	100% survival				[8]	L; pH = 7.8
		16.5 mg/L	8.7 µg/g (whole body) 139 µg/g (gill) 23.4 µg/g (digestive tract) 24.8 µg/g (liver) 43.2 µg/g (kidney)	25% survival				[8]	L; pH = 6.5

Summary of Biological Effects Tissue Concentrations for Chromium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Oncorhynchus mykiss (Salmo gairdneri), Rainbow trout		16.5 mg/L	8.9 µg/g (whole body) 35.3 µg/g (gill) 22.6 µg/g (digestive tract) 25.9 µg/g (liver) 24.6 µg/g (kidney)	63% survival				[8]	L; pH = 7.8
		50 mg/L		0% survival				[8]	L; pH = 6.5
		50 mg/L	10.5 µg/g (whole body) 37.6 µg/g (gill) 45.0 µg/g (digestive tract) 84.6 µg/g (liver) 70.3 µg/g (kidney)	50% survival				[8]	L; pH = 7.8
Oncorhynchus mykiss, Rainbow trout			45 mg/kg (digestive tract)[4]	Mortality, ED50				[14]	L; pH 7.8; increased mortality relative to control
			37.6 mg/kg (gill)[4]	Mortality, ED50				[14]	L; pH 7.8; increased mortality relative to control
			70.3 mg/kg (kidney)[4]	Mortality, ED50				[14]	L; pH 7.8; increased mortality relative to control
			85.6 mg/kg (liver)[4]	Mortality, ED50				[14]	L; pH 7.8; increased mortality relative to control

Summary of Biological Effects Tissue Concentrations for Chromium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			10.5 mg/kg (whole body)[4]	Mortality, ED50				[14]	L; pH 7.8; increased mortality relative to control
			23.4 mg/kg (digestive tract)[4]	Mortality, ED75				[14]	L; pH 6.5; increased mortality relative to control
			139 mg/kg (gill)[4]	Mortality, ED75				[14]	L; pH 6.5; increased mortality relative to control
			43.1 mg/kg (kidney)[4]	Mortality, ED75				[14]	L; pH 6.5; increased mortality relative to control
			24.8 mg/kg (liver)[4]	Mortality, ED75				[14]	L; pH 6.5; increased mortality relative to control
			8.7 mg/kg (whole body)[4]	Mortality, ED75				[14]	L; pH 6.5; increased mortality relative to control
			22.6 mg/kg (digestive tract)[4]	Mortality, NA				[14]	L; pH 7.8; increased mortality relative to control
			35.3 mg/kg (gill)[4]	Mortality, NA				[14]	L; pH 7.8; increased mortality relative to control

Summary of Biological Effects Tissue Concentrations for Chromium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			24.6 mg/kg (kidney)[4]	Mortality, NA				[14]	L; pH 7.8; increased mortality relative to control
			25.9 mg/kg (liver)[4]	Mortality, NA				[14]	L; pH 7.8; increased mortality relative to control
			8.9 mg/kg (whole body)[4]	Mortality, NA				[14]	L; pH 7.8; increased mortality relative to control
			9.5 mg/kg (digestive tract)[4]	Mortality, NOED				[14]	L; pH 6.5; no increased mortality relative to control
			11.2 mg/kg (digestive tract)[4]	Mortality, NOED				[14]	L; pH 7.8; no increased mortality relative to control
			51.8 mg/kg (gill)[4]	Mortality, NOED				[14]	L; pH 6.5; no increased mortality relative to control
			10.6 mg/kg (gill)[4]	Mortality, NOED				[14]	L; pH 7.8; no increased mortality relative to control
			10.7 mg/kg (kidney)[4]	Mortality, NOED				[14]	L; pH 6.5; no increased mortality relative to control

Summary of Biological Effects Tissue Concentrations for Chromium

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			12.2 mg/kg (kidney)[4]	Mortality, NOED				[14]	L; ph 7.8; no increased mortality relative to control
			3.8 mg/kg (liver)[4]	Mortality, NOED				[14]	L; pH 6.5; no increased mortality relative to control
			5.1 mg/kg (liver)[4]	Mortality, NOED				[14]	L; pH 7.8; no increased mortality relative to control
			5.5 mg/kg (whole body)[4]	Mortality, NOED				[14]	L; pH 6.5; no increased mortality relative to control
			2.3 mg/kg (whole body)[4]	Mortality, NOED				[14]	L; pH 7.8; no increased mortality relative to control

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
[4] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed and the reader is strongly urged to consult the publication to confirm the information presented here.

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Chemical Category: POLYNUCLEAR AROMATIC HYDROCARBON (high molecular weight)

Chemical Name (Common Synonyms): CHRYSENE **CASRN:** 218-01-9

Chemical Characteristics

Solubility in Water: 0.0020 mg/L at 25°C [1]

Half-Life: 1.02 yrs - 2.72 yrs based on aerobic soil die-away test data. [2]

Log K_{ow}: 5.70 [3]

Log K_{oc}: 5.60 L/kg organic carbon

Human Health

Oral RfD: No data [4]

Confidence: —

Critical Effect: —

Oral Slope Factor (Reference): Not available [4]

Carcinogenic Classification: B2 [4]

Wildlife

Partitioning Factors: Partitioning factors for chrysene in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for chrysene in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: Partitioning factors for chrysene in aquatic organisms were not found in the literature.

Food Chain Multipliers: Food chain multipliers for chrysene in aquatic organisms were not found in the literature. Log BAF values found in the literature ranged from -0.68 for the clam *Macoma nasuta* [7] to 4.31 for the amphipod *Pontoporeia hoyi* [9].

Toxicity/Bioaccumulation Assessment Profile

The results from the laboratory experiments performed by Harkey [5] indicated that accumulation of chrysene from elutriates was significantly lower than that from whole sediment, and the elutriate-sediment accumulations followed a downward curve over time. A similar curve was observed for pore water-to-sediment accumulation ratios. The concentrations of chrysene in whole sediment and pore water were 34.2 ng/g and 0.305 mg/mL, respectively [5]. Uptake rate coefficients for *Diporeia* spp. were highest in pore water (244.3 $\mu g/g_{oc}/h$) and lowest in elutriate (55.2 $\mu g/g_{oc}/h$). The authors concluded that aqueous extracts of whole sediment did not accurately represent the exposure observed in whole sediment [5]. The aqueous extracts of whole sediment underexposed organisms, compared to whole sediment, even after adjusting accumulation to the fraction of organic carbon contained in the test media. While the total chrysene concentration in the sediment stayed constant, total concentration decreased appreciably in pore water and elutriate over the course of the exposure, and it is likely that the bioavailability concentrations in these media also decreased. Benthic amphipods, *Gammarus pulex,* exposed to sediments containing polynuclear aromatic hydrocarbons (PAHs) and water spiked with sediment extract from PAH-contaminated sediment, accumulated chrysene in direct proportion to exposure concentrations [6].

Summary of Biological Effects Tissue Concentrations for Chrysene

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Invertebrates									
Macoma nasuta, Clam	7.4 ng/g		29 ng/g			-0.21		[7]	F
	5.9 ng/g		8.1 ng/g			-0.68		[7]	F
	50 ng/g		29.8 ng/g			-0.40		[7]	F
	41 ng/g		30 ng/g			-0.28		[7]	F
	174 ng/g		88 ng/g			-0.33		[7]	F
	249 ng/g		72 ng/g			-0.41		[7]	F
Diporeia spp., Amphipod	15 nmol/g		213 nmol/g					[8]	L
Diporeia spp., Amphipod			2.6 mg/kg (whole body)[4]	Mortality, NOED				[5]	L; no increase in mortality in 96 hours
Pontoporeia hoyi, Amphipod	50 ng/g	7 ng/mL	600 ng/g			4.31		[9]	L
	30 ng/g	1.5 ng/mL	180 ng/g					[9]	L

Summary of Biological Effects Tissue Concentrations for Chrysene

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Fishes									
Oncorhynchus mykiss, Rainbow trout			30 mg/kg (whole body)[4]	Physiological, LOED				[11]	L; induction of hepatic mixed function oxidases
Cyprinus carpio, Common carp			109 mg/kg (liver)[4]	Physiological, NA				[10]	L; significant increase in EROD enzyme and P450 1a protein content

1 Concentration units based on wet weight unless otherwise noted.
2 BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
3 L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
4 This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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Chemical Category: METAL

Chemical Name (Common Synonyms): COPPER **CASRN:** 7440-50-8

Chemical Characteristics

Solubility in Water: Insoluble [1]

Half-Life: Not applicable, stable [1]

Log K_{ow}: —

Log K_{oc}: —

Human Health

Oral RfD: Not available [2]

Confidence: —

Critical Effect: —

Oral Slope Factor: No data [2]

Carcinogenic Classification: D [2]

Wildlife

Partitioning Factors: Partitioning factors for copper in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for copper in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: Up to 29 different species of copper can be present in aqueous solution in the pH range from 6 to 9. Aqueous copper speciation and toxicity depend on the ionic strength of the water. The hydroxide species and free copper ions are mostly responsible for toxicity, while copper complexes consisting of carbonates, phosphates, nitrates, ammonia, and sulfates are weakly toxic or nontoxic. Copper in the aquatic environment can partition to dissolved and particulate organic carbon. The bioavailability of copper also can be influenced to some extent by total water hardness. Bioavailability of copper in sediments is controlled by the acid-volatile sulfide (AVS) concentration [12]. A log BCF of 3.77 was reported for the midge [4].

Food Chain Multipliers: Little evidence exists to support the general occurrence of biomagnification of copper in the aquatic environment [3]. Copper is taken up by aquatic organisms primarily through dietary exposure.

Toxicity/Bioaccumulation Assessment Profile

The free copper ions are the most bioavailable inorganic forms, although they might account for only a minor proportion of the total dissolved metal. The concentration of copper found in interstitial water is usually much lower than that in surface water. The amount of bioavailable copper in sediment is controlled in large part by the concentration of AVS and organic matter. A considerable number of aquatic species are sensitive to dissolved concentrations of copper in the range of 1-10 µg/L. Metal metabolism by aquatic biota has significant affects on metal accumulation, distribution in tissues, and toxic effects. Concentration of copper in benthic organisms from contaminated areas can be one to two orders of magnitude higher than normal. Copper is accumulated by aquatic organisms primarily through dietary exposure [3]. However, most organisms retain only a small proportion of the heavy metals ingested with their diet.

Rule and Alden [13] studied the relationship between uptake of cadmium and copper from the sediment by blue mussel (*Mytilus edulis*), grass shrimp (*Palaemonetes pugio*), and hard clam (*Mercenaria mercenaria*). The uptake of copper by all organisms was related only to copper concentration in sediment.

Summary of Biological Effects Tissue Concentrations for Copper

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Plants									
Eichhornia crassipes, Water Hyacinth			11.4 mg/kg (leaf)	Growth, LOED				[22]	L; reduced growth rate, chlorosis
			549 mg/kg (root)	Growth, LOED				[22]	L; reduced growth rate, chlorosis
			37.8 mg/kg (stem)	Growth, LOED				[22]	L; reduced growth rate, chlorosis
			11.4 mg/kg (leaf)	Morphology, LOED				[22]	L; chlorosis, browning, necrosis, waterlogging of tissues
			549 mg/kg (root)	Morphology, LOED				[22]	L; chlorosis, browning, necrosis, waterlogging of tissues
			37.8 mg/kg (stem)	Morphology, LOED				[22]	L; chlorosis, browning, necrosis, waterlogging of tissues
			13.8 mg/kg (leaf)	Growth, NA				[22]	L; reduced growth rate, chlorosis
			1,750 mg/kg (root)	Growth, NA				[22]	L; reduced growth rate, chlorosis
			74.4 mg/kg (stem)	Growth, NA				[22]	L; reduced growth rate, chlorosis

Summary of Biological Effects Tissue Concentrations for Copper									
Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			13.8 mg/kg (leaf)	Morphology, NA				[22]	L; chlorosis, browning, necrosis, waterlogging of tissues
			1,750 mg/kg (root)	Morphology, NA				[22]	L; chlorosis, browning, necrosis, waterlogging of tissues
			74.4 mg/kg (stem)	Morphology, NA				[22]	L; chlorosis, browning, necrosis, waterlogging of tissues
			4.6 mg/kg (leaf)	Growth, NOED				[22]	L; no effect on growth
			7.8 mg/kg (leaf)	Growth, NOED				[22]	L; no effect on growth
			20.8 mg/kg (root)	Growth, NOED				[22]	L; no effect on growth
			82.8 mg/kg (root)	Growth, NOED				[22]	L; no effect on growth
			10 mg/kg (stem)	Growth, NOED				[22]	L; no effect on growth
			15.2 mg/kg (stem)	Growth, NOED				[22]	L; no effect on growth
			4.6 mg/kg (leaf)	Morphology, NOED				[22]	L; no effect on plant appearance

Summary of Biological Effects Tissue Concentrations for Copper									
Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			7.8 mg/kg (leaf)	Morphology, NOED				[22]	L; no effect on plant appearance
			20.8 mg/kg (root)	Morphology, NOED				[22]	L; no effect on plant appearance
			82.8 mg/kg (root)	Morphology, NOED				[22]	L; no effect on plant appearance
			10 mg/kg (stem)	Morphology, NOED				[22]	L; no effect on plant appearance
			15.2 mg/kg (stem)	Morphology, NOED				[22]	L; no effect on plant appearance
Invertebrates									
Invertebrates field-collected	Total µg/g; SEM µg/g	Filt µg/L; Nonfilt µg/L	Body					[10]	F
	7,820; 6,971	79; 11,080	1,382 µg/g						
	583; 325	36; 698	122 µg/g						
	480; 287	16; 274	181 µg/g						
	478; 251	9; 184	266 µg/g						
	128; 77	9; 58	48 µg/g						
	16; <12	2; 35	26 µg/g						
Tubificidae	172 µg/g		17.14 mg/g					[9]	F
	185 µg/g		10.23 mg/g						
	175 µg/g		16.11 mg/g						
	125 µg/g		20.12 mg/g						
	130 µg/g		14.73 mg/g						

Summary of Biological Effects Tissue Concentrations for Copper

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Nereis diversicolor, Polychaete worm	41 µg/g		28 µg/g					[5]	L
	44 µg/g		22 µg/g						
	52 µg/g		33 µg/g						
	73 µg/g		31 µg/g						
	436 µg/g		106 µg/g						
	591 µg/g		257 µg/g						
	3,020 µg/g		1,142 µg/g						
Meretrix casta, Marine clam			201 mg/kg (whole body)[4]	Mortality, ED50				[25]	L; lethal body burden
Mytilus edulis, Mussel			67.4 mg/kg (whole body)[4]	Mortality, ED50				[21]	L; lethal body burden after 7 - 8 days
			67.4 mg/kg (whole body)[4]	Behavior, LOED				[21]	L; total valve closure, increased mucus production, reduced byssus production
			80 mg/kg (whole body)[4]	Mortality, ED100				[26]	L; lethal body burden
			36 mg/kg (whole body)[4]	Mortality, ED100				[26]	L; lethal body burden
			23 mg/kg (whole body)[4]	Mortality, ED100				[26]	L; lethal body burden
			15 mg/kg (whole body)[4]	Mortality, ED100				[26]	L; lethal body burden

Summary of Biological Effects Tissue Concentrations for Copper

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			12 mg/kg (whole body)[4]	Mortality, ED100				[26]	L; lethal body burden
			12 mg/kg (whole body)[4]	Mortality, ED100				[26]	L; lethal body burden
			12 mg/kg (whole body)[4]	Mortality, ED100				[26]	L; lethal body burden
			56 mg/kg (whole body)[4]	Mortality, ED100				[26]	L; lethal body burden
Mytilus galloprovincialis, Mussel			1.9-3.1 mg/kg				0.04	[14]	F
Dreissena polymorpha, Zebra mussel			8.1 mg/kg (whole body)[4]	Physiological; LOED				[24]	L; indicative of breakdown of internal Cu regulatory process
			2.7 mg/kg (whole body)[4]	Physiological, NOED				[24]	L; no effect on internal Cu regulatory process

Summary of Biological Effects Tissue Concentrations for Copper

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Elliptio complanata, Freshwater mussel	0.1-23.7 µg/g		5.4 µg/g (foot) 2.4 µg/g (muscle) 8.5 µg/g (visceral) 29.0 µg/g (hepatopancreas) 29.5 µg/g (gill) 17.6 µg/g (mantle)					[11]	F
	0.1-40.7 µg/g		5.4 µg/g (foot) 2.7 µg/g (muscle) 10.5 µg/g (visceral) 28.8 µg/g (hepatopancreas) 27.8 µg/g (gill) 11.8 µg/g (mantle)						
	0.2-106 µg/g		12.7 µg/g (foot) 11.7 µg/g (muscle) 16.5 µg/g (visceral) 44.5 µg/g (hepatopancreas) 214 µg/g (gill) 94 µg/g (mantle)						

Summary of Biological Effects Tissue Concentrations for Copper									
Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Elliptio complanata, Freshwater mussel	0.3-142 µg/g		13.1 µg/g (foot) 10.7 µg/g (muscle) 16.1 µg/g (visceral) 72.9 µg/g (hepatopancreas) 132 µg/g (gill) 81.7 µg/g (mantle)						
Unio pictorum, Freshwater mussel			6.5 mg/kg (digestive gland)[4]	Physiological; LOED				[24]	L; indicative of breakdown of internal Cu regulatory process
			10 mg/kg (gill)[4]	Physiological; LOED				[24]	L; indicative of breakdown of internal Cu regulatory process
			4.6 mg/kg (mantle)[4]	Physiological; LOED				[24]	L; indicative of breakdown of internal Cu regulatory process
			2.7 mg/kg (digestive gland)[4]	Physiological; NOED				[24]	L; no effect on internal Cu regulatory process

Summary of Biological Effects Tissue Concentrations for Copper

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			1.9 mg/kg (gill)[4]	Physiological; NOED				[24]	L; no effect on internal Cu regulatory process
			1.7 mg/kg (gonad)[4]	Physiological; NOED				[24]	L; no effect on internal Cu regulatory process
			4 mg/kg (gonad)[4]	Physiological; NOED				[24]	L; no effect on internal Cu regulatory process
			2 mg/kg (kidney)[4]	Physiological; NOED				[24]	L; no effect on internal Cu regulatory process
			3.7 mg/kg (kidney)[4]	Physiological; NOED				[24]	L; no effect on internal Cu regulatory process
			1.1 mg/kg (mantle)[4]	Physiological; NOED				[24]	L; no effect on internal Cu regulatory process

Summary of Biological Effects Tissue Concentrations for Copper

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Daphnia magna, Cladoceran			5.8 mg/kg (whole body)[4]	Reproduction, ED10				[7]	L; 10% reduction in number of offspring
			68 mg/kg (whole body)[4]	Mortality, ED50				[7]	L; lethal body burden after 21 day exposure
Hyalella azteca, Amphipod		7.7 µg/L	91 µg/g	54% survival				[6]	L
		10.7 µg/L	92 µg/g	50% survival					
		16.7 µg/L	95 µg/g	40% survival					
		25.4 µg/L	88 µg/g	29% survival					
		43.8 µg/L	80 µg/g	6% survival					
		81.3 µg/L	—	0% survival					
Hyalella azteca, Amphipod	Total µg/g · SEM µg/g	Filt µg/L · Nonfilt µg/L	Body;					[10]	F
	7,820 · 6,971	79 · 11,080	249 µg/g						
	583 · 325	36 · 698	87 µg/g						
	480 · 287	16 · 274	124 µg/g						
	478 · 251	9 · 184	127 µg/g						
	128 · 77	9 · 58	124 µg/g						
	16 · <12	2 · 35	84 µg/g						

Summary of Biological Effects Tissue Concentrations for Copper

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Corophium volutator, Amphipod			16.9 mg/kg (whole body)[4]	NA, LOED				[18]	L; 100% dissolved oxygen saturation during test
Balanus crenatus, Barnacle			80 mg/kg (whole body)[4]	Behavior, NOED				[29]	L; regulation of metals endpoint-summer experiment
Orconectes rusticus, Crayfish			24 mg/kg (abdomen)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			26 mg/kg (abdomen)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			32 mg/kg (abdomen)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			42 mg/kg (abdomen)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			52 mg/kg (abdomen)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			17.8 mg/kg (claw)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			24 mg/kg (claw)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			24 mg/kg (claw)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			30 mg/kg (claw)[4]	Mortality, NOED				[19]	L; no effect on survivorship

Summary of Biological Effects Tissue Concentrations for Copper

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			34 mg/kg (claw)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			42 mg/kg (thorax)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			50 mg/kg (thorax)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			56 mg/kg (thorax)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			60 mg/kg (thorax)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			70 mg/kg (thorax)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			2 mg/kg (whole body)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			9 mg/kg (whole body)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			11.2 mg/kg (whole body)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			19.2 mg/kg (whole body)[4]	Mortality, NOED				[19]	L; no effect on survivorship
			26 mg/kg (whole body)[4]	Mortality, NOED				[19]	L; no effect on survivorship

Summary of Biological Effects Tissue Concentrations for Copper

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
Chironomus riparius, Midge		0.087 mg/L	500 µg/g		3.77			[4]	F
Chironomus thummi, Midge	12.55 mg/kg		35.7 mg/kg 39.7 mg/kg	Normal larvae Deformed larvae				[8]	F
Chironomus decorus, Midge			1,000 mg/kg (whole body)[4]	Mortality, ED100				[23]	L; 100% mortality
			142 mg/kg (whole body)[4]	Mortality, ED50				[23]	L; ED50
			107 mg/kg (whole body)[4]	Mortality, LOED				[23]	L; significant mortality
			126 mg/kg (whole body)[4]	Mortality, LOED				[23]	L; significant mortality
			86.2 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on mortality
			130 mg/kg (pupal exuviae)[4]	Development, LOED				[23]	L; increased time to adult emergence by 10 days
			18 mg/kg (whole body)[4]	Development, LOED				[23]	L; increased time to adult emergence by 10 days
			14.8 mg/kg (pupal exuviae)[4]	Development, NOED				[23]	L; no effect on time to adult emergence

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			75.6 mg/kg (pupal exuviae)[4]	Development, NOED				[23]	L; no effect on time to adult emergence
			2.28 mg/kg (whole body)[4]	Development, NOED				[23]	L; no effect on time to adult emergence
			7.2 mg/kg (whole body)[4]	Development, NOED				[23]	L; no effect on time to adult emergence
			13 mg/kg (whole body)[4]	Development, NOED				[23]	L; no effect on time to adult emergence
			7.14 mg/kg (whole body)[4]	Morphology, NOED				[8]	L; 4th instar larvae
Fishes									
Oncorhynchus mykiss, Rainbow trout			40 mg/kg (whole body)[4]	Physiological; LOED				[16]	L; induction of metallothionein
			1.6 mg/kg (whole body)[4]	Mortality, ED100				[17]	L; 100% mortality in non-metallo-thionein-induced fish
			6.8 mg/kg (whole body)[4]	Physiological, LOED				[17]	L; induction of metallothionein
			2.22 mg/kg (whole body)[4]	Mortality, LOED				[20]	L; 50% mortality in 7 hours

Summary of Biological Effects Tissue Concentrations for Copper

Summary of Biological Effects Tissue Concentrations for Copper

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			4.48 mg/kg (whole body)[4]	Survival, LOED				[27]	L
			3.92 mg/kg (whole body)[4]	Not applicable, NOED				[27]	L
Pimephales promelas, Fathead minnow	78.9 µg/g		10.28 mg/g					[9]	F
	110 µg/g		9.32 mg/g						
	125 µg/g		9.13 mg/g						
	130 µg/g		9.70 mg/g						
	130 µg/g		9.86 mg/g						
	172 µg/g		6.92 mg/g						
	175 µg/g		7.28 mg/g						
	175 µg/g		10.96 mg/g						
	185 µg/g		9.37 mg/g						
Cyprinus carpio, Common carp			12.1 mg/kg (whole body)[4]	Morphology, LOED				[29]	L; larval deformation, pH 6.3, body burden from graph
			12.1 mg/kg (whole body)[4]	Morphology, LOED				[29]	L; larval deformation, pH 7.6, body burden from graph
			12.1 mg/kg (whole body)[4]	Mortality, LOED				[29]	L; larval mortality, pH 6.3, body burden from graph

Summary of Biological Effects Tissue Concentrations for Copper

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			12.1 mg/kg (whole body)[4]	Mortality, LOED				[29]	L; larval mortality, pH 7.6, body burden from graph
			24.1 mg/kg (whole body)[4]	Reproduction, LOED				[29]	L; egg mortality, pH 6.3, body burden from graph
			7.62 mg/kg (whole body)[4]	Morphology, NOED				[29]	L; larval deformation, pH 7.6, body burden from graph
			7.62 mg/kg (whole body)[4]	Mortality, NOED				[29]	L; larval mortality, pH 7.6, body burden from graph
			12.1 mg/kg (whole body)[4]	Reproduction, NOED				[29]	L; egg mortality, pH 7.6, body burden from graph
			12.1 mg/kg (whole body)[4]	Reproduction, NOED				[29]	L; egg mortality, pH 6.3, body burden from graph
Lepomis macrochirus, Bluegill			13 mg/kg (gill)[4]	Growth, LOED				[15]	L; duration = 22 months or 660 days

Summary of Biological Effects Tissue Concentrations for Copper

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			44 mg/kg (kidney)[4]	Growth, LOED				[15]	L; duration = 22 months or 660 days
			480 mg/kg (liver)[4]	Growth, LOED				[15]	L; duration = 22 months or 660 days
			13 mg/kg (gill)[4]	Mortality, LOED				[15]	L; duration = 22 months or 660 days
			44 mg/kg (kidney)[4]	Mortality, LOED				[15]	L; duration = 22 months or 660 days
			480 mg/kg (liver)[4]	Mortality, LOED				[15]	L; duration = 22 months or 660 days
			13 mg/kg (gill)[4]	Reproduction, LOED				[15]	L; duration = 22 months or 660 days
			44 mg/kg (kidney)[4]	Reproduction, LOED				[15]	L; duration = 22 months or 660 days
			480 mg/kg (liver)[4]	Reproduction, LOED				[15]	L; duration = 22 months or 660 days
			6 mg/kg (gill)[4]	Growth, NOED				[15]	L; duration = 22 months or 660 days
			12 mg/kg (kidney)[4]	Growth, NOED				[15]	L; duration = 22 months or 660 days

Summary of Biological Effects Tissue Concentrations for Copper

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			57 mg/kg (liver)[4]	Growth, NOED				[15]	L; duration = 22 months or 660 days
			6 mg/kg (gill)[4]	Mortality, NOED				[15]	L; duration = 22 months or 660 days
			12 mg/kg (kidney)[4]	Mortality, NOED				[15]	L; duration = 22 months or 660 days
			57 mg/kg (liver)[4]	Mortality, NOED				[15]	L; duration = 22 months or 660 days
			6 mg/kg (gill)[4]	Reproduction, NOED				[15]	L; duration = 22 months or 660 days
			12 mg/kg (kidney)[4]	Reproduction, NOED				[15]	L; duration = 22 months or 660 days
			57 mg/kg (liver)[4]	Reproduction, NOED				[15]	L; duration = 22 months or 660 days

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
[4] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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