United States
Environmental Protection
Agency

Office of Water
Regulations and Standards
Criteria and Standards Division
Washington DC 20460

440586009

Water

EPA

# Ambient Water Quality Criteria for

# Pentachlorophenol - 1986

# AMBIENT AQUATIC LIFE WATER QUALITY CRITERIA FOR

# PENTACHLOROPHENOL

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## NOTICES

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# FOREWORD

Section 304(a)(1) of the Clean Water Act of 1977 (P.L. 95-217) requires the Administrator of the Environmental Protection Agency to publish water quality criteria that accurately reflect the latest scientific knowledge on the kind and extent of all identifiable effects on health and welfare that might be expected from the presence of pollutants in any body of water, including ground water. This document is a revision of proposed criteria based upon consideration of comments received from other Federal agencies, State agencies, special interest groups, and individual scientists. Criteria contained in this document replace any previously published EPA aquatic life criteria for the same pollutant(s).

The term "water quality criteria" is used in two sections of the Clean Water Act, section 304(a)(1) and section 303(c)(2). The term has a different program impact in each section. In section 304, the term represents a non-regulatory, scientific assessment of ecological effects. Criteria presented in this document are such scientific assessments. If water quality criteria associated with specific stream uses are adopted by a State as water quality standards under section 303, they become enforceable maximum acceptable pollutant concentrations in ambient waters within that State. Water quality criteria adopted in State water quality standards could have the same numerical values as criteria developed under section 304. However, in many situations States might want to adjust water quality criteria developed under section 304 to reflect local environmental conditions and human exposure patterns before incorporation into water quality standards. It is not until their adoption as part of State water quality standards that criteria become regulatory.

Guidelines to assist States in the modification of criteria presented in this document, in the development of water quality standards, and in other water-related programs of this Agency, have been developed by EPA.

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ACKNOWLEDGMENTS

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## Introduction*

Pentachlorophenol (PCP) and its sodium salt, sodium pentachlorophenate (NaPCP), are collectively the second most heavily used pesticide in the United States (Cirelli 1978). The principal uses of PCP and NaPCP are in the treatment of various wood products and as a wide-spectrum fungicide and bactericide. PCP** has been found in fresh and salt water at ng/L to mg/L concentrations (Buhler et al. 1973; Fountaine et al. 1976, Fox and Joshi 1984; Murray et al. 1981; Pierce 1978; Pierce et al. 1977; Renberg et al. 1983) with higher concentrations associated with point discharges. PCP has also been found in tissues of fish (De Vault 1985; Kuehl et al. 1980; Paasivirta et al. 1980,1983; Pierce 1978; Pierce et al. 1977; Veith et al. 1981; Zitko et al. 1974), in plankton, invertebrates, and sediment (DeLaune et al. 1983; Murray et al. 1980, Paasivirta et al. 1980; Pierce 1978; Pierce et al. 1977; Ray et al. 1983), and in humans (Bevenue et al. 1967; Dougherty 1978; Dougherty et al. 1980; Kuehl et al. 1980).

Several impurities are present in commercial-grade PCP, including lower chlorinated phenols (e.g., tetrachlorophenols) and chlorinated dibenzodioxins, dibenzofurans, diphenylethers, and 2-phenoxyphenols (Ahlborg and Thunberg 1980; Nilsson et al. 1978). The highly toxic 2,3,7,8-tetrachlorodibenzo-p-dioxin has not been found in PCP or NaPCP, and due to the methods of synthesis, is not expected to occur (Ahlborg

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* An understanding of the "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses" (Stephan et al. 1985), hereafter referred to as the Guidelines, and the response to public comment (U.S. EPA 1985a) is necessary in order to understand the following text, tables, and calculations.

** "PCP" is often used in the text to refer to the total amount of un-ionized pentachlorophenol and the pentachlorophenate ion that occurs in water regardless of whether PCP or NaPCP was initially added to water.

and Thunberg 1980). Cleveland et al. (1982) reported that a composite of three commercial PCP formulations contained much higher concentrations of hepta-, octa- and nonachlorophenoxyphenols, heptachlorodibenzodioxin, octachlorodibenzodioxin, and octachlorodibenzofuran, and was more toxic to fish, than either purified PCP (99% PCP) or Dowicide EC-7 (91% PCP). Dowicide EC-7 contained less of the hepta-, octa- and nonachlorophenoxyphenols than purified PCP, and was less toxic than purified PCP. Although the toxicities of the individual impurities are unknown and their concentrations apparently vary from batch to batch of PCP, Dowicide EC-7 seems to be an acceptable source of PCP for toxicity and bioconcentration tests. A more recent study has shown that ultrapure PCP is considerably less toxic than a mixture of the major impurities in commercial PCP, consisting mainly of octa- and nonachlorophenoxyphenols (Hamilton et al. 1986). Data concerning PCP should be reassessed as more information becomes available regarding the toxicities of various grades of PCP and their impurities to various species and the composition of the PCP that is produced, used, and discharged.

The toxicity of PCP to animals is due to the uncoupling of oxidative phosphorylation in the mitochondria (Ishak et al. 1970; Weinbach 1954,1956) and resultant reduced production of ATP. This is accompanied by an acceleration of metabolic rate and the utilization of tissue energy reserves, causing loss of weight (Cantelmo et al. 1978; Holmberg et al. 1972; Rao et al. 1979). Activities of various enzymes are also affected by PCP (Bostrom and Johansson 1972; Holmberg et al. 1972; Rao et al. 1979).

PCP is a weak acid with a pKa of about $10^{-5}$ (Blackman et al. 1955; Callahan et al. 1979; Cessna and Grover 1978; Mrak 1974). Consequently, its toxicity and potential for uptake by organisms are pH-dependent (Crandall and Goodnight 1959; Kobayashi and Kishino 1980; Saarikoski and

Viluksela 1981; Spenar et al. 1985). Both bioconcentration and toxicity increase as pH decreases, due to the greater penetration of cell membranes by un-ionized PCP molecules than by the pentachlorophenate ion. Transfer of PCP from water to fish is considered to be mainly by passive diffusion of the un-ionized form across the gill membrane (Kishino and Kobayashi 1980).

Unless otherwise noted, all concentrations reported herein are expressed as pentachlorophenol, not as the material tested. The criteria presented herein supersede previous aquatic life water quality criteria for PCP (U.S. EPA 1980) because these new criteria were derived using improved procedures and additional information. Whenever adequately justified, a national criterion may be replaced by a site-specific criterion (U.S. EPA 1983a), which may include not only site-specific criterion concentrations (U.S. EPA 1983b), but also site-specific durations of averaging periods and site-specific frequencies of allowed excursions (U.S. EPA 1985b). The latest comprehensive literature search for information for this document was conducted in July, 1986; some more recent information might have been included.

## Acute Toxicity to Aquatic Animals

The acute toxicity of PCP to freshwater fish depends on the life stage of the fish and the pH, temperature, and concentration of dissolved oxygen in the water. Van Leeuwen et al. (1985) found that fry of rainbow trout were much more sensitive than embryos. PCP was more toxic to the fathead minnow (Crandall and Goodnight 1959) and to a nonresident fish, *Notopterus notopterus*, (Gupta et al. 1983b) at higher temperatures. Also, Goodnight (1942) observed that fish succumbed more rapidly at higher temperatures (28-30°C) than at cooler temperatures (9-24°C). Acute toxicity to *Notopterus*

notopterus increased with a decrease in the concentration of dissolved oxygen (Gupta et al. 1983a).

Of the variables studied, however, pH is the only one for which quantitative data are available for a variety of freshwater species. The acute value increases and toxicity decreases as pH increases. An analysis of covariance (Dixon and Brown 1979; Neter and Wasserman 1974) was performed using the natural logarithm of the acute value as the dependent variable, species as the treatment or grouping variable, and pH as the covariate or independent variable. This analysis of covariance model was fit to the data in Table 1 for the five freshwater species for which acute values are available over a range of pH. The slopes for all five species are between 0.67 and 1.2 (see end of Table 1). An F-test showed that, under the assumption of equality of slopes, the probability of obtaining five slopes as dissimilar as these is P = 0.28. This was interpreted as indicating that it is not unreasonable to assume that the slopes for the five species are the same.

The pooled slope of 1.005 was used with the data in Table 1 to adjust the acute values to pH = 6.5, where possible. Species Mean Acute Values were calculated as geometric means of the adjusted acute values, and Genus Mean Acute Values at pH = 6.5 (Table 3) were then calculated as geometric means of the available freshwater Species Mean Acute Values. Acute values are available for more than one species in each of three genera and the range of Species Mean Acute Values within each genus is less than a factor of 2.3. Of the 33 genera for which acute values are available, the most sensitive genus, Cyprinus, was over 10,000 times more sensitive than the most resistant, Orconectes. The freshwater Final Acute Value (FAV) for PCP at pH = 6.5 was calculated to be 10.97 μg/L using the procedure

described in the Guidelines and the Genus Mean Acute Values in Table 3. The only Species Mean Acute Value that is lower than the FAV is that for the common carp, Cyprinus carpio. The freshwater Criterion Maximum Concentration (in µg/L) = $e^{[1.005(pH)-4.830]}$.

Tests of the acute toxicity of PCP to resident North American saltwater animals have been performed with 13 species of invertebrates and five species of fish (Table 1). The range of acute values for invertebrates extends from 36.95 µg/L for embryos of the American oyster, Crassostrea virginica (Borthwick and Schimmel 1978) to 18,000 µg/L for the adult stage of the blue mussel, Mytilus edulis (Adema and Vink 1981). The range of acute values for saltwater fish is narrower, extending from 22.63 µg/L for late yolk-sac larvae of the Pacific herring, Clupea harengus pallasi (Vigers et al. 1978) to 442 µg/L for juvenile sheepshead minnow, Cyprinodon variegatus (Parrish et al. 1978). Fish appear to be generally more sensitive than invertebrates to PCP.

Embryos and larvae of the polychaete worm, Ophryotrocha diadema, and the mussel, Mytilus edulis, were more sensitive to PCP than adults of the same species (Adema and Vink 1981; Woelke 1972). Tests with Pacific herring, Clupea harengus pallasi, (Vigers et al. 1978) and the nonresident plaice, Pleuronectes platessa, (Adema and Vink 1981) revealed that sensitivity to PCP increases between the newly hatched yolk-sac larval stage and the late larval premetamorphosis stage. Juveniles and adults are slightly less sensitive than larvae.

Environmental factors, such as temperature, pH, and salinity, might have an effect on the acute toxicity of PCP to some saltwater animals. With the oligochaete worms, Limnodriloides verrucosus and Monophelephorus cuticulatus, sensitivity to PCP increased somewhat between 1°C and 10°C

at pH = 7, and between pH = 6 and pH = 8 at a temperature of 10°C (Chapman et al. 1982b). Larvae of the blue mussel, Mytilus edulis, were more sensitive to PCP at a salinity of 24 g/kg than at a salinity of 28 g/kg (Dimick and Breese 1965; Woelke 1972).

With some saltwater crustaceans, the stage of the molt cycle also seems to affect sensitivity to PCP. Late premolt and molting grass shrimp, Palaemonetes pugio, were more than five times as sensitive to PCP as intermolt animals (Conklin and Rao 1978a,b; Rao and Doughtie 1984). This effect was attributed to the greater permeability of the integument of the shrimp during molting.

Of the 17 saltwater genera for which acute values are available, the most sensitive genus, Clupea, is more than 247 times more sensitive than the most resistant, Crepidula (Table 3). The four most sensitive genera include two fish and two invertebrates and the range of the four Genus Mean Acute Values is a factor of 3.5. The saltwater Final Acute Value calculated from the values in Table 3 is 25.05 µg/L, which is very close to the acute value for the most sensitive tested saltwater species.

## Chronic Toxicity to Aquatic Animals

Of the freshwater species with which chronic tests have been conducted on PCP, the cladoceran, Ceriodaphnia reticulata, is the most sensitive (Table 2), with a reduction in offspring occurring at 4.1 µg/L, the lowest concentration tested (Hedtke et al. 1986). Production of embryos by the snail, Physa gyrina, was reduced at a PCP concentration of 26 µg/L, the lowest concentration tested (Hedtke et al. 1986). A chronic value of 240 µg/L for Daphnia magna was based upon mortality (Adema 1978). Similarly, survival was the endpoint that determined the chronic values of 177 and 221 µg/L for Simocephalus vetulus (Hedtke et al. 1986).

Significant increases in mortality and decreases in length and weight occurred among rainbow trout at 19 μg/L after a 72-day exposure (Dominguez and Chapman 1984), but the trout were not affected at 11 μg/L. Dominguez and Chapman used a pure form of PCP (99+%) and found that yolk sac edema and cranial malformations were rare as compared to their more common incidences in studies with technical-grade PCP.

Several studies with the fathead minnow in the pH range from 6.5 to 8.5 resulted in chronic values from 24 to 144 μg/L (Table 2). Spehar et al. (1985) studied the relationship between pH and chronic toxicity, and obtained chronic values of 24, 40, 49, and 89 μg/L at pH = 6.5, 7.5, 8.0, and 8.5, respectively. A linear regression of ln(chronic value) on pH resulted in a slope of 0.6174. This slope is similar to the slope of 0.6782 obtained by the same investigators in an acute toxicity study with the fathead minnow. However, because data are available for chronic toxicity versus pH for only one species, the acute pooled slope of 1.005 was also applied to the freshwater chronic data in Table 2, where possible, to adjust the chronic values to pH = 6.5, to allow a comparison of freshwater chronic values at a common pH.

The long-term sublethal toxicity of PCP to fish has been shown to be affected by temperature and concentration of dissolved oxygen (Table 6). Newly hatched rainbow trout were affected more at 6°C than at 10°C, whereas after yolk sac sorption, a greater effect on growth occurred at 20°C than at 12°C (Hodson and Blunt 1981). They concluded that, if these laboratory data were applied in the field to wild trout populations, temperature effects on PCP toxicity would be greatest both during embryo development and subsequent growth of young trout.

Decreased concentrations of dissolved oxygen in the water increased the toxicity of PCP to young rainbow trout (Chapman and Shumway 1978). After a 24-day exposure to 37 µg/L, alevins reared at dissolved oxygen concentrations of 3, 5, and 10 mg/L suffered 76, 20, and 7% mortality, respectively. Also, the time required for trout to attain maximum growth was prolonged at the two lower concentrations of dissolved oxygen.

Usable data, according to the Guidelines, on the chronic toxicity of PCP are available for only two saltwater species, the polychaete worm, Ophryotrocha diadema, (Table 6) and the sheepshead minnow, Cyprinodon variegatus, (Table 2). Test populations of Ophryotrocha diadema were exposed to PCP in a renewal life-cycle test extending from 2 to 3-day-old larvae to two-week-old second generation larvae (Hooftman and Vink 1980). The most sensitive effect was an apparent inhibition of reproduction at 11 µg/L. This value was not used in Table 2 because the authors did not report any statistical analyses of the data. A complete life-cycle test was conducted with the sheepshead minnow, Cyprinodon variegatus (Parrish et al. 1978). The most sensitive effect was decreased long-term survival of the first generation fish at 88 µg/L. At 195 µg/L, survival of second generation embryos and juveniles was reduced.

The seven available Species Mean Acute-Chronic Ratios range from 0.8945 to over 15.79 (Table 3), but the two highest values are both "greater than" values and were obtained with two freshwater species that are much more acutely resistant than the other four freshwater species. Therefore, the Final Acute-Chronic Ratio of 3.166 was calculated as the geometric mean of the five Species Mean Acute-Chronic Ratios ranging from 0.8945 to 6.873. When this ratio is used with the freshwater Final Acute Value and the pooled slope for the pH-toxicity relationship (Table 3), the resulting

freshwater Final Chronic Value (in µg/L) = $e^{[1.005(pH)-5.290]}$. Division of the saltwater Final Acute Value by the Final Acute-Chronic Ratio results in a saltwater Final Chronic Value of 7.912 µg/L. This is about a factor of 8 below the only available saltwater chronic value, but no chronic test on PCP has been conducted with any of the 13 acutely most sensitive saltwater species.

Toxicity to Aquatic Plants

Freshwater plants are sensitive to PCP over a range of concentrations from 7.5 to 3,200 µg/L (Tables 4 and 6). Blackman et al. (1955) observed that the degree of chlorosis in a 48-hr exposure of *Lemna minor* was very sensitive to small changes in PCP concentrations. Only a slight concentration increase was required to induce 50% chlorosis in all of the duckweed fronds as compared to 50 % induction in none of the fronds. In a prolonged exposure of the vascular plant, *Elodea canadensis*, significant biomass reductions occurred at progressively lower concentrations of PCP as duration of exposure increased (Hedtke et al. 1986). Biomass reductions were detected at 1,440 µg/L after 7 days, 810 µg/L after 14 days, and 380 µg/L after 21 days (Table 6). Biomass was not affected at any time by the next lower concentration of 230 µg/L. In contrast, neither reduced frond production nor chlorosis was observed in *Lemna minor* at the highest PCP concentration of 1,440 µg/L (Hedtke et al. 1986). The river water used in both of these tests might have had some effect upon the results.

Complete destruction of chlorophyll in *Chlorella pyrenoidosa* occurred at a PCP concentration of 7.5 µg/L (Huang and Gloyna 1967). In a 7-day study with *Selenastrum capricornutum*, cell numbers and population growth rates were significantly reduced by 50 µg/L, but were not affected by 10

µg/L (Adams et al. 1985). Concentrations near 300 µg/L resulted in 50% reductions of Selenastrum populations in two separate studies (Crossland and Wolff 1985; Richter 1982). The 4-day EC50 for Scenedesmus subspicatus was 90 µg/L (Geyer et al. 1985).

Usable data on the toxicity of PCP to saltwater plants are available for eight phytoplankters, one macroalgal species, and one vascular plant (Table 4). The 96-hr EC50s, based on reduction of cell population growth, range from 17.40 µg/L for the diatom, Skeletonema costatum (Walsh et al. 1982) to 3,600 µg/L for the green alga, Dunaliella tertiolecta (Adema and Vink 1981). Giant kelp, Macrocystis pyrifera, and seagrass, Thalassia testudinum, are about as sensitive as the phytoplankters. The range of sensitivities of saltwater plants to PCP is similar to that for saltwater animals and, therefore, a criterion that protects saltwater animals will probably also protect saltwater plants.

Bioaccumulation

Bioconcentration of PCP from water, like toxicity, has been shown to be inversely related to pH (Kobayashi and Kishino 1980; Spehar et al. 1985). PCP bioconcentrated in the tissues of fish from 7.3 to 1,066 times (Table 5), with test durations from 16 to 115 days. The gall bladder concentrated the highest levels of PCP (Glickman et al. 1977, Kobayashi and Akitake 1975b, McKim et al., Manuscript), whereas muscle and skin contained the lowest concentrations of PCP in rainbow trout exposed to 0.78 to 1.15 µg/L (McKim et al., Manuscript). The lowest bioconcentration factor (BCF) of 7.3 was obtained in bluegill muscle (Pierce 1978; Pruitt et al. 1977). BCFs of 320 and 378 were estimated from uptake and depuration rates using the rainbow trout (McKim et al., Manuscript) and the non-resident killifish, Oryzias latipes (Sugiura et al. 1984).

Residues of PCP in fish drop quite rapidly upon termination of exposure. Ninety-six percent of whole body $^{14}C$-labelled PCP was eliminated by fathead minnows within 3.5 days (Huckins and Petty 1983), whereas about 85 percent of the PCP residues in bluegill muscle were eliminated in 4 days (Pruitt et al. 1977). A first-order simulation model developed from empirical data indicated a half-life of 2.7 days in rainbow trout, with 95% elimination in 11.7 days (McKim et al., Manuscript).

McKim et al. (1985) studied the efficiency of chemical uptake by rainbow trout gills using 14 different chemicals including PCP. They found that PCP was in a group of chemicals, all with log n-octanol/water partition coefficients (log P) between 2.84 and 6.18, that were taken up more efficiently by gills than chemicals with either lower or higher partition coefficients. The rate of elimination of the chemicals in this log P range largely determined their BCFs. In this range, the elimination rates decreased as log P increased. PCP, with a log P of 3.32, would be expected to be eliminated quite readily. Indeed, this has been shown, as indicated above.

Several studies have shown that PCP is conjugated with glucuronic acid in fish (Huckins and Petty 1983; Kobayashi 1978,1979; Kobayashi and Nakamura 1979b; Kobayashi et al. 1977; Lech et al. 1978). Reduced glucuronidation occurred in fathead minnows exposed to industrial PCP, as compared to purified PCP, and it was suggested that this might play a role in the elevated toxicity of the impure form (Huckins and Petty 1983). Pentachlorophenylsulfate has been found in goldfish exposed to PCP (Akitake and Kobayashi 1975; Kobayashi 1978,1979; Kobayashi and Nakamura 1979a,b; Kobayashi et al. 1984), but not in rainbow trout (Lech et al. 1978) or fathead minnows (Huckins and Petty 1983).

Probable steady-state BCFs for PCP are available for the eastern oyster, Crassostrea virginica (Schimmel and Garnas 1985; Schimmel et al. 1978), the sheepshead minnow, Cyprinodon variegatus (Parrish et al. 1978) and the longnose killifish, Fundulus similis (Trujillo et al. 1982). In tests with oysters, the steady-state BCF ranged from 34 to 82, and was reached in 14 to 96 hours. In a life-cycle test with the sheepshead minnow, BCFs were 5 to 27 with adult fish, 13 to 22 with embryos, and 16 to 48 with 28-day-old young (Schimmel et al. 1978). A steady-state BCF of 64 was obtained in a 7-day test with the longnose killifish (Trujillo et al. 1982). In four-day acute toxicity tests, Schimmel et al. (1978) found BCFs ranging from 0.26 for brown shrimp to 38.0 for striped mullet, Mugil cephalus. Using radio-labeled PCP, Carr and Neff (1981) reported a 14-day BCF of 280 with the sand worm, Nereis virens.

No U.S. FDA action level or other maximum acceptable concentration in tissue is available for pentachlorophenol, and, therefore, no Final Residue Value can be calculated.

Other Data

Cleveland et al. (1982) and Hamilton et al. (1986) studied the effects of four samples of PCP on the survival and growth of fathead minnows for 90 days. In the range of 60 to 142 µg/L, both a purified PCP and an ultrapure PCP reduced growth by 10 to 25%, whereas Dowicide EC-7 increased growth by 18 to 21%. An industrial composite PCP was much more toxic; 13 µg/L reduced growth by 20%, 27 µg/L reduced growth by 40%, and 67 µg/L killed all the fish. Analyses of the four PCP samples for fourteen polychlorinated impurities and a test on the effects of a mixture of some of the impurities indicated that some of the effects seen in the tests on PCP were probably due to the measured impurities.

Webb and Brett (1973) found that growth and food conversion of sockeye salmon (Oncorhynchus nerka) were affected in a 56-day exposure to PCP concentrations of 1.74 and 1.80 µg/L, respectively, at a pH of 6.8 (Table 6). These are the lowest effect concentrations that have been reported for any species. Growth of salmonids was reduced by 10 to 27% at PCP concentrations ranging from 3.2 to 28 µg/L (Chapman 1969; Chapman and Shumway 1978; Matida et al. 1976). The thresholds for reduction of growth of rainbow trout exposed to PCP through 4-week post swim-up were about 10 and 20 µg/L in warm and cold regimes, respectively (Hodson and Blunt 1981). Reduced growth of largemouth bass, Micropterus salmoides, was observed at 50.4 µg/L after 7 days of exposure (Mathers et al. 1985), of the guppy at 320 µg/L after 28 days of exposure and of the amphibian, Xenopus laevis, at 100 µg/L after 100 days of exposure (Slooff and Canton 1983).

Whitley (1968) and Kobayashi and Kishino (1980) reported that an increase in pH decreased the 24-hr LC50s for both tubificid worms and goldfish. Some reduction in toxicity appeared to result from the presence of sediment in acute toxicity tests conducted with several species of tubificid worms (Chapman et al. 1982a). Similarly, Mississippi River water afforded some protection to various invertebrate species when their LC50s were compared with values obtained in Lake Superior water (Hedtke et al. 1986). The tubificids, Limnodrilus hoffmeisteri and Tubifex tubifex, were more resistant to PCP when tested as mixed species than when each species was tested individually (Chapman et al. 1982a,b). Schauerte et al. (1982) found that 1,000 µg/L decreased daphnids and autotrophic phytoplankton in compartments in a pond, and Yount and Richter

(1986) found that periphyton biomass in experimental streams was inversely related to pentachlorophenol in the range from 48 to 432 µg/L.

A wide variety of acute, chronic, and sublethal effects of PCP have been reported for saltwater organisms (Table 6). Several effects of PCP on polychaete worms have been reported such as reduced feeding activity by Arenicola cristata (Rubinstein 1978). depletion of glycogen reserves, increased tissue ascorbic acid concentrations, and disruption of osmoregulation Nereis virens (Carr and Neff 1981); and reproductive impairment in Ophryotrocha diadema (Hooftman and Vink 1980). PCP induced developmental abnormalities in embryos and larvae of the mussel, Mytilus edulis, (Dimick and Breese 1965) and oyster, Crassostrea virginica, (Davis and Hidu 1969) and inhibited shell growth of juvenile oysters (Schimmel et al. 1978). Exposure for 18 weeks to 460 µg/L resulted in reduced resistance of the quahog clam, Mercenaria mercenaria, to bacterial infection (Anderson et al. 1981).

The grass shrimp, Palaemonetes pugio, exhibited a variety of sublethal physiological effects during exposure to PCP concentrations of 400 to 4,600 µg/L (Brannon and Conklin 1978: Cantelmo et al. 1978; Doughtie and Rao 1978; Rao and Doughtie 1984; Rao et al. 1978,1979,1981) such as histological damage to epithelia of the gills, gut, and hepatopancreas, increased metabolic rate, decreased rate of limb regeneration, and increased weight of the molted exoskeleton.

Saltwater fish exposed to 50 to 200 µg/L exhibited elevation of the concentration of acid-soluble thiols in liver of winter flounder (Thomas and Wofford 1984) and elevation of blood cortisol, leading to hyperglycemia, depletion of liver glycogen reserves, and an increase in liver ascorbic acid concentration in mullet (Thomas et al. 1981).

In a series of benthic colonization studies conducted in the laboratory under flow-through conditions, PCP concentrations of 55 to 140 µg/L reduced both species richness and total faunal abundances of benthic macrofauna (Hansen and Tagatz 1980; Tagatz et al. 1977,1980,1981). At a concentration of 15.8 µg/L, PCP, administered as Dowicide G-ST, reduced total faunal abundances, but not species richness. Molluscs were generally most sensitive, but other phyla were also affected.

Unused Data

Some data on the effects of PCP on aquatic organisms were not used because the studies were conducted with species that are not resident in North America (e.g., Adema and Vink 1981; Dalela et al. 1980a,b,c, Dave 1984; Hanumante and Kulkarni 1979; Goel and Prasad 1978; Gupta 1983; Gupta and Dalela 1986; Gupta and Durve 1984a,b, Gupta and Rao 1982; Gupta et al. 1982b,1983a,b; Hattori et al. 1984; Kaila and Saarikoski 1977, Khangarot et al. 1985; Kobayashi et al. 1969, Nagendran and Shakuntala 1979; Rao et al. 1983; Shim and Self 1973; Slooff 1978; Slooff et al. 1983b; Tomiyama et al. 1962; Van Dijk et al. 1977; Verma et al. 1980,1981a,b,1982,1984). Results (e.g., Adema and Vink 1981) of tests conducted with brine shrimp, Artemia sp., were not used because these species are from a unique saltwater environment. Adelman et al. (1976b), Ahlborg and Thurnberg (1980), Alexander et al. (1983), Bevenue and Beckman (1967), Buikema et al. (1979), Conklin and Fox (1978), Hall and Kier (1984a,b), Koch (1982), Kozak et al. (1979), National Research Council of Canada (1982), Rao et al. (1979), von Rumker et al. (1974), and Strufe (1968) only contain data that have been published elsewhere.

Results were not used if either the test procedures or the test material was not adequately described (e.g., Benoit-Guyod et al. 1984a;

Canton and Slooff 1979; Clemens and Sneed 1959; Hashimoto and Nishiuchi 1983; Klein et al. 1984; Knie et al. 1983; Konemann and Musch 1981; Wong 1984), or if PCP was a component of a mixture (Hermens et al. 1985; Statham and Lech 1975). Tests were not used if PCP comprised only eight percent of the formulation (Batte and Swanson 1952; Inglis and Davis 1972). Data were not used if PCP was a component of a sediment (e.g., D'Asaro and Wilkes 1982) or if the organisms were exposed by injection (e.g., Bose and Fujiwara 1978; Tripp et al. 1984) or in food (e.g., Niimi and Cho 1983). Anderson et al. (1984), Bols et al. (1985), Cantelmo and Rao (1978a), Fox and Rao (1978), and Kwasniewska et al. (1979) only exposed enzymes, excised or homogenized tissue, cell cultures, or sewage bacteria.

Tests conducted with too few test organisms (e.g., Coglianese and Neff 1982; McLeese et al. 1979) and tests in which the concentrations fluctuated widely (e.g., Thomas et al. 1981) were not used. The 60-day test reported by Verma et al. (1981c) was not used because there were no replicate test chambers. The early life-stage toxicity data of Johansen et al. (1985) were not used due to high mortality of control fish and an interruption in the exposure. Results were not used if organisms were not cultured and tested in the same dilution water (Berglind and Dave 1984).

Studies with physiological endpoints only were not used (e.g., Bostrom and Johansson 1972; Chowdary et al. 1979; Gupta et al. 1983c,d; Hanke et al. 1983; Holmberg et al. 1972; Huber et al. 1982; Jayaweera et al. 1982; Kaila 1982; Kaila and Saarikoski 1980,1981; LeBlanc and Cochrane 1985. Liu 1981; Oikari and Nitcyla 1985; Oikari et al. 1985; Peer et al. 1983; Saarikoski and Kaila 1977; Sarojini et al. 1983; Sloley et al. 1986; Tiedge et al. 1986; Verma 1981b; Verma et al. 1982; Yousri and Hanke 1985). A study of histological effects on bluegills was not used (Owen and Rosso

1981). Toxicity data were not used if they were only qualitative (Palmer and Maloney 1955) or were presented in graphic form (Norup 1972). A study by Anderson and Weber (1975) was not used because acute toxicity results for the guppy were presented only as linear regressions on body size.

A study on the uptake and metabolism of PCP in rice plants (Weiss et al. 1982) was not used, nor were uptake studies in which exposure was via the food (Niimi and Cho 1983) or by gavage (Niimi and Palazzo 1985). Bioconcentration studies were not used if the test was not flow-through or renewal (e.g., Ernst 1979) or if the exposures were of insufficient duration for steady state to have been achieved (Glickman et al. 1977; Kobasyahi and Akitake 1975a,b; Kobayashi et al. 1979; Kuehl et al. 1983; Lech et al. 1978: McKim et al., Manuscript). Reports of the concentrations of PCP in wild aquatic organisms (e.g., Butte et al. 1983; Faas and Moore 1979; Folke et al. 1983: Fox and Joshi 1984; Kuehl and Dougherty 1980; Murray et al. 1980,1981: Ray et al. 1983) were not used if the number of measurements of the concentration in water was too small or if the range of the measured concentrations in water was too great. Studies of the concentration or accumulation of PCP in organisms were not used if the data provided were considered insufficient for determination of a bioconcentration or bioaccumulation factor (Gotham and Rhee 1982; Hallas 1973; Klein et al. 1984; Korte et al. 1978; Oikari 1986; Oikari and Anas 1985; Paasivirta et al. 1981), if the data were being reported secondarily (Branson 1980; Davies and Dobbs 1984), if water and biota samples were not collected at the same times (Metcalfe et al. 1984), or if the measurements were of total radiolabel rather than PCP itself (Fisher and Wadleigh 1986, Freitag et al. 1985; Geyer et al. 1981,1984; Gluth et al. 1985). Bioaccumulation and fate data

from model ecosystems or microcosm studies were not used (e.g., Brockway et al. 1984; Knowlton and Huckins 1983; Lu and Metcalf 1975; Robinson-Wilson et al. 1983; Tomizawa and Kazano 1979).

Summary

The acute and chronic toxicity of PCP to freshwater animals increased as pH and dissolved oxygen concentration of the water decreased. Generally, toxicity also increased with increased temperature. The estimated acute sensitivities of 36 species at pH = 6.5 ranged from 4.355 µg/L for larval common carp to >43,920 µg/L for a crayfish. At pH = 6.5, the lowest and highest estimated chronic values of <1.835 and 79.66 µg/L, respectively, were obtained with different cladoceran species. Chronic toxicity to fish was affected by the presence of impurities, with industrial-grade PCP being more toxic than purified samples. Mean acute-chronic ratios for six freshwater species ranged from 0.8945 to >15.79, but the mean ratios for the four most acutely sensitive species only ranged from 0.8945 to 5.035. Freshwater algae were affected by concentrations as low as 7.5 µg/L, whereas vascular plants were affected at 189 µg/L and above. Bioconcentration factors ranged from 7.3 to 1,066 for three species of fish.

Acute acute toxicity values from tests with 18 species of saltwater animals, representing 17 genera, range from 22.63 µg/L for late yolk-sac larvae of the Pacific herring, Clupea harengus pallasi, to 18,000 µg/L for adult blue mussels, Mytilus edulis. The embryo and larval stages of invertebrates and the late larval premetamorphosis stage of fish appear to be the most sensitive life stages to PCP. With few exceptions, fish are more sensitive than invertebrates to PCP. Salinity, temperature, and pH have a slight effect on the toxicity of PCP to some saltwater animals.

Life-cycle toxicity tests have been conducted with the sheepshead minnow, Cyprinodon variegatus, and the polychaete worm, Ophryotrocha diadema. The chronic value for the minnow is 64.31 µg/L and the acute-chronic ratio is 6.873. Unfortunately, no statistical analysis of the data from the test with the worm is available.

The EC50s for saltwater plants range from 17.40 µg/L for the diatom, Skeletonema costatum, to 3,600 µg/L for the green algae, Dunaliella tertiolecta. Apparent steady-state BCFs are available for the eastern oyster, Crassostrea virginica, and two saltwater fishes and range from 10 to 82.

## National Criteria

The procedures described in the "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses" indicate that, except possibly where a locally important species is very sensitive, freshwater aquatic organisms and their uses should not be affected unacceptably if the four-day average concentration (in µg/L) of pentachlorophenol does not exceed the numerical value given by $e^{[1.005(pH)-5.290]}$ more than once every three years on the average and if the one-hour average concentration (in µg/L) does not exceed the numerical value given by $e^{[1.005(pH)-4.830]}$ more than once every three years on the average. For example, at pH = 6.5, 7.8, and 9.0 the four-day average concentrations of pentachlorophenol are 3.5, 13, and 43 µg/L, respectively, and the one-hour average concentrations are 5.5, 20, and 68 µg/L. At pH = 6.8, a pentachlorophenol concentration of 1.74 µg/L caused a 50% reduction in the growth of yearling sockeye salmon in a 56-day test.

The procedures described in the "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses" indicate that, except possibly where a locally important species is very sensitive, saltwater aquatic organisms and their uses should not be affected unacceptably if the four-day average concentration of pentachlorophenol does not exceed 7.9 μg/L more than once every three years on the average and if the one-hour average concentration does not exceed 13 μg/L more than once every three years on the average.

Three years is the Agency's best scientific judgment of the average amount of time aquatic ecosystems should be provided between excursions (U.S. EPA 1985b). The resiliencies of ecosystems and their abilities to recover differ greatly, however, and site-specific allowed excursion frequencies may be established if adequate justification is provided.

Use of criteria for developing water quality-based permit limits and for designing waste treatment facilities requires selection of an appropriate wasteload allocation model. Dynamic models are preferred for the application of these criteria (U.S. EPA 1985b). Limited data or other considerations might make their use impractical, in which case one must rely on a steady-state model (U.S. EPA 1986).

Table 1. Acute Toxicity of Pentachlorophenol to Aquatic Animals

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| | | | | FRESHWATER SPECIES | | | |
| Hydra, *Hydra oligactis* | S, U | PCP (>98%) | - | 730 | - | - | Slooff et al. 1983a |
| Tubificid worm, *Branchiura sowerbyi* | R, U | NaPCP | 7.0 | 257.7 | 155.9 | 155.9 | Chapman et al. 1982a |
| Tubificid worm, *Limnodrilus hoffmeisteri* | R, U | NaPCP | 7.0 (10°C) | 303.8 | 183.8 | - | Chapman et al. 1982a,b,c |
| Tubificid worm, *Limnodrilus hoffmeisteri* | R, U | NaPCP | 7.0 (1°C) | 478.7† | 289.6 | - | Chapman et al. 1982b |
| Tubificid worm, *Limnodrilus hoffmeisteri* | R, U | NaPCP | 7.0 (20°C) | 451.0† | 272.9 | - | Chapman et al. 1982b |
| Tubificid worm, *Limnodrilus hoffmeisteri* | R, U | NaPCP | 6.0 (10°C) | 303.8† | 502.1†† | - | Chapman et al. 1982b |
| Tubificid worm, *Limnodrilus hoffmeisteri* | R, U | NaPCP | 8.0 (10°C) | 345.2† | 76.45 | 182.5 | Chapman et al. 1982b |
| Tubificid worm, *Quistradrilus multisetosus* | R, U | NaPCP | 7.0 | 524.7 | 317.5 | 317.5 | Chapman et al. 1982a,b |
| Tubificid worm, *Rhyacodrilus montana* | R, U | NaPCP | 7.0 | 690.4 | 417.7 | 417.7 | Chapman et al. 1982a |
| Tubificid worm, *Spirosperma ferox* | R, U | NaPCP | 7.0 | 395.8 | 239.5 | 239.5 | Chapman et al. 1982a |
| Tubificid worm, *Spirosperma nikolskyi* | R, U | NaPCP | 7.0 | 902.1 | 545.8 | 545.8 | Chapman et al. 1982a |
| Tubificid worm, *Stylodrilus heringianus* | R, U | NaPCP | 7.0 | 579.9 | 350.8 | - | Chapman et al. 1982a,b |
| Tubificid worm, *Stylodrilus heringianus* | R, U | NaPCP | 7.0 (1°C) | 1,638† | 991.0 | - | Chapman et al. 1982b |
| Tubificid worm, *Stylodrilus heringianus* | R, U | NaPCP | 7.0 (20°C) | 681.2† | 412.1 | - | Chapman et al. 1982b |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Tubificid worm, *Stylodrilus heringianus* | R, U | NaPCP | 6.0 (10°C) | 690.4† | 1,141†† | - | Chapman et al. 1982b |
| Tubificid worm, *Stylodrilus heringianus* | R, U | NaPCP | 8.0 (10°C) | 874.5† | 193.7 | 408.2 | Chapman et al. 1982b |
| Tubificid worm, *Tubifex tubifex* | R, U | NaPCP | 7.0 (10°C) | 349.8 | 211.6 | - | Chapman et al. 1982a,b,c |
| Tubificid worm, *Tubifex tubifex* | R, U | NaPCP | 7.0 (1°C) | 607.5† | 367.6 | - | Chapman et al. 1982b |
| Tubificid worm, *Tubifex tubifex* | R, U | NaPCP | 7.0 (2°C) | 405.0† | 245.0 | - | Chapman et al. 1982b |
| Tubificid worm, *Tubifex tubifex* | R, U | NaPCP | 6.0 (10°C) | 340.6† | 563.0†† | - | Chapman et al. 1982b |
| Tubificid worm, *Tubifex tubifex* | R, U | NaPCP | 8.0 (10°C) | 598.3† | 132.5 | 224.2 | Chapman et al. 1982b |
| Tubificid worm, *Varichaeta pacifica* | R, U | NaPCP | 7.0 | 96.65 | 58.47 | 58.47 | Chapman et al. 1982a |
| Snail (adult), *Aplexa hypnorum* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 157 | 63.54 | - | Phipps and Holcombe 1985 |
| Snail (adult), *Aplexa hypnorum* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 142 | 57.47 | 60.43 | Phipps and Holcombe 1985 |
| Snail, *Physa gyrina* | F, M | Dowicide EC-7 (93.7% PCP) | 7.2 | 267 | 132.1 | 132.1 | Hedtke et al. 1986 |
| Snail, *Lymnaea stagnalis* | - | PCP | - | 240 | - | - | Adema and Vink 1981 |
| Snail, *Gillia altilis* | S, U | PCP (99%) | 6.7 | 810 | 662.5 | - | Stuart and Robertson 1985 |
| Snail, *Gillia altilis* | R, U | PCP (99%) | 6.7 | 300 | 245.4 | 403.2 | Stuart and Robertson 1985 |

Table 1. (continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Cladoceran (<4 hr), *Ceriodaphnia reticulata* | S, U | Dowicide EC-7 (93.7% PCP) | 7.2-7.4 | 153.7 | 68.79 | - | Mount and Norberg 1984 |
| Cladoceran (<6 hr), *Ceriodaphnia reticulata* | S, U | NaPCP | 7.7 | 260 | 77.84 | - | Hall et al. 1986 |
| Cladoceran (<6 hr), *Ceriodaphnia reticulata* | S, U | NaPCP | 7.7 | 510 | 152.7 | - | Hall et al. 1986 |
| Cladoceran (<6 hr), *Ceriodaphnia reticulata* | S, U | NaPCP | 7.8 | 290 | 78.52 | - | Hall et al. 1986 |
| Cladoceran (<6 hr), *Ceriodaphnia reticulata* | S, U | NaPCP | 7.8 | 410 | 111.0 | - | Hall et al. 1986 |
| Cladoceran (<24 hr), *Ceriodaphnia reticulata* | S, U | PCP (reagent grade) | 8.0 | 900 | 199.3 | - | Elnabarawy et al. 1986 |
| Cladoceran (<24 hr), *Ceriodaphnia reticulata* | F, M | Dowicide EC-7 (93.7% PCP) | 7.3 | 150 | 67.13 | 67.13 | Hedtke et al. 1986 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | - | 7.4-9.4 | 680 | 100.7 | - | LeBlanc 1980 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | - | 250 | - | - | Canton and Adema 1978 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | - | 400 | - | - | Canton and Adema 1978 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | - | 800 | - | - | Canton and Adema 1978 |
| Cladoceran (24 hr), *Daphnia magna* | S, M | PCP | - | 600 | - | - | Adema 1978 |
| Cladoceran (larva), *Daphnia magna* | - | PCP | - | 1,050 | - | - | Adema and Vink 1981 |
| Cladoceran (adult), *Daphnia magna* | - | PCP. | - | 1,400 | - | - | Adema and Vink 1981 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Cladoceran (<24 hr), *Daphnia magna* | S, U | - | - | 280 | - | - | Hermens et al. 1984 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | Dowicide EC-7 (93.7% PCP) | 7.2-7.4 | 134.0 | 59.97 | - | Mount and Norberg 1984 |
| Cladoceran (<24 hr), *Daphnia magna* | S, M | PCP (99%) | 8.58 | 145 | 17.93 | - | Thurston et al. 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 300 | 40.20 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 350 | 46.90 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 380 | 50.92 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 300 | 40.20 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 350 | 46.90 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 300 | 40.20 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 280 | 37.52 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 310 | 41.54 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 290 | 38.86 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 370 | 49.58 | - | Lewis and Weber 1985 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 350 | 46.90 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 370 | 49.58 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 340 | 45.56 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 510 | 68.33 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 840 | 112.6 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP | 8.5 | 510 | 68.33 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | NaPCP | 7.7 | 450 | 134.7 | - | Hall et al. 1986 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | NaPCP | 7.7 | 1,030 | 308.4 | - | Hall et al. 1986 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | NaPCP | 7.8 | 960 | 259.9 | - | Hall et al. 1986 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | NaPCP | 7.8 | 830 | 224.7 | - | Hall et la. 1986 |
| Cladoceran (<24 hr), *Daphnia magna* | S, U | PCP (reagent grade) | 8.0 | 1,000 | 221.5 | - | Elnabarawy et al. 1986 |
| Cladoceran (6 d), *Daphnia magna* | S, M | PCP (99+%) | 7.5 | 183 | 66.99 | 55.03 | Brooke et al. Manuscript |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | - | 2,000 | - | - | Canton and Adema 1978 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 260 | 47.10 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 490 | 88.76 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 480 | 86.95 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 470 | 85.13 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 290 | 52.53 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 170 | 30.79 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 250 | 45.28 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 390 | 70.64 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 190 | 34.42 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 330 | 59.78 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 560 | 101.4 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 550 | 99.63 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 560 | 101.4 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 440 | 79.70 | - | Lewis and Weber 1985 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 590 | 106.9 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 550 | 99.63 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 680 | 123.2 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP | 8.2 | 350 | 63.40 | - | Lewis and Weber 1985 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | NaPCP | 7.7 | 1,000 | 299.4 | - | Hall et al. 1986 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | NaPCP | 7.8 | 960 | 259.9 | - | Hall et al. 1986 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | NaPCP | 7.8 | 1,050 | 284.3 | - | Hall et al. 1986 |
| Cladoceran (<24 hr), *Daphnia pulex* | S, U | PCP (reagent grade) | 8.0 | 1,100 | 243.6 | 90.83 | Elnabarawy et al. 1986 |
| Cladoceran (<24 hr), *Simocephalus vetulus* | S, U | Dowicide EC-7 (93.7% EC50) | 7.2-7.4 | 203.3 | 91.00 | - | Mount and Norberg 1984 |
| Cladoceran (<24 hr), *Simocephalus vetulus* | F, M | Dowicide EC-7 (93.7% PCP) | 7.3 | 160 | 71.61 | - | Hedtke et al. 1986 |
| Cladoceran (<24 hr), *Simocephalus vetulus* | F, M | Dowicide EC-7 (93.7% PCP) | 7.7 | 250 | 74.85 | - | Hedtke et al. 1986 |
| Cladoceran (<24 hr), *Simocephalus vetlulus* | F, M | Dowicide EC-7 (93.7% PCP) | 8.0 | 255 | 56.47 | - | Hedtke et al. 1986 |
| Cladoceran (<24 hr), *Simocephalus vetulus* | F, M | Dowicide EC-7 (93.7% PCP) | 8.3 | 364 | 59.63 | - | Hedtke et al. 1986 |
| Cladoceran (<24 hr), *Simocephalus vetulus* | F, M | Dowicide EC-7 (93.7% PCP) | 7.9-8.4 | 196 | 35.50 | 57.72 | Hedtke et al. 1986 |
| Amphipod (juvenile), *Crangonyx pseudogracilis* | F, M | Dowicide EC-7 (88% PCP) | 6.5 | 139 | 139.0 | - | Spehar et al. 1985 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Amphipod (juvenile), *Crangonyx pseudogracilis* | F, M | Dowicide EC-7 (88% PCP) | 7.5 | 465 | 170.2 | - | Spehar et al. 1985 |
| Amphipod (juvenile), *Crangonyx pseudogracilis* | F, M | Dowicide EC-7 (88% PCP) | 8.0 | 929 | 205.7 | - | Spehar et al. 1985 |
| Amphipod (juvenile), *Crangonyx pseudogracilis* | F, M | Dowicide EC-7 (88% PCP) | 8.5 | 1,344 | 180.1 | 172.1 | Spehar et al. 1985 |
| Amphipod (11 mm), *Gammarus pseudolimnaeus* | S, M | PCP (99+%) | 7.5 | 296 | 108.35 | - | Brooke et al. Manuscript |
| Amphipod (0.050 g), *Gammarus pseudolimnaeus* | F, M | PCP (99+%) | 7.2 | 280 | 138.56 | - | Call et al. 1983 |
| Amphipod (juvenile), *Gammarus pseudolimnaeus* | F, M | Dowicide EC-7 (88% PCP) | 6.5 | 92 | 92.00 | - | Spehar et al. 1985 |
| Amphipod (juvenile), *Gammarus pseudolimnaeus* | F, M | Dowicide EC-7 (88% PCP) | 7.5 | 121 | 44.29 | - | Spehar et al. 1985 |
| Amphipod (juvenile), *Gammarus pseudolimnaeus* | F, M | Dowicide EC-7 (88% PCP) | 8.0 | 484 | 107.19 | - | Spehar et al. 1985 |
| Amphipod (juvenile), *Gammarus pseudolimnaeus* | F, M | Dowicide EC-7 (88% PCP) | 8.5 | 790 | 105.85 | 122.1 | Spehar et al. 1985 |
| Amphipod, *Hyalella azteca* | S, M | PCP (99+%) | 7.5 | 239 | 87.48 | 87.48 | Brooke et al. Manuscript |
| Crayfish (0.4-2.0 g), *Orconectes immunis* | F, M | PCP (99%) | 7.92 | >183,000 | >43,920 | >43,920 | Thurston et al. 1985 |
| Mosquito (3rd instar), *Aedes aegypti* | S, U | PCP (>98%) | - | 7,200 | - | - | Slooff et al. 1983a |
| Mosquito (3rd instar), *Culex pipiens* | S, U | PCP (>98%) | - | 34,000 | - | - | Slooff et al. 1983a |
| Midge (3rd, 4th instar), *Tanytarsus dissimilis* | S, M | PCP (99%) | 8.51 | 31,300 | 4,152 | - | Thurston et al. 1985 |
| Midge (3rd, 4th instar), *Tanytarsus dissimilis* | S, M | PCP (99%) | 8.55 | 19,000 | 2,421 | - | Thurston et al. 1985 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Midge (3rd, 4th instar), *Tanytarsus dissimilis* | F, M | PCP (99+%) | 7.9 | 46,000 | 11,260 | 11,260 | Call et al. 1983 |
| Sciomyzid (1st instar), *Sepedon fuscipennis* | S, U | NaPCP (90%) | 8 | 28,000 | 6,201 | - | McCoy and Joy 1977 |
| Sciomyzid (1st instar), *Sepedon fuscipennis* | S, U | NaPCP (90%) | 7 | 30,000 | 18,150 | 10,610 | McCoy and Joy 1977 |
| Coho salmon (1-3 g), *Oncorhynchus kisutch* | S, U | NaPCP | 7.01 | 89 | 53.31 | - | Davis and Hoos 1975 |
| Coho salmon (1-3 g), *Oncorhynchus kisutch* | S, U | NaPCP | 7.01 | 34 | 20.36 | - | Davis and Hoos 1975 |
| Coho salmon (2.7 g, 6.2 cm), *Oncorhynchus kisutch* | F, U | NaPCP | 6.9-7.5 | 60 | 29.69 | 31.82 | Iwama and Greer 1980 |
| Sockeye salmon (yearling), *Oncorhynchus nerka* | F, U | NaPCP | 6.8 | 58 | 42.90 | - | Webb and Brett 1973 |
| Sockeye salmon (1-3 g), *Oncorhynchus nerka* | S, U | NaPCP | 7.19 | 46 | 22.99 | - | Davis and Hoos 1975 |
| Sockeye salmon (1-3 g), *Oncorhynchus nerka* | S, U | NaPCP | 7.70 | 120 | 35.93 | 32.85 | Davis and Hoos 1975 |
| Chinook salmon (1 g), *Oncorhynchus tshawytscha* | S, U | PCP (96%) | 7.2-7.5 | 65.28 | 27.78 | - | Johnson and Finley 1980 |
| Chinook salmon (1 g), *Oncorhynchus tshawytscha* | S, U | NaPCP (90%) | 7.2-7.5 | 56.53 | 24.06 | 25.85 | Johnson and Finley 1980 |
| Rainbow trout (1-3 g), *Salmo gairdneri* | S, U | NaPCP | 6.96 | 85 | 53.54 | - | Davis and Hoos 1975 |
| Rainbow trout (1-3 g), *Salmo gairdneri* | S, U | NaPCP | 7.0 | 89 | 53.85 | - | Davis and Hoos 1975 |
| Rainbow trout (1-3 g), *Salmo gairdneri* | S, U | NaPCP | 7.0 | 46 | 27.83 | - | Davis and Hoos 1975 |
| Rainbow trout (1-3 g), *Salmo gairdneri* | S, U | NaPCP | 7.02 | 92 | 54.55 | - | Davis and Hoos 1975 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Rainbow trout (1-3 g), *Salmo gairdneri* | S, U | NaPCP | 5.7 | 44 | 98.32 | - | Davis and Hoos 1975 |
| Rainbow trout (1-3 g), *Salmo gairdneri* | S, U | NaPCP | 7.0 | 69 | 41.75 | - | Davis and Hoos 1975 |
| Rainbow trout (1.0 g), *Salmo gairdneri* | S, U | - | 7.0 | 75 | 45.38 | - | Bentley et al. 1975 |
| Rainbow trout (1.0 g), *Salmo gairdneri* | S, U | - | 7.5 | 92 | 33.68 | - | Bentley et al. 1975 |
| Rainbow trout (0.3-0.4 g), *Salmo gairdneri* | S, U | NaPCP | 6.2-6.8 | 83 | 83.00 | - | Vigers and Maynard 1977 |
| Rainbow trout (1 g), *Salmo gairdneri* | S, U | PCP (96%) | 7.2-7.5 | 49.92 | 21.25 | - | Johnson and Finley 1980 |
| Rainbow trout (1 g), *Salmo gairdneri* | S, U | NaPCP (90%) | 7.2-7.5 | 45.72 | 19.46 | - | Johnson and Finley 1980 |
| Rainbow trout (10 wk), *Salmo gairdneri* | F, U | PCP (99+%) | 7.4 | 66 | 26.71 | - | Dominguez and Chapman 1984 |
| Rainbow trout (embryo; 0 h), *Salmo gairdneri* | R, U | PCP (97%) | 7.2 | 3,000 | 1,485 | - | Van Leeuwen et al. 1985 |
| Rainbow trout (embryo; 24 h), *Salmo gairdneri* | R, U | PCP (97%) | 7.2 | 1,300 | 643.3 | - | Van Leeuwen et al. 1985 |
| Rainbow trout (early eyed embryo; 14 d), *Salmo gairdneri* | R, U | PCP (97%) | 7.2 | 3,000 | 1,485 | - | Van Leeuwen et al. 1985 |
| Rainbow trout (late eyed embryo; 28 d), *Salmo gairdneri* | R, U | PCP (97%) | 7.2 | 480 | 237.5 | - | Van Leeuwen et al. 1985 |
| Rainbow trout (sac fry; 42 d), *Salmo gairdneri* | R, U | PCP (97%) | 7.2 | 32 | 15.84 | - | Van Leeuwen et al. 1985 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Rainbow trout (early fry; 77 d), *Salmo gairdneri* | R, U | PCP (97%) | 7.2 | 18 | 8.907 | - | Van Leeuwen et al. 1985 |
| Rainbow trout (0.81 g), *Salmo gairdneri* | S, M | PCP (99+%) | 7.5 | 47.2 | 17.28 | - | Brook et al. Manuscript |
| Rainbow trout (1.2-7.9 g), *Salmo gairdneri* | F, M | NaPCP | 8.0-8.3 | 210 | 38.04 | - | Fogels and Sprague 1977 |
| Rainbow trout (1-4 g), *Salmo gairdneri* | F, M | PCP | 7.6-8.2 | 160 | 39.18 | - | Hodson et al. 1984; McCarty et al. 1985 |
| Rainbow trout (0.6-8.0 g), *Salmo gairdneri* | F, M | PCP (99%) | 7.85 | 115 | 29.61 | 35.34 | Thurston et al. 1985 |
| Brook trout (adult), *Salvelinus fontinalis* | F, M | PCP (99+%) | 7.89 | 138 | 34.13 | 34.13 | Cardwell et al. 1976 |
| Goldfish (2.36 g), *Carassius auratus* | F, M | NaPCP | 7.81 | 210 | 56.29 | - | Adelman and Smith 1976 |
| Goldfish (2.57 g), *Carassius auratus* | F, M | NaPCP | 7.78 | 220 | 60.78 | - | Adelman and Smith 1976 |
| Goldfish (1.46 g), *Carassius auratus* | F, M | NaPCP | 7.77 | 230 | 64.18 | - | Adelman and Smith 1976 |
| Goldfish (1.50 g), *Carassius auratus* | F, M | NaPCP | 7.75 | 210 | 59.79 | - | Adelman and Smith 1976 |
| Goldfish (1.55 g), *Carassius auratus* | F, M | NaPCP | 7.62 | 170 | 55.16 | - | Adelman and Smith 1976 |
| Goldfish (1.40 g), *Carassius auratus* | F, M | NaPCP | 7.68 | 170 | 51.93 | - | Adelman and Smith 1976 |
| Goldfish (2.46 g), *Carassius auratus* | F, M | NaPCP | 7.54 | 220 | 77.36 | - | Adelman and Smith 1976 |
| Goldfish (2.70 g), *Carassius auratus* | F, M | NaPCP | 7.59 | 230 | 76.91 | - | Adelman and Smith 1976 |
| Goldfish (1.66 g), *Carassius auratus* | F, M | NaPCP | 7.58 | 240 | 81.06 | - | Adelman and Smith 1976 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Goldfish (1.74), *Carassius auratus* | F, M | NaPCP | 7.59 | 240 | 80.25 | - | Adelman and Smith 1976 |
| Goldfish (1.69 g), *Carassius auratus* | F, M | NaPCP | 7.58 | 200 | 67.55 | - | Adelman and Smith 1976 |
| Goldfish (1.65 g), *Carassius auratus* | F, M | NaPCP | 7.60 | 190 | 62.90 | - | Adelman and Smith 1976 |
| Goldfish (2.31 g), *Carassius auratus* | F, M | NaPCP | 7.83 | 290 | 76.19 | - | Adelman and Smith 1976 |
| Goldfish (2.31 g), *Carassius auratus* | F, M | NaPCP | 7.84 | 300 | 78.03 | - | Adelman and Smith 1976 |
| Goldfish (1.76 g), *Carassius auratus* | F, M | NaPCP | 7.73 | 200 | 58.10 | - | Adelman and Smith 1976 |
| Goldfish (1.54 g), *Carassius auratus* | F, M | NaPCP | 7.76 | 250 | 70.47 | - | Adelman and Smith 1976 |
| Goldfish (1-2 g), *Carassius auratus* | F, M | NaPCP | - | 247††† | - | - | Adelman and Smith 1976; Adelman et al. 1976a |
| Goldfish (2-4 g), *Carassius auratus* | F, M | NaPCP | - | 190††† | - | - | Adelman and Smith 1976; Adelman et al. 1976a |
| Goldfish (1.9 g), *Carassius auratus* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 117 | 47.36 | - | Phipps and Holcombe 1985 |
| Goldfish (1.2 g), *Carassius auratus* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 156 | 63.14 | - | Phipps and Holcombe 1985 |
| Goldfish (1.7 g), *Carassius auratus* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 191 | 77.31 | - | Phipps and Holcombe 1985 |
| Goldfish (1.0-4.0 g), *Carassius auratus* | F, M | PCP (99%) | 7.94 | 328 | 77.15 | - | Thurston et al. 1985 |
| Goldfish (1.0-4.0 g), *Carassius auratus* | F, M | PCP (99%) | 7.84 | 200 | 52.02 | 65.53 | Thurston et al. 1985 |
| Common carp (8 mm), *Cyprinus carpio* | R, U | NaPCP | 7.2 | 8.8 | 4.355 | 4.355 | Verma et al. 1981c |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Fathead minnow (4-8 wk), *Pimephales promelas* | S, U | PCP | - | 600 | - | - | Mattson et al. 1976 |
| Fathead minnow (1.1 g), *Pimpehales promelas* | S, U | PCP (96%) | 7.2-7.5 | 196.8 | 83.76 | - | Johnson and Finley 1980 |
| Fathead minnow (40 d), *Pimephales promelas* | F, U | PCP (99%) | 7.4 | 470 | 190.2 | - | Cleveland et al. 1982 |
| Fathead minnow (14-30 d), *Pimephales promelas* | S, U | NaPCP | 7.7 | 18 | 5.389 | - | Hall et al. 1986 |
| Fathead minnow (adult), *Pimephales promelas* | F, M | - | 7.92-8.20 | 194 (15°C) | 40.45 | - | Ruesink and Smith 1975 |
| Fathead minnow (adult), *Pimephales promelas* | F, M | - | 7.81-8.20 | 314 (25°C) | 69.54 | - | Ruesink and Smith 1975 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.82 | 200 | 53.08 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.83 | 180 | 47.29 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.72 | 220 | 64.56 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.72 | 180 | 52.82 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.69 | 190 | 57.46 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.68 | 210 | 64.15 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.86 | 220 | 56.08 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.78 | 180 | 49.73 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.59 | 190 | 63.53 | - | Adelman and Smith 1976 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.62 | 190 | 61.65 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.65 | 240 | 75.56 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.65 | 200 | 62.96 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.63 | 200 | 64.24 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.58 | 190 | 64.18 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.83 | 270 | 70.94 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | 7.82 | 230 | 61.04 | - | Adelman and Smith 1976 |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | - | 227††† | - | - | Adelman and Smith 1976; Adelman et al. 1976a |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | - | 203††† | - | - | Adelman and Smith 1976; Adelman et al. 1976a |
| Fathead minnow (4 wk), *Pimephales promelas* | F, M | NaPCP | - | 198†††† | - | - | Adelman and Smith 1976; Adelman et al. 1976a |
| Fathead minnow (7 wk), *Pimephales promelas* | F, M | NaPCP | - | 230†††† | - | - | Adelman and Smith 1976; Adelman et al. 1976a |
| Fathead minnow (11 wk), *Pimephales promelas* | F, M | NaPCP | - | 222†††† | - | - | Adelman and Smith 1976; Adelman et al. 1976a |
| Fathead minnow (14 wk), *Pimephales promelas* | F, M | NaPCP | - | 190†††† | - | - | Adelman and Smith 1976; Adelman et al. 1976a |
| Fathead minnow ( 3 mo), *Pimephales promelas* | F, M | PCP (99+%) | 7.83 | 285 | 74.88 | - | Cardwell et al. 1976 |
| Fathead minnow (30-35 d), *Pimephales promelas* | F, M | - | 7.41-8.33 | 220 | 55.52 | - | Phipps et al. 1981 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Fathead minnow (30-35 d), *Pimephales promelas* | F, M | - | 7.41-8.33 | 230 | 58.05 | - | Phipps et al. 1981 |
| Fathead minnow (30-35 d), *Pimephales promelas* | F, M | - | 7.41-8.33 | 232 | 58.55 | - | Hall et al. 1984 |
| Fathead minnow (juvenile), *Pimephales promelas* | F, M | Dowicide EC-7 (88% PCP) | 6.5 | 95 | 95.00 | - | Spehar et al. 1985 |
| Fathead minnow (juvenile), *Pimephales promelas* | F, M | Dowicide EC-7 (88% PCP) | 7.5 | 218 | 79.80 | - | Spehar et al. 1985 |
| Fathead minnow (juvenile), *Pimephales promelas* | F, M | Dowicide EC-7 (88% PCP) | 8.0 | 261 | 57.80 | - | Spehar et al. 1985 |
| Fathead minnow (juvenile), *Pimephales promelas* | F, M | Dowicide EC-7 (88% PCP) | 8.5 | 378 | 50.65 | - | Spehar et al. 1985 |
| Fathead minnow (0.5 g), *Pimephales promelas* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 223 | 90.26 | - | Phipps and Holcombe 1985 |
| Fathead minnow (0.4 g), *Pimephales promelas* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 286 | 115.76 | - | Phipps and Holcombe 1985 |
| Fathead minnow (0.4 g), *Pimephales promelas* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 244 | 98.76 | - | Phipps and Holcombe 1985 |
| Fathead minnow (0.2-1.0 g), *Pimephales promelas* | F, M | PCP (99%) | 8.01 | 266 | 58.32 | 63.11 | Thurston et al. 1985 |
| Channel catfish (0.8 g), *Ictalurus punctatus* | S, U | PCP (96%) | 7.2-7.5 | 65.28 | 27.78 | - | Johnson and Finley 1980 |
| Channel catfish (0.8 g), *Ictalurus punctatus* | S, U | NaPCP (90%) | 7.2-7.5 | 64.01 | 27.24 | - | Johnson and Finley 1980 |
| Channel catfish (1.4 g), *Ictalurus punctatus* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | <53 | <21.45†† | - | Phipps and Holcombe 1985 |
| Channel catfish (1.4 g), *Ictalurus punctatus* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 54 | 21.86 | - | Phipps and Holcombe 1985 |
| Channel catfish (1.9 g), *Ictalurus punctatus* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 54 | 21.86 | - | Phipps and Holcombe 1985 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Channel catfish (0.3-4.0 g), *Ictalurus punctatus* | F, M | PCP (99%) | 7.71 | 132 | 39.12 | 26.54 | Thurston et al. 1985 |
| Flagfish (0.1-0.3 g), *Jordanella floridae* | F, M | NaPCP (79%) | 8.0-8.3 | 1,610 | 291.6 | 291.6 | Fogels and Sprague 1977 |
| Mosquitofish (0.1-1.0 g), *Gambusia affinis* | F, M | PCP (99%) | 8.05 | 288 | 60.62 | - | Thurston et al. 1985 |
| Mosquitofish (0.1-1.0 g), *Gambusia affinis* | F, M | PCP (99%) | 8.02 | 278 | 60.34 | 60.50 | Thurston et al. 1985 |
| Guppy (young), *Poecilia reticulata* | - | PCP | - | 720 | - | - | Adema and Vink 1981 |
| Guppy (young), *Poecilia reticulata* | - | PCP | - | 880 | - | - | Adema and Vink 1981 |
| Guppy (adult), *Poecilia reticulata* | - | PCP | - | 450 | - | - | Adema and Vink 1981 |
| Guppy, *Poecilia reticulata* | R, M | - | 7.0 | 400 | 242.0 | - | Salkinoja-Salonen et al. 1981 |
| Guppy (0.04-0.06 g), *Poecilia reticulata* | R, U | PCP | 5 | 42.6 | 192.4 | - | Saarikoski and Viluksela 1981,1982 |
| Guppy (0.04-0.06 g), *Poecilia reticulata* | R, U | PCP | 6 | 117 | 193.4 | - | Saarikoski and Viluksela 1981,1982 |
| Guppy (0.04-0.06 g), *Poecilia reticulata* | R, U | PCP | 7 | 442 | 267.4 | - | Saarikoski and Viluksela 1981,1982 |
| Guppy (0.04-0.06 g), *Poecilia reticulata* | R, U | PCP | 8 | 911 | 201.8 | - | Saarikoski and Viluksela 1981, 1982 |
| Guppy (0.0875 g), *Poecilia reticulata* | R, U | PCP | 8.1 | 970 | 194.3 | - | Gupta et al. 1982a |
| Guppy (0.0875 g), *Poecilia reticulata* | R, U | NaPCP | 8.1 | 711 | 142.4 | - | Gupta et al. 1982a |
| Guppy, *Poecilia reticulata* | R, U | PCP | 7.7 | 204 | 61.08 | - | Khangarot 1983 |

Table 1. (Continued)

| Species | Method* | Chemical** | pH | LC50 or EC50 (µg/L)*** | Adjusted LC50 or EC50 (µg/L)**** | Species Mean Acute Value (µg/L)***** | Reference |
|---|---|---|---|---|---|---|---|
| Guppy (juvenile), *Poecilia reticulata* | R, U | PCP | 7.2 | 1,020 | 504.7 | 195.4 | Brown et al. 1985 |
| Bluegill (1.1 g), *Lepomis macrochirus* | S, U | - | 7.0 | 60 | 36.30 | - | Bentley et al. 1975 |
| Bluegill (1.1 g), *Lepomis macrochirus* | S, U | - | 7.5 | 77 | 28.19 | - | Bentley et al. 1975 |
| Bluegill (6 mo), *Lepomis macrochirus* | R, U | PCP | 7.2-7.7 | 260 | 105.23 | - | Prultt et al. 1977; Pierce 1978 |
| Bluegill (6 mo), *Lepomis macrochirus* | R, U | PCP | 7.2-7.7 | 305 | 123.5 | - | Prultt et al. 1977; Pierce 1978 |
| Bluegill (0.4 g), *Lepomis macrochirus* | S, U | PCP (96%) | 7.2-7.5 | 30.72 | 13.07 | - | Johnson and Finley 1980 |
| Bluegill (0.4 g), *Lepomis macrochirus* | S, U | NaPCP (90%) | 7.2-7.5 | 36.58 | 15.57 | - | Johnson and Finley 1980 |
| Bluegill (0.2 g), *Lepomis macrochirus* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 150 | 60.71 | - | Phipps and Holcombe 1985 |
| Bluegill (0.3 g), *Lepomis macrochirus* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 152 | 61.52 | - | Phipps and Holcombe 1985 |
| Bluegill (0.4 g), *Lepomis macrochirus* | F, M | Dowicide EC-7 (88% PCP) | 7.1-7.8 | 115 | 46.55 | - | Phipps and Holcombe 1985 |
| Bluegill (0.3-2.0 g), *Lepomis macrochirus* | F, M | PCP (99%) | 8.03 | 202 | 43.41 | 56.41 | Thurston et al. 1985 |
| Largemouth bass (14 d), *Micropterus salmoides* | R, U | PCP (99%) | 7.2 | 287 | 142.0 | - | Johansen et al. 1985 |
| Largemouth bass (28 d), *Micropterus salmoides* | R, U | PCP (99%) | 7.2 | 275 | 136.1 | - | Johansen et al. 1985 |
| Largemouth bass (49 d), *Micropterus salmoides* | R, U | PCP (99%) | 7.2 | 136 | 67.30 | - | Johansen et al. 1985 |
| Largemouth bass (84 d), *Micropterus salmoides* | R, U | PCP (99%) | 7.2 | 189 | 93.53 | 105.0 | Johansen et al. 1985 |
| Bullfrog (tadpole), *Rana catesbeiana* | F, M | PCP (99%) | 8.3 | 207 | 44.48 | 44.48 | Thurston et al. 1985 |

Table 1. (Continued)

| Species | Method* | Chemical** | Salinity (g/kg) | LC50 or EC50 (µg/L)*** | Species Mean Acute Value (µg/L) | Reference |
|---|---|---|---|---|---|---|
| | | | SALTWATER SPECIES | | | |
| Polychaete worm (adult), *Nereis arenaceodentata* | S, U | PCP (98%) | 28 | 435 | 435 | Rubenstein 1981 |
| Polychaete worm (3-d larva), *Ophryotrocha diadema* | R, M | PCP | 33 | 620 | - | Adema and Vink 1981; Hooftman and Vink 1980 |
| Polychaete worm (adult), *Ophryotrocha diadema* | R, M | PCP | 33 | 1,200 | 862.6 | Adema and Vink 1981; Hooftman and Vink 1980 |
| Oligochaete worm (adult), *Limnodriloides verrucosus* | R, U | NaPCP | 20 (10°C, pH 6) | 64.43†,†† | - | Chapman et al. 1982b |
| Oligochaete worm (adult), *Limnodriloides verrucosus* | R, U | NaPCP | 20 (10°C, pH 7) | 230.1 | 397.2 | Chapman et al. 1982a,b |
| Oligochaete worm (adult), *Limnodriloides verrucosus* | R, U | NaPCP | 20 (10°C, pH 8) | 441.8† | - | Chapman et al. 1982b |
| Oligochaete worm (adult), *Limnodriloides verrucosus* | R, U | NaPCP | 20 (1°C, pH 7) | 644.4† | - | Chapman et al. 1982b |
| Oligochaete worm, *Monophelephorus cuticulatus* | R, U | NaPCP | 20 (1°C, pH 7) | 1,473† | - | Chapman et al. 1982b |
| Oligochaete worm, *Monophelephorus cuticulatus* | R, U | NaPCP | 20 (10°C, pH 7) | 487.9 | - | Chapman et al. 1982a,b |
| Oligochaete worm, *Monophelephorus cuticulatus* | R, U | NaPCP | 20 (20°C, pH 7) | 492.5† | - | Chapman et al. 1982b |
| Oligochaete worm, *Monophelephorus cuticulatus* | R, U | NaPCP | 20 (10°C, pH 6) | 423.4†,†† | - | Chapman et al. 1982b |
| Oligochaete worm, *Monophelephorus cuticulatus* | R, U | NaPCP | 20 (10°C, pH 8) | 635.6† | - | Chapman et al. 1982b |
| Oligochaete worm, *Monophelephorus cuticulatus* | R, U | NaPCP | 10 (10°C, pH 7) | 340.6† | 598.2 | Chapman et al. 1982b |

Table 1. (Continued)

| Species | Method* | Chemical** | Salinity (g/kg) | LC50 or EC50 (µg/L)*** | Species Mean Acute Value (µg/L) | Reference |
|---|---|---|---|---|---|---|
| Oligochaete worm, *Tubificoides gabriellae* | R, U | NaPCP | 20 (10°C, pH 7) | 423.4 | 423.4 | Chapman et al. 1982a |
| Common Atlantic slippershell (larva), *Crepidula fornicata* | Averaged results from S, R, F; M | PCP | - | 1,200 | 1,200 | Adema and Vink 1981 |
| Blue mussel (adult), *Mytilus edulis* | Averaged results from S, R, F; M | PCP | - | 18,000†† | - | Adema and Vink 1981 |
| Blue mussel (embryo), *Mytilus edulis* | S, U | NaPCP | 24 | 328.8††††† | 328.8 | Woelke 1972 |
| Pacific oyster (embryo), *Crassostrea gigas* | S, U | NaPCP | - | 40.83††††† | 40.83 | Woelke 1972 |
| Eastern oyster (embryo), *Crassostrea virginica* | S, U | NaPCP | 17 | 36.95 | - | Borthwick and Schimmel 1978 |
| Eastern oyster (embryo), *Crassostrea virginica* | S, U | PCP (98%) | 30 | 430 | - | Zaroogian 1981 |
| Eastern oyster (embryo), *Crassostrea virginica* | S, U | PCP (98%) | 30 | 49 | - | Zaroogian 1981 |
| Eastern oyster (embryo), *Crassostrea virginica* | S, U | PCP (98%) | 30 | >180 | - | Zaroogian 1981 |
| Eastern oyster (embryo), *Crassostrea virginica* | S, U | PCP (98%) | 30 | 640 | †††††† | Zaroogian 1981 |
| Copepod (adult), *Pseudodiaptomus coronatus* | S, U | NaPCP | 18 | 62.81 | 62.81 | Hauch et al. 1980 |
| Copepod (adult), *Temora longicornus* | Averaged results from S, R, F; M | PCP | - | 170 | 170 | Adema and Vink 1981 |
| Brown shrimp (adult), *Penaeus aztecus* | F, M | NaPCP | 26.5 | >195 | >195 | Schimmel et al. 1978 |

Table 1. (Continued)

| Species | Method* | Chemical** | Salinity (g/kg) | LC50 or EC50 (µg/L)*** | Species Mean Acute Value (µg/L) | Reference |
|---|---|---|---|---|---|---|
| Pink shrimp (adult), *Penaeus duorarum* | S, U | PCP | 25 | 5,600 | 5,600 | Bentley et al. 1975 |
| Grass shrimp (adult intermolt), *Palaemonetes pugio* | R, U | NaPCP | 10 | 2,431†† | - | Conklin and Rao 1978a |
| Grass shrimp (adult early premolt), *Palaemonetes pugio* | R, U | NaPCP | 10 | 2,534†† | - | Conklin and Rao 1978a |
| Grass shrimp (adult late premolt), *Palaemonetes pugio* | R, U | NaPCP | 10 | 402.7 | - | Conklin and Rao 1978a,b |
| Grass shrimp (24-hr larva), *Palaemonetes pugio* | S, U | NaPCP | 24 | 599.5 | - | Borthwick and Schimmel 1978 |
| Grass shrimp (juvenile), *Palaemonetes pugio* | F, M | NaPCP | 24.3 | >515.0†† | 491.3 | Schimmel et al. 1978 |
| Pacific herring (day 1 yolk sac larva), *Clupea harengus pallasi* | S, U | NaPCP | 24-27 | 147.8†,†† | - | Vigers et al. 1978 |
| Pacific herring (day 12 larva), *Clupea harengus pallasi* | S, U | NaPCP | 24-27 | 63.74†,†† | - | Vigers et al. 1978 |
| Pacific herring (day 52 larva), *Clupea harengus pallasi* | S, U | NaPCP | 24-27 | 23.09† | - | Vigers et al. 1978 |
| Pacific herring (day 180 juvenile), *Clupea harengus pallasi* | S, U | NaPCP | 24-27 | 27.71† | 25.29 | Vigers et al. 1978 |
| Sheepshead minnow (1-day juvenile), *Cyprinodon variegatus* | S, U | PCP | 10 | 329 | - | Borthwick and Schimmel 1978 |

Table 1. (Continued)

| Species | Method* | Chemical** | Salinity (g/kg) | LC50 or EC50 (µg/L)*** | Species Mean Acute Value (µg/L) | Reference |
|---|---|---|---|---|---|---|
| Sheepshead minnow (2-week juvenile), *Cyprinodon variegatus* | S, U | PCP | 10 | 392 | - | Borthwick and Schimmel 1978 |
| Sheepshead minnow (4-week juvenile), *Cyprinodon variegatus* | S, U | PCP | 10 | 240 | - | Borthwick and Schimmel 1978 |
| Sheepshead minnow (6-week juvenile), *Cyprinodon variegatus* | S, U | PCP | 10 | 223 | - | Borthwick and Schimmel 1978 |
| Sheepshead minnow (2-week juvenile) *Cyprinodon variegatus* | S, U | Dowicide (79% NaPCP) | 24 | 376.5 | - | Borthwick and Schimmel 1978 |
| Sheepshead minnow (juvenile), *Cyprinodon variegatus* | F, M | PCP | 24 | 442 | 442 | Parrish et al. 1978 |
| Longnose killifish (juvenile), *Fundulus similis* | F, M | NaPCP | 22.9 | >306 | >306 | Schimmel et al. 1978 |
| Pinfish (larva), *Lagodon rhomboides* | S, U | NaPCP | 26 | 35.10 | - | Borthwick and Schimmel 1978 |
| Pinfish (larva), *Lagodon rhomboides* | S, U | Dowicide (79% NaPCP) | 26 | 48.16 | - | Borthwick and Schimmel 1978 |
| Pinfish (adult), *Lagodon rhomboides* | F, M | NaPCP | 20.8 | 53.2 | 53.2 | Schimmel et al. 1978 |
| Striped mullet (juvenile), *Mugil cephalus* | F, M | NaPCP | 25.5 | 112.1 | 112.1 | Schimmel et al. 1978 |

Table 1. (Continued)

* S = static; R = renewal; F = flow-through; U = unmeasured, M = measured.

** PCP = pentachlorophenol; NaPCP = sodium pentachlorophenate. Percent purity is given in parentheses when available.

*** Results are expressed as pentachlorophenol. If the concentrations were not measured and the published results were not reported to be adjusted for purity, the published results were multiplied by the purity if it was reported to be less than 97%.

**** Freshwater LC50s and EC50s were adjusted to pH = 6.5 using the pooled slope of 1.005 (see text).

***** Freshwater Species Mean Acute Values are at pH = 6.5.

† Interpolated from graph.

†† Not used in calculation of Species Mean Acute Value.

††† Mean of three LC50s.

†††† Mean of four LC50s.

††††† Calculated using moving average method and author's raw data.

†††††† No Species Mean Acute Value calculated because acute values are too divergent for this species.



Results of Covariance Analysis of Freshwater Acute Toxicity versus pH

| Species | n | Slope | 95% Confidence Limits | | Degrees of Freedom |
|---|---|---|---|---|---|
| *Simocephalus vetulus* | 4 | 0.760 | 0.128, | 1.393 | 2 |
| *Crangonyx pseudogracilis* | 4 | 1.164 | 0.844, | 1.484 | 2 |
| *Gammarus pseudolimnaeus* | 4 | 1.129 | -0.319, | 2.578 | 2 |
| Fathead minnow | 4 | 0.678 | 0.413, | 0.943 | 2 |
| Guppy | 4 | 1.052 | 0.710, | 1.394 | 2 |
| All of above | 20 | 1.005* | 0.841, | 1.169 | 14 |

* P = 0.28 for equality of slopes.

Table 2. Chronic Toxicity of Pentachlorophenol to Aquatic Animals

| Species | Test[a] | Chemical[**] | pH | Limits (µg/L)[***] | Chronic Value (µg/L) | Adjusted Chronic Value (µg/L)[****] | Reference |
|---|---|---|---|---|---|---|---|
| | | | FRESHWATER SPECIES | | | | |
| Snail, *Physa gyrina* | LC | Dowicide EC-7 (93.7% PCP) | 7.4-7.7 | <26[†] | <26 | <8.607 | Hedtke et al. 1986 |
| Cladoceran, *Ceriodaphnia reticulata* | LC | Dowicide EC-7 (93.7% PCP) | 7.3 | <22[†] | <22 | <9.846 | Hedtke et al. 1986 |
| Cladoceran, *Ceriodaphnia reticulata* | LC | Dowicide EC-7 (93.7% PCP) | 7.3 | <4.1[†] | <4.1 | <1.835 | Hedtke et al. 1986 |
| Cladoceran, *Daphnia magna* | LC | PCP | - | 180-320 | 240 | - | Adema 1978 |
| Cladoceran, *Simocephalus vetulus* | LC | Dowicide EC-7 (93.7% PCP) | 7.3 | 119-264 | 177.2 | 79.66 | Hedtke et al. 1986 |
| Cladoceran, *Simocephalus vetulus* | LC | Dowicide EC-7 (93.7% PCP) | 7.9-8.4[††] | 137-357 | 221.2 | 40.03 | Hedtke et al. 1986 |
| Rainbow trout, *Salmo gairdneri* | ELS | PCP (99+%) | 7.4 | 11-19 | 14.46 | 5.666 | Dominguez and Chapman 1984 |
| Fathead minnow, *Pimephales promelas* | ELS | PCP (Reagent grade) | 7.2-7.9 | 44.9-73.0 | 57.25 | 18.94 | Holcombe et al. 1982 |
| Fathead minnow, *Pimephales promelas* | ELS | Dowicide EC-7 (88% PCP) | 6.5 | 16.5-34.6 | 23.89 | 23.89 | Spehar et al. 1985 |

Table 2. (Continued)

| Species | Test* | Chemical** | pH | Limits (µg/L)*** | Chronic Value (µg/L) | Adjusted Chronic Value (µg/L)**** | Reference |
|---|---|---|---|---|---|---|---|
| Fathead minnow, *Pimephales promelas* | ELS | Dowicide EC-7 (88% PCP) | 7.5 | 27.6-58.2 | 40.08 | 14.64 | Spehar et al. 1985 |
| Fathead minnow, *Pimephales promelas* | ELS | Dowicide EC-7 (88% PCP) | 8.0 | 32.0-75.0 | 48.99 | 10.85 | Spehar et al. 1985 |
| Fathead minnow, *Pimephales promelas* | ELS | Dowicide EC-7 (88% PCP) | 8.5 | 63.7-125.0 | 89.23 | 11.92 | Spehar et al. 1985 |
| | | | | SALTWATER SPECIES | | | |
| Sheepshead minnow, *Cyprinodon variegatus* | LC | PCP | - | 47-88 | 64.31 | - | Parrish et al. 1978 |

* LC = life-cycle or partial life-cycle; ELS = early life-stage.

** PCP = pentachlorophenol. Percent purity is given in parentheses when available.

*** Results are based on measured concentrations of pentachlorophenol.

**** Freshwater chronic values were adjusted to pH = 6.5 using the pooled slope of 1.005 (see text).

† Unacceptable effects occurred at all concentrations tested.

†† Controlled daily pH fluctuation consisting of 16 hours at 8.4 and 8 hours at 7.9.

Table 2. (Continued)

| Species | pH | Acute Value (µg/L) | Chronic Value (µg/L) | Acute-Chronic Ratio: Ratio |
|---|---|---|---|---|
| Snail, *Physa gyrina* | 7.2-7.7 | 267 | <26 | >10.27 |
| Cladoceran, *Ceriodaphnia reticulata* | 7.3 | 150 | <22 | >6.818 |
| Cladoceran, *Ceriodaphnia reticulata* | 7.3 | 150 | <4.1 | >36.59 |
| Cladoceran, *Daphnia magna* | - | 600 | 240 | 2.500 |
| Cladoceran, *Simocephalus vetulus* | 7.3 | 160 | 177.2 | 0.9029 |
| Cladoceran, *Simocephalus vetulus* | 7.9-8.4 | 196 | 221.2 | 0.8861 |
| Rainbow trout, *Salmo gairdneri* | 7.4 | 66 | 14.46 | 4.564 |
| Fathead minnow, *Pimephales promelas* | 7.1-8.3 | 224.9* | 57.25 | 3.928 |
| Fathead minnow, *Pimephales promelas* | 6.5 | 95 | 23.89 | 3.977 |
| Fathead minnow, *Pimephales promelas* | 7.5 | 218 | 40.08 | 5.439 |
| Fathead minnow, *Pimephales promelas* | 8.0 | 261 | 48.99 | 5.328 |
| Fathead minnow, *Pimephales promelas* | 8.5 | 378 | 89.23 | 4.236 |
| Sheepshead minnow, *Cyprinodon variegatus* | - | 442 | 64.31 | 6.873 |

* Geometric mean of 2 acute values obtained by Phipps et al. (1981) (see Table 1).

Table 3. Ranked Genus Mean Acute Values with Species Mean Acute-Chronic Ratios

| Rank* | Genus Mean Acute Value (µg/L) | Species | Species Mean Acute Value (µg/L)** | Species Mean Acute-Chronic Ratio*** |
|---|---|---|---|---|
| | | FRESHWATER SPECIES | | |
| 33 | >43,920 | Crayfish, *Orconectes immunis* | >43,920 | - |
| 32 | 11,260 | Midge, *Tanytarsus dissimilis* | 11,260 | - |
| 31 | 10,610 | Sciomyzid, *Sepedon fuscipennis* | 10,610 | - |
| 30 | 417.7 | Tubificid worm, *Rhyacodrilus montana* | 417.7 | - |
| 29 | 408.2 | Tubificid worm, *Stylodrilus heringianus* | 408.2 | - |
| 28 | 403.2 | Snail, *Gillia altilis* | 403.2 | - |
| 27 | 361.6 | Tubificid worm, *Spirosperma ferox* | 239.5 | - |
| | | Tubificid worm, *Spirosperma nikolskyi* | 545.8 | - |
| 26 | 317.5 | Tubificid worm, *Quistradrilus multisetosus* | 317.5 | - |
| 25 | 291.6 | Flagfish, *Jordanella floridae* | 291.6 | - |
| 24 | 224.2 | Tubificid worm, *Tubifex tubifex* | 224.2 | - |
| 23 | 182.5 | Tubificid worm, *Limnodrilus hoffmeisteri* | 182.5 | - |
| 22 | 172.1 | Amphipod, *Crangonyx pseudogracilis* | 172.1 | - |
| 21 | 195.4 | Guppy, *Lebistes reticulata* | 195.4 | - |

Table 3. (Continued)

| Rank* | Genus Mean Acute Value (µg/L) | Species | Species Mean Acute Value (µg/L)** | Species Mean Acute-Chronic Ratio*** |
|---|---|---|---|---|
| 20 | 155.9 | Tubificid worm, *Branchiura sowerbyi* | 155.9 | - |
| 19 | 132.1 | Snail, *Physa gyrina* | 132.1 | >10.27 |
| 18 | 121.1 | Amphipod, *Gammarus pseudolimnaeus* | 122.1 | - |
| 17 | 105.0 | Largemouth bass, *Micropterus salmoides* | 105.0 | - |
| 16 | 87.48 | Amphipod, *Hyalella azteca* | 87.48 | - |
| 15 | 78.10 | Cladoceran, *Daphnia pulex* | 90.83 | - |
| | | Cladoceran, *Daphnia magna* | 67.15 | 2.500 |
| 14 | 67.13 | Cladoceran, *Ceriodaphnia reticulata* | 67.13 | >15.79† |
| 13 | 65.53 | Goldfish, *Carassius auratus* | 65.53 | - |
| 12 | 63.11 | Fathead minnow, *Pimephales promelas* | 63.11 | 4.535†† |
| 11 | 60.50 | Mosquitofish, *Gambusia affinis* | 60.50 | - |
| 10 | 60.43 | Snail, *Aplexa hypnorum* | 60.43 | - |
| 9 | 58.47 | Tubificid worm, *Varichaeta pacifica* | 58.47 | - |
| 8 | 57.72 | Cladoceran, *Simocephalus vetulus* | 57.72 | 0.8945† |

Table 3. (Continued)

| Rank* | Genus Mean Acute Value (µg/L) | Species | Species Mean Acute Value (µg/L)** | Species Mean Acute-Chronic Ratio*** |
|---|---|---|---|---|
| 7 | 56.41 | Bluegill, *Lepomis macrochirus* | 56.41 | - |
| 6 | 44.48 | Bullfrog, *Rana catesbiana* | 44.48 | - |
| 5 | 35.34 | Rainbow trout, *Salmo gairdneri* | 35.34 | 4.564 |
| 4 | 34.13 | Brook trout, *Salvelinus fontinalis* | 34.13 | - |
| 3 | 30.01 | Coho salmon, *Oncorhynchus kisutch* | 31.82 | - |
| | | Sockeye salmon, *Oncorhynchus nerka* | 32.85 | - |
| | | Chinook salmon, *Oncorhynchus tshawytscha* | 25.85 | - |
| 2 | 26.54 | Channel catfish, *Ictalurus punctatus* | 26.54 | - |
| 1 | 4.355 | Common carp, *Cyprinus carpio* | 4.355 | - |
| | | SALTWATER SPECIES | | |
| 17 | 1,200 | Common Atlantic slippersheil, *Crepidula fornicata* | 1,200 | - |
| 16 | >1,045 | Brown shrimp, *Penaeus aztecus* | >195 | - |
| | | Pink shrimp, *Penaeus duorarum* | 5,600 | - |
| 15 | 862.6 | Polychaete worm, *Ophryotrocha diadema* | 862.6 | - |

Table 3. (Continued)

| Rank* | Genus Mean Acute Value (µg/L) | Species | Species Mean Acute Value (µg/L)** | Species Mean Acute-Chronic Ratio*** |
|---|---|---|---|---|
| 14 | 598.2 | Oligochaete worm, *Monopylephorus cuticulatus* | 598.2 | - |
| 13 | 491.3 | Grass shrimp, *Palaemonetes pugio* | 491.3 | - |
| 12 | 442 | Sheepshead minnow, *Cyprinodon variegatus* | 442 | 6.873 |
| 11 | 435 | Polychaete worm, *Nereis arenaceodentata* | 435 | - |
| 10 | 423.4 | Oligochaete worm, *Tubificoides gabriellae* | 423.4 | - |
| 9 | 397.2 | Oligochaete worm, *Limnodriloides verrucosus* | 397.2 | - |
| 8 | 328.8 | Blue mussel, *Mytilus edulis* | 328.8 | - |
| 7 | >306 | Longnose killifish, *Fundulus similis* | >306 | - |
| 6 | 170 | Copepod, *Temora longicornis* | 170 | - |
| 5 | 112.1 | Striped mullet, *Mugil cephalus* | 112.1 | - |
| 4 | 62.81 | Copepod, *Pseudodiaptomus coronatus* | 62.81 | - |
| 3 | 53.2 | Pinfish, *Lagodon rhomboides* | 53.2 | - |
| 2 | 40.83 | Pacific oyster, *Crassostrea gigas* | 40.83 | - |

Table 3. (Continued)

| Rank* | Genus Mean Acute Value (µg/L) | Species | Species Mean Acute Value (µg/L)** | Species Mean Acute-Chronic Ratio*** |
|---|---|---|---|---|
| 1 | 25.29 | Pacific herring, *Clupea harengus pallasi* | 25.29 | - |

* Ranked from most resistant to most sensitive based on Genus Mean Acute Value. Inclusion of "greater than" values does not necessarily imply a true ranking, but does allow use of all genera for which data are available so that the Final Acute Value is not unnecessarily lowered.

** From Table 1.

*** From Table 2.

† Geometric mean of two values in Table 2.

†† Geometric mean of five values in Table 2.

**Table 3. (Continued)**

Fresh water

Final Acute Value = 10.97 µg/L (at pH = 6.5)

Criterion Maximum Concentration = (10.97 µg/L) / 2 = 5.485 µg/L (at pH = 6.5)

Pooled Slope = 1.005 (see Table 1)

ln(Criterion Maximum Intercept) = ln(5.485) - [slope x 6.5]

= 1.702 - (1.005 x 6.5) = -4.830

Criterion Maximum Concentration = $e^{[1.005(pH)-4.830]}$

Final Acute-Chronic Ratio = 3.166 (see text)

Final Chronic Value = (10.97 µg/L) / 3.166 = 3.465 µg/L (at pH = 6.5)

ln(Final Chronic Intercept) = ln(3.465) - [slope x 6.5]

= 1.243 - (1.005 x 6.5) = -5.290

Final Chronic Value = $e^{[1.005(pH)-5.290]}$

Salt water

Final Acute Value = 25.05 µg/L

Criterion Maximum Concentration = (25.05 µg/L) / 2 = 12.52 µg/L

Final Acute-Chronic Ratio = 3.166 (see text)

Final Chronic Value = (25.05 µg/L) / 3.166 = 7.912 µg/L

Table 4. Toxicity of Pentachlorophenol to Aquatic Plants

| Species | Chemical* | pH | Duration (days) | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| | | | FRESHWATER SPECIES | | | |
| Alga, *Chlorella vulgaris* | NaPCP (98%) | - | 11 | EC50 | 600 | Burrell et al. 1985 |
| Alga, *Chlorella pyrenoidosa* | - | 7.0 | 3 | EC100 (chlorosis) | 7.5 | Huang and Gloyna 1967 |
| Alga, *Chlorella pyrenoidosa* | PCP | - | 4 | EC50 (growth) | 7,000 | Adema and Vink 1981 |
| Alga, *Scenedesmus quadricauda* | PCP | - | 4 | EC50 (growth) | 80 | Adema and Vink 1981 |
| Alga, *Scenedesmus subspicatus* | PCP (99%) | 7.0 | 4 | EC50 | 90 | Geyer et al. 1985 |
| Alga, *Selenastrum capricornutum* | NaPCP | - | 7 | Reduced growth | 50 | Adams et al. 1985 |
| Alga, *Selenastrum capricornutum* | PCP | - | 4 | EC50 (growth) | 290 | Crossland and Wolff 1985 |
| Alga, *Selenastrum capricornutum* | PCP | - | 4 | EC50 (growth) | 312 | Richter 1982 |
| Alga, *Ankistrodesmus braunii* | NaPCP (98%) | - | 11 | EC50 | 830 | Burrell et al. 1985 |
| Duckweed, *Lemna minor* | - | 5.1 | 2 | EC50 (chlorosis) | 189.1 | Blackman et al. 1955 |
| | | | SALTWATER SPECIES | | | |
| Green alga, *Chlamydomonas* sp. | PCP | - | 4 | EC50 (population growth) | 1,400 | Adema and Vink 1981 |
| Green alga, *Dunaliella tertiolecta* | PCP | 30*** | 4 | EC50 (population growth) | 206 | Walsh et al. 1982 |
| Green alga, *Dunaliella tertiolecta* | PCP | 30*** | 4 | EC50 (population growth) | 170 | Walsh et al. 1982 |
| Green alga, *Dunaliella* sp. | PCP | - | 4 | EC50 (population growth) | 3,600 | Adema and Vink 1981 |

Table 4. (Continued)

| Species | Chemical* | pH | Duration (days) | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Golden brown alga, *Monochrysis* sp. | PCP | - | 4 | EC50 (population growth) | 200 | Adema and Vink 1981 |
| Diatom, *Skeletonema costatum* | PCP | 30*** | 4 | EC50 (population growth) | 20.30 | Walsh et al. 1982 |
| Diatom, *Skeletonema costatum* | PCP | 30*** | 4 | EC50 (population growth) | 17.40 | Walsh et al. 1982 |
| Diatom, *Skeletonema costatum* | PCP | 30*** | 4 | EC50 (population growth) | 17.80 | Walsh et al. 1982 |
| Diatom, *Thalassiosira pseudonana* | PCP | 30*** | 4 | EC50 (population growth) | 205 | Walsh et al. 1982 |
| Diatom, *Thalassiosira pseudonana* | PCP | 30*** | 4 | EC50 (population growth) | 189 | Walsh et al. 1982 |
| Diatom, *Thalassiosira pseudonana* | PCP | 30*** | 4 | EC50 (population growth) | 179 | Walsh et al. 1982 |
| Diatom, *Phaeodactylum tricornutum* | PCP | - | 4 | EC50 (population growth) | 3,000 | Adema and Vink 1981 |
| Giant kelp (young fronds), *Macrocystis pyrifera* | NaPCP (Santobrite) | - | 4 | EC50 (photosynthetic activity) | 277.1 | Clendenning and North 1959 |

* PCP = pentachlorophenol; NaPCP = sodium pentachlorophenate. Percent purity is given in parentheses when available.

** Results are expressed as pentachlorophenol. If the concentrations were not measured and the published results were not reported to be adjusted for purity, the published results were multiplied by the purity if it was reported to be less than 97%.

*** Salinity (g/kg), not pH.

Table 5. Bioaccumulation of Pentachlorophenol by Aquatic Organisms

| Species | Chemical* | Concentration in Water (µg/L)** | pH | Duration (days) | Tissue | BCF or BAF*** | Reference |
|---|---|---|---|---|---|---|---|
| | | | FRESHWATER SPECIES | | | | |
| Rainbow trout (400 g), *Salmo gairdneri* | PCP (Reagent grade) | 0.035 | - | 115 | **** | 406 | Niimi and McFadden 1982 |
| Rainbow trout (400 g), *Salmo gairdneri* | PCP (Reagent grade) | 0.660 | - | 115 | **** | 168 | Niimi and McFadden 1982 |
| Fathead minnow (6 mo), *Pimephales promelas* | - | - | 7.49 | 32 | Whole body | 770 | Veith et al. 1979 |
| Fathead minnow (0.5-1.5 g), *Pimephales promelas* | PCP (99%) | 50 | - | 31 | Whole body | 163 | Huckins and Petty 1983 |
| Fathead minnow (0.5-1.5 g), *Pimephales promelas* | PCP (88%) | 50 | - | 31 | Whole body | 211 | Huckins and Petty 1983 |
| Fathead minnow (juvenile), *Pimephales promelas* | Dowicide EC-7 (88% PCP) | 3.1-34.6 | 6.5 | 32 | Whole body | 1,066 | Spehar et al. 1985 |
| Fathead minnow (juvenile), *Pimephales promelas* | Dowicide EC-7 (88% PCP) | 5.6-58.2 | 7.5 | 32 | Whole body | 434 | Spehar et al. 1985 |
| Fathead minnow (juvenile), *Pimephales promelas* | Dowicide EC-7 (88% PCP) | 12.7-161.0 | 8.0 | 32 | Whole body | 426 | Spehar et al. 1985 |
| Fathead minnow (juvenile), *Pimephales promelas* | Dowicide EC-7 (88% PCP) | 29.3-125.0 | 8.5 | 32 | Whole body | 281 | Spehar et al. 1985 |
| Bluegill (6 mo), *Lepomis macrochirus* | PCP | 100 | 7.2-7.7 | 16 | Muscle | 7.3 | Prultt et al. 1977; Pierce 1978 |
| | | | SALTWATER SPECIES | | | | |
| Eastern oyster (adult), *Crassostrea virginica* | NaPCP | 25 | - | 28 | Soft tissue | 41 | Schimmel et al. 1978 |
| Eastern oyster (adult), *Crassostrea virginica* | NaPCP | 2.5 | - | 28 | Soft tissue | 78 | Schimmel et al. 1978 |

Table 5. (Continued)

| Species | Chemical* | Concentration in Water (µg/L)** | pH | Duration (days) | Tissue | BCF or BAF*** | Reference |
|---|---|---|---|---|---|---|---|
| Eastern oyster (adult), *Crassostrea virginica* | NaPCP | 3.7±1.4 | - | Steady state | Soft tissue | 82 | Schimmel and Garnas 1985 |
| Eastern oyster (adult), *Crassostrea virginica* | NaPCP | 9.5±3.4 | - | Steady state | Soft tissue | 34 | Schimmel and Garnas 1985 |
| Eastern oyster (adult), *Crassostrea virginica* | NaPCP | 11.3±1.7 | - | Steady state | Soft tissue | 76 | Schimmel and Garnas 1985 |
| Sheepshead minnow (embryo), *Cyprinodon variegatus* | PCP | 18-195 | - | Parents exposed 133-142 days | Whole body | 19.39† | Parrish et al. 1978 |
| Sheepshead minnow (juvenile), *Cyprinodon variegatus* | PCP | 18-195 | - | 28 | Whole body | 31.56† | Parrish et al. 1978 |
| Sheepshead minnow (adult), *Cyprinodon variegatus* | PCP | 18-195 | - | 151 | Whole body | 10.75† | Parrish et al. 1978 |
| Longnose killifish, *Fundulus similis* | PCP | 57-120 | - | 7 (Steady state) | Whole body | 64 | Trujillo et al. 1982 |

* PCP = pentachlorophenol; NaPCP = sodium pentachlorophenate. Percent purity is given in parentheses when available.

** Measured concentration of pentachlorophenol.

*** Bioconcentration factors (BCFs) and bioaccumulation factors (BAFs) are based on measured concentrations of pentachlorophenol in water and in tissue.

**** Whole body minus intestines, liver, and gall bladder.

† Geometric mean of values from four test concentrations.

Table 6. Other Data on Effects of Pentachlorophenol on Aquatic Organisms

| Species | Chemical* | pH | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| | | | FRESHWATER SPECIES | | | |
| Alga, *Scenedesmus pannonicus* | PCP | - | 4 days | Reduced biomass | 100-320 | Slooff and Canton 1983 |
| Pond phytoplankton community | PCP | - | 10 days | Community structural change | 1,000 | Boyle et al. 1984 |
| Vascular plant, *Elodea canadensis* | Dowicide EC-7 (93.7% PCP) | 7.7-8.2 | 21 days | Reduced growth (river water) | 380 | Hedtke et al. 1986 |
| Duckweed, *Lemna minor* | PCP | - | 7 days | Reduced specific growth rate | 1,000-3,200 | Slooff and Canton 1983 |
| Duckweed, *Lemna minor* | Dowicide EC-7 (93.7% PCP) | 7.7-8.2 | 21 days | Reduced growth (river water) | >1,440 | Hedtke et al. 1986 |
| Bacterium, *Pseudomonas fluorescens* | PCP | - | 0.3 days | Reduced specific growth rate | 1,000-3,200 | Slooff and Canton 1983 |
| Cyanobacterium, *Microcystis aeruginosa* | PCP | - | 4 days | Reduced specific growth rate | 1,000-3,200 | Slooff and Canton 1983 |
| Detritus mixed microbial community | Dowicide EC-7 (88% PCP) | - | 56 days | Reduction in biomass and activity | 8,131 | Fairchild et al. 1984 |
| Amoeba, *Amoeba proteus* | - | 4.5 | 30 min | Reduced survival | 1,332 | Smith and Ord 1979 |
| Ciliate protozoan, *Colpidium campylum* | - | - | 43 hr | Minimal active dose | 600 | Dive et al. 1980 |
| Hydra, *Hydra oligactis* | PCP (>98%) | - | 48 hr | LC50 | 730 | Slooff 1983 |
| Hydra, *Hydra oligactis* | PCP | - | 21 days | Reduced specific growth rate | 32-100 | Slooff and Canton 1983 |
| Planarian, *Dugesia lugubris* | PCP (>98%) | - | 48 hr | LC50 | 130 | Slooff 1983 |

Table 6. (Continued)

| Species | Chemical[a] | pH | Duration | Effect | Concentration (µg/L)[aa] | Reference |
|---|---|---|---|---|---|---|
| Rotifer, *Brachionus rubens* | - | - | 24 hr | LC50 | 160 | Halbach et al. 1983 |
| Rotifer, *Brachionus rubens* | PCP | - | 5 days | LC100 | 200 | Halbach 1984 |
| Rotifer, *Brachionus rubens* | PCP | - | 23 days | Reduced population density | 50 | Halbach 1984 |
| Tubificid worm, *Branchiura sowerbyi* | NaPCP | 7.0 | 96 hr | LC50 (with sediment) | 515.5 | Chapman et al. 1982a |
| Tubificid worm, *Limnodrilus hoffmeisteri* | NaPCP | 7.0 | 96 hr | LC50 (with sediment) | 1,150 | Chapman et al. 1982a |
| Tubificid worm, *Quistradrilus multisetosus* | NaPCP | 7.0 | 96 hr | LC50 (with sediment) | 846.9 | Chapman et al. 1982a |
| Tubificid worm, *Spirosperma nikolskyi* | NaPCP | 7.0 | 96 hr | LC50 (with sediment) | 3,314 | Chapman et al. 1982a |
| Tubificid worm, *Stylodrilus heringianus* | NaPCP | 7.0 | 96 hr | LC50 (with sediment) | 1,243 | Chapman et al. 1982a |
| Tubificid worm, *Tubifex tubifex* | NaPCP | 7.0 | 96 hr | LC50 (with sediment) | 754.8 | Chapman et al. 1982a |
| Mixed tubificid worms, *Tubifex tubifex* and *Limnodrilus hoffmeisteri* | NaPCP | 7.0 | 96 hr | LC50 | 533.9 | Chapman et al. 1982c |
| Mixed tubificid worms, *Tubifex tubifex* and *Limnodrilus hoffmeisteri* | NaPCP | 7.5 | 24 hr | LC50 | 290 | Whitley 1968 |
| Mixed tubificid worms, *Tubifex tubifex* and *Limnodrilus hoffmeisteri* | NaPCP | 8.5 | 24 hr | LC50 | 620 | Whitley 1968 |
| Mixed tubificid worms, *Tubifex tubifex* and *Limnodrilus hoffmeisteri* | NaPCP | 9.5 | 24 hr | LC50 | 1,290 | Whitley 1968 |

Table 6. (Continued)

| Species | Chemical[a] | pH | Duration | Effect | Concentration (µg/L)[aa] | Reference |
|---|---|---|---|---|---|---|
| Snail, *Lymnaea stagnalis* | PCP (>98%) | - | 48 hr | LC50 | 560 | Slooff 1983 |
| Snail, *Lymnaea stagnalis* | PCP | - | 40 days | Reduced hatching | 3.2-10 | Slooff and Canton 1983 |
| Snail, *Physa gyrina* | Dowicide EC-7 (93.7% PCP) | 7.7-7.9 | 96 hr | LC50 (river water) | 1,380 | Hedtke et al. 1986 |
| Snail, *Physa gyrina* | Dowicide EC-7 (93.7% PCP) | 7.8-8.5 | 12 wk | Reduced population density | 365 | Zischke et al.1985 |
| Snail, *Physa gyrina* | Dowicide EC-7 (93.7% PCP) | 7.6-8.0 | 96 hr | LC50 (river water) | 1,250 | Hedtke et al. 1986 |
| Snail, *Physa gyrina* | Dowicide EC-7 (93.7% PCP) | 7.7-8.1 | 96 hr | LC50 (river water) | 730 | Hedtke and Arthur 1985; Hedtke et al. 1986 |
| Snail, *Physa gyrina* | Dowicide EC-7 (93.7% PCP) | 8.2-8.4 | 96 hr | LC50 (river water) | 620 | Hedtke et al. 1986 |
| Snail, *Physa gyrina* | Dowicide EC-7 (93.7% PCP) | 8.0-8.2 | 96 hr | LC50 (river water) | 220 | Hedtke et al. 1986 |
| Snail, *Physa gyrina* | Dowicide EC-7 (93.7% PCP) | 7.9-8.1 | 96 hr | LC50 (river water) | 260 | Hedtke et al. 1986 |
| Snail, *Physa gyrina* | Dowicide EC-7 (93.7% PCP) | 7.8-7.9 | 96 hr | LC50 (river water) | 580 | Hedtke et al. 1986 |
| Snail, *Physa gyrina* | Dowicide EC-7 (93.7% PCP) | 7.7-7.9 | 96 hr | LC50 (river water) | 810 | Hedtke et al. 1986 |
| Cladoceran, *Ceriodaphnia affinis/dubia* | Dowicide EC-7 (93.7% PCP) | 7.9-8.0 | 7 days | MATC (river water) | 110 | Hedtke et al. 1986 |
| Cladoceran, *Ceriodaphnia affinis/dubia* | Dowicide EC-7 (93.7% PCP) | 8.0 | 48 hr | LC50 (river water) | 307 | Hedtke et al. 1986 |
| Cladoceran, *Ceriodaphnia affinis/dubia* | Dowicide EC-7 (93.7% PCP) | 7.9-8.0 | 48 hr | LC50 (river water) | 347 | Hedtke et al. 1986 |

Table 6. (Continued)

| Species | Chemical* | pH | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Cladoceran, *Ceriodaphnia reticulata* | Dowicide EC-7 (93.7% PCP) | 7.8-7.9 | 48 hr | LC50 (river water) | 240 | Hedtke et al. 1986 |
| Cladoceran, *Ceriodaphnia reticulata* | Dowicide EC-7 (93.7% PCP) | 7.8-8.0 | 48 hr | LC50 (river water) | 700 | Hedtke et al. 1986 |
| Cladoceran, *Daphnia magna* | PCP | - | 21 days | LC50 | 480 | Adema 1978 |
| Cladoceran, *Daphnia magna* | PCP | - | 21 days | LC50 | 510 | Adema 1978 |
| Cladoceran, *Daphnia magna* | PCP | - | 21 days | LC50 | 400 | Adema 1978 |
| Cladoceran, *Daphnia magna* | PCP | - | 21 days | LC50 | 470 | Adema 1978 |
| Cladoceran, *Daphnia magna* | PCP | - | 21 days | LC50 | 430 | Adema 1978 |
| Cladoceran, *Daphnia magna* | PCP | - | 21 days | LC50 | 490 | Adema 1978 |
| Cladoceran, *Daphnia magna* | PCP | - | 21 days | LC50 | 170 | Adema 1978 |
| Cladoceran, *Daphnia magna* | PCP | - | 21 days | LC50 | 190 | Adema 1978 |
| Cladoceran, *Daphnia magna* | PCP | - | 14 days | LC50 | 440 | Adema 1978 |
| Cladoceran, *Daphnia magna* | PCP | - | 14 days | LC50 | 460 | Adema 1978 |
| Cladoceran, *Daphnia magna* | PCP | - | 21 days | No effect on reproduction | 340 | Adema and Vink 1981 |
| Cladoceran, *Daphnia magna* | PCP | - | 21 days | Reduced survival and reproduction | 100-320 | Slooff and Canton 1983 |

Table 6. (Continued)

| Species | Chemical* | pH | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Cladoceran (<24 hr), Daphnia magna | - | - | 16 days | EC50 (reproduction) | 150 | Hermens et al. 1984 |
| Cladoceran (6 d), Daphnia magna | PCP (99+%) | 7.9 | 48 hr | EC50 (river water) | 254 | Brooke et al. Manuscript |
| Cladoceran (6 d), Daphnia magna | PCP (99+%) | 7.6 | 48 hr | EC50 (river water) | 599 | Brooke et al. Manuscript |
| Cladoceran, Simocephalus vetulus | Dowicide EC-7 (93.7% PCP) | 7.8-7.9 | 48 hr | LC50 (river water) | 670 | Hedtke and Arthur 1985; Hedtke et al. 1986 |
| Cladoceran, Simocephalus vetulus | Dowicide EC-7 (93.7% PCP) | 8.0 | 48 hr | LC50 (river water) | 204 | Hedtke et al. 1986 |
| Isopod, Asellus racovitzai | Dowicide EC-7 (93.7% PCP) | 7.7-7.9 | 96 hr | LC50 (river water) | >7,770 | Hedtke et al. 1986 |
| Isopod, Asellus racovitzai | Dowicide EC-7 (93.7% PCP) | 7.6-8.0 | 96 hr | LC50 (river water) | 4,320 | Hedtke et al. 1986 |
| Isopod, Asellus racovitzai | Dowicide EC-7 (93.7% PCP) | 7.7-8.1 | 96 hr | LC50 (river water) | 2,370 | Hedtke and Arthur 1985; Hedtke et al. 1986 |
| Isopod, Asellus racovitzai | Dowicide EC-7 (93.7% PCP) | 7.8-7.9 | 96 hr | LC50 (river water) | 3,400 | Hedtke et al. 1986 |
| Amphipod, Crangonyx pseudogracilis | Dowicide EC-7 (93.7% PCP) | 7.7-7.9 | 96 hr | LC50 (river water) | 3,120 | Hedtke et al. 1986 |
| Amphipod, Crangonyx pseudogracilis | Dowicide EC-7 (93.7% PCP) | 7.7-8.1 | 96 hr | LC50 (river water) | 2,770 | Hedtke et al. 1986 |
| Amphipod, Crangonyx pseudogracilis | Dowicide EC-7 (93.7% PCP) | 7.7-8.1 | 96 hr | LC50 (river water) | 1,890 | Hedtke and Arthur 1985; Hedtke et al. 1986 |
| Amphipod, Crangonyx pseudogracilis | Dowicide EC-7 (93.7% PCP) | 8.2-8.4 | 96 hr | LC50 (river water) | 500 | Hedtke et al. 1986 |
| Amphipod, Crangonyx pseudogracilis | Dowicide EC-7 (93.7% PCP) | 8.0-8.1 | 96 hr | LC50 (river water) | 320 | Hedtke et al. 1986 |

Table 6. (Continued)

| Species | Chemical* | pH | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Amphipod, *Crangonyx pseudogracilis* | Dowicide EC-7 (93.7% PCP) | 8.0-8.1 | 96 hr | LC50 (river water) | 220 | Hedtke et al. 1986 |
| Amphipod, *Crangonyx psedogracilis* | Dowicide EC-7 (93.7% PCP) | 7.8-7.9 | 96 hr | LC50 (river water) | 1,550 | Hedtke et al. 1985 |
| Amphipod, *Crangonyx pseudogracilis* | Dowicide EC-7 (93.7% PCP) | 7.7-7.9 | 96 hr | LC50 (rver water) | 2,000 | Hedtke et al. 1986 |
| Amphipod (11 mm), *Gammarus pseudolimnaeus* | PCP (99+%) | 7.9 | 96 hr | LC50 (river water) | 451 | Brooke et al. Manuscript |
| Amphipod (11 mm), *Gammarus pseudolimnaeus* | PCP (99+%) | 7.6 | 96 hr | LC50 (river water) | 450 | Brooke et al. Manuscript |
| Amphipod, *Hyalella azteca* | PCP (99+%) | 7.9 | 96 hr | LC50 (river water) | 286 | Brooke et al. Manuscript |
| Amphipod, *Hyalella azteca* | PCP (99+%) | 7.6 | 96 hr | LC50 (river water) | 353 | Brooke et al. Manuscript |
| Mayfly, *Callibaetis skokianus* | Dowicide EC-7 (93.7% PCP) | 7.5-7.7 | 96 hr | LC50 (river water) | 1,780 | Hedtke and Arthur 1985; Hedtke et al. 1986 |
| Mayfly, *Callibaetis skokianus* | Dowicide EC-7 (93.7% PCP) | 7.8-7.9 | 96 hr | LC50 (river water) | 1,300 | Hedtke et al. 1986 |
| Mayfly (larvae), *Cloeon dipterum* | PCP (>98%) | - | 48 hr | LC50 | 5,900 | Slooff 1983 |
| Caddisfly, *Philarctus quaeris* | Dowicide EC-7 (93.7% PCP) | 7.5-7.7 | 96 hr | LC50 (river water) | 1,260 | Hedtke and Arthur 1985; Hedtke et al. 1986 |
| Sciomyzid fly (1st instar), *Sepedon fuscipennis* | NaPCP (90%) | - | 96 hr | LC50 (fed) | 2,200 | McCoy and Joy 1977 |
| Mosquito (1st instar), *Culex pipiens* | PCP | - | 25 days | Reduced survival and development | 3,200-10,000 | Slooff and Canton 1983 |

Table 6. (Continued)

| Species | Chemical* | pH | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Midge (4th instar), *Chironomus riparius* | PCP (97%) | 7.0 | 24 hr (15°C) (25°C) (35°C) | LC50 | 1,176 1,556 631 | Fisher 1986 |
| Midge (4th instar), *Chironomus riparius* | PCP (reagent grade) | 4.0 6.0 9.0 | 24 hr | LC50 | 384 465 1,948 | Fisher and Wadleigh 1986 |
| Sockeye salmon (<1 yr), *Oncorhynchus nerka* | NaPCP | 6.8 | 21 days | LC50 | 57 | Webb and Brett 1973 |
| Sockeye salmon (<1 yr), *Oncorhynchus nerka* | NaPCP | 6.8 | 42 days | 10% growth inhibition | 3.2 | Webb and Brett 1973 |
| Sockeye salmon (<1 yr), *Oncorhynchus nerka* | NaPCP | 6.8 | 56 days | EC50 (growth) | 1.74 | Webb and Brett 1973 |
| Sockeye salmon (<1 yr), *Oncorhynchus nerka* | NaPCP | 6.8 | 56 days | EC50 (food conversion) | 1.80 | Webb and Brett 1973 |
| Chinook salmon (juvenile), *Oncorhynchus tschawytscha* | NaPCP | 7.0–7.1 | 96 hr | LC50 (high loading) | 72 | Iwama and Greer 1979 |
| Chinook salmon (juvenile), *Oncorhynchus tschawytscha* | - | 6.5–6.9 | 8 days | LC100 (with bacterial disease injection) | 36 | Iwama and Greer 1982 |
| Rainbow trout (alevin), *Salmo gairdneri* | Santobrite (>90% NaPCP) | - | 20 days | 11% growth inhibition | 28 | Chapman 1969 |
| Rainbow trout (alevin), *Salmo gairdneri* | Santobrite (>90% NaPCP) | - | 20 days | 18% growth inhibition | 28 | Chapman 1969 |
| Rainbow trout (alevin), *Salmo gairdneri* | Santobrite (>90% NaPCP) | - | 21 days | 18% growth inhibition | 28 | Chapman 1969 |

Table 6. (Continued)

| Species | Chemical[a] | pH | Duration | Effect | Concentration (µg/L)[aa] | Reference |
|---|---|---|---|---|---|---|
| Rainbow trout (alevin), *Salmo gairdneri* | Santobrite (>90% NaPCP) | - | 28 days | 12% growth inhibition | 28 | Chapman 1969 |
| Rainbow trout (embryo and alevin), *Salmo gairdneri* | Santobrite (>90% NaPCP) | - | 41 days | LC100 | 46 | Chapman 1969 |
| Rainbow trout, *Salmo gairdneri* | Santobrite (>90% NaPCP) | 7.8 | Fertilization and yolk sac resorption | 25% mortality | 18 | Chapman and Shumway 1978 |
| Rainbow trout (alevin), *Salmo gairdneri* | Santobrite (>90% NaPCP) | 7.8 | 71 days | 9.1% growth reduction | 18 | Chapman and Shumway 1978 |
| Rainbow trout, *Salmo gairdneri* | - | - | 28 days | 27% growth inhibition | 7.4 | Matida et al. 1976 |
| Rainbow trout (2.1-11.4 g), Nisqually strain, *Salmo gairdneri* | - | 7.4-7.7 | 8.8 hr | Median survival time | 250 | Alexander and Clarke 1978 |
| Rainbow trout (2.1-11.4 g), Idaho strain, *Salmo gairdneri* | - | 7.4-7.7 | 7.1 hr | Median survival time | 250 | Alexander and Clarke 1978 |
| Rainbow trout, *Salmo gairdneri* | - | 8.0 | 24 hr | Increased respiration | 70 | Slooff 1979 |
| Rainbow trout, *Salmo gairdneri* | NaPCP | 7.78-7.89 | 4 wk post swim-up | Biomass reduction (lower temperature) | 20-80 | Hodson and Blunt 1981 |
| Rainbow trout, *Salmo gairdneri* | NaPCP | 7.96-8.08 | 4 wk post swim-up | Biomass reduction (higher temperature) | >16 | Hodson and Blunt 1981 |
| Rainbow trout (0.81 g), *Salmo gairdneri* | PCP | 7.9 | 96 hr | LC50 (river water) | 70.1 | Brooke et al. Manuscript |

Table 6. (Continued)

| Species | Chemical* | pH | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Rainbow trout (0.81 g), *Salmo gairdneri* | PCP (99+%) | 7.6 | 96 hr | LC50 (river water) | 85.6 | Brooke et al. Manuscript |
| Atlantic salmon, *Salmo salar* | NaPCP | - | 24 hr | Altered temperature preference | 46 | Peterson 1976 |
| Brown trout (4.5 g), *Salmo trutta* | PCP (99%) | - | 24 hr | LC50 | 200 | Hattula et al. 1981 |
| Central stoneroller (10 g), *Campostoma anomalum* | NaPCP | 7.6 | 4.3 hr | LC100 | 400 | Goodnight 1942 |
| Goldfish (1.5 g), *Carasslus auratus* | PCP | - | 24 hr | LC90 | 1,600 | Lemma and Yau 1974 |
| Goldfish (108.0 g), *Carasslus auratus* | PCP | - | 24 hr | LC90 | 1,600 | Lemma and Yau 1974 |
| Goldfish (adult), *Carasslus auratus* | PCP (99+%) | 7.59 | 46 hr | LC50 | 270 | Cardwell et al. 1976 |
| Goldfish (juvenile), *Carasslus auratus* | NaPCP | 7.59 | 21 hr | LC50 | 369 | Cardwell et al. 1976 |
| Goldfish (juvenile), *Carasslus auratus* | NaPCP | 7.59 | 120 hr | LC50 | 253 | Cardwell et al. 1976 |
| Goldfish (juvenile), *Carasslus auratus* | NaPCP | 7.59 | 336 hr | LC50 | 189 | Cardwell et al. 1976 |
| Goldfish (2 g), *Carasslus auratus* | - | - | 24 hr | LC50 | 270 | Kobayashi et al. 1979 |
| Goldfish (1.3 g), *Carasslus auratus* | - | 5.5 | 24 hr | LC50 | 52 | Kobayashi and Kishino 1980 |
| Goldfish (1.3 g), *Carasslus auratus* | - | 6 | 24 hr | LC50 | 60 | Kobayashi and Kishino 1980 |
| Goldfish (1.3 g), *Carasslus auratus* | - | 7 | 24 hr | LC50 | 82 | Kobayashi and Kishino 1980 |

Table 6. (Continued)

| Species | Chemical* | pH | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Goldfish (1.3 g), *Carassius auratus* | - | 8 | 24 hr | LC50 | 250 | Kobayashi and Kishino 1980 |
| Goldfish (1.3 g), *Carassius auratus* | - | 9 | 24 hr | LC50 | 2,200 | Kobayashi and Kishino 1980 |
| Goldfish (1.3 g), *Carassius auratus* | - | 10 | 24 hr | LC50 | 16,000 | Kobayashi and Kishino 1980 |
| Common carp (eyed embryo), *Cyprinus carpio* | PCP | - | 24 hr | LC50 | 180 | Hashimoto et al. 1982 |
| Common carp (1-3 days), *Cyprinus carpio* | PCP | - | 24 hr | LC50 | 140 | Hashimoto et al. 1982 |
| Common carp (5-6 days), *Cyprinus carpio* | PCP | - | 24 hr | LC50 | 150 | Hashimoto et al. 1982 |
| Common carp (9-10 days), *Cyprinus carpio* | PCP | - | 24 hr | LC50 | 130 | Hashimoto et al. 1982 |
| Common carp (17-19 days), *Cyprinus carpio* | PCP | - | 24 hr | LC50 | 110 | Hashimoto et al. 1982 |
| Common carp (25-33 days), *Cyprinus carpio* | PCP | - | 24 hr | LC50 | 100 | Hashimoto et al. 1982 |
| Common carp (50-60 days), *Cyprinus carpio* | PCP | - | 24 hr | LC50 | 110 | Hashimoto et al. 1982 |
| Common carp (70-80 days), *Cyprinus carpio* | PCP | - | 24 hr | LC50 | 110 | Hashimoto et al. 1982 |
| Common carp (15.1-28.8 g), *Cyprinus carpio* | PCP | - | 50 min | LT50 | 3,000 | Peer et al. 1983 |
| Silverjaw minnow (2 g), *Ericymba buccata* | NaPCP | 7.6 | 6.25 hr | LC100 | 400 | Goodnight 1942 |
| Redfin shiner (2 g), *Notropis umbratilis* | NaPCP | 7.6 | 2.67 hr | LC100 | 600 | Goodnight 1942 |

Table 6. (Continued)

| Species | Chemical* | pH | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Steelcolor shiner (2 g), *Notropis ahippiwi* | NaPCP | 7.6 | 5.25 hr | LC100 | 400 | Goodnight 1942 |
| Bluntnose minnow (3 g), *Pimephales notatus* | NaPCP | 7.6 | 7.45 hr | LC100 | 400 | Goodnight 1942 |
| Fathead minnow (2 inches), *Pimephales promelas* | NaPCP | 7.4-7.5 | 24 hr | LC50 | 300-320 | Crandall and Goodnight 1959 |
| Fathead minnow (juvenile), *Pimephales promelas* | NaPCP | 7.83 | 336 hr | LC50 | 153 | Cardwell et al. 1976 |
| Fathead minnow, *Pimephales promelas* | PCP | - | 48 hr | LC50 | 210 | Slooff 1982 |
| Fathead minnow, *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 7.7-8.4 | 12 wk | Reduced growth and larval drift | 111 | Zischke et al. 1985 |
| Fathead minnow (adult), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 8.0-8.1 | 96 hr | LC50 (river water) | 300 | Hedtke et al. 1986 |
| Fathead minnow (adult), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 7.9-8.2 | 96 hr | LC50 (river water) | 190 | Hedtke et al. 1986 |
| Fathead minnow (adult), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 7.9-8.1 | 96 hr | LC50 (river water) | 170 | Hedtke et al. 1986 |
| Fathead minnow (adult), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 8.0-8.2 | 96 hr | LC50 (river water) | 160 | Hedtke et al. 1986 |
| Fathead minnow (adult), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 7.7-8.1 | 96 hr | LC50 (river water) | 120 | Hedtke et al. 1986 |
| Fathead minnow (adult), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 7.9-8.1 | 96 hr | LC50 (river water) | 208 | Hedtke and Arthur 1985; Hedtke et al. 1986 |
| Fathead minnow (adult), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 7.4-7.9 | 96 hr | LC50 (river water) | 120 | Hedtke et al. 1986 |
| Fathead minnow (juvenile), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 7.8-8.2 | 96 hr | LC50 (river) water) | 396 | Hedtke et al. 1986 |

Table 6. (Continued)

| Species | Chemical* | pH | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Fathead minnow (juvenile), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 7.8-8.1 | 96 hr | LC50 (river water) | 510 | Hedtke et al. 1986 |
| Fathead minnow (fry), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 7.9-8.2 | 96 hr | LC50 (river water) | 314 | Hedtke et al. 1986 |
| Fathead minnow (embryo), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 7.8-8.1 | 96 hr | LC50 (river water) | 465 | Hedtke et al. 1986 |
| Fathead minnow (embryo), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 8.0-8.1 | 96 hr | LC50 (river water) | 480 | Hedtke et al. 1986 |
| Fathead minnow (embryo, fry), *Pimephales promelas* | Dowicide EC-7 (93.7% PCP) | 7.8-8.1 | 32 days | Reduced survival or growth (river water) | 118-176 | Hedtke et al. 1986 |
| Fathead minnow (<2 wk), *Pimephales promelas* | PCP (purified; 99%) | 7.4 | 90 days | Decreased growth 24% | 85 | Cleveland et al. 1982 |
| | | | | Decreased growth 18% | 142 | |
| Fathead minnow (<2 wk), *Pimephales promelas* | Dowicide EC-7 (91%) | 7.4 | 90 days | Increased growth 18% | 60 | Cleveland et al. 1982 |
| | | | | Increased growth 21% | 139 | |
| Fathead minnow (<2 wk), *Pimephales promelas* | PCP (industrial composite) | 7.4 | 90 days | Decreased growth 20% | 13 | Cleveland et al. 1982 |
| | | | | Decreased growth 40% | 27 | |
| | | | | 100% mortality | 67 | |
| Fathead minnow (7 day), *Pimephales promelas* | PCP (ultrapure) | 7.4 | 90 days | Reduced growth 10% | 66 | Hamilton et al. 1986 |
| | | | | Reduced growth 17% | 130 | |
| Creek chub (12 g), *Semotilus atromaculatus* | NaPCP | 7.6 | 3.92 hr | LC100 | 600 | Goodnight 1942 |
| White sucker, *Catostomus commersoni* | Dowicide EC-7 (93.7% PCP) | 7.7-8.2 | 96 hr | LC50 (river water) | 85 | Hedtke et al. 1986 |

Table 6. (Continued)

| Species | Chemical[a] | pH | Duration | Effect | Concentration (µg/L)[a] | Reference |
|---|---|---|---|---|---|---|
| Blackstripe topminnow (3 g), *Fundulus notatus* | NaPCP | 7.6 | 9.75 hr | LC100 | 800 | Goodnight 1942 |
| Guppy, *Poecilia reticulata* | NaPCP | 8.4-8.6 | 180 days | Damaged liver and kidney | 462 | Crandall and Goodnight 1962,1963 |
| Guppy, *Poecilia reticulata* | PCP | - | 60 days | No effect on growth | 180 | Adema and Vink 1981 |
| Guppy, *Poecilia reticulata* | PCP | - | 28 days | Reduced growth | 100-320 | Slooff and Canton 1983 |
| Guppy (2-3 mo), *Poecilia reticulata* | - | 7.7 | 24 hr | LC50 | 40 | Benoit-Guyod et al. 1984a |
| Threespine stickleback (0.6 g), *Gasterosteus aculeatus* | PCP | - | 24 hr | LC90 | 370 | Lemma and Yau 1974 |
| Orangespotted sunfish (2 g), *Lepomis humilis* | NaPCP | 7.6 | 6.75 hr | LC100 | 400 | Goodnight 1942 |
| Bluegill (juvenile), *Lepomis macrochirus* | PCP (99+%) | 7.94 | 30 hr | LC50 | 303 | Cardwell et al. 1976 |
| Bluegill (juvenile), *Lepomis macrochirus* | PCP (99+%) | 7.94 | 336 hr | LC50 | 215 | Cardwell et al. 1976 |
| Bluegill, *Lepomis macrochirus* | Dowicide EC-7 (93.7% PCP) | 7.7-7.9 | 96 hr | LC50 (river water) | 200 | Hedtke and Arthur 1985; Hedtke et al. 1986 |
| Bluegill, *Lepomis macrochirus* | Dowicide EC-7 (93.7% PCP) | 7.8-7.9 | 96 hr | LC50 (river water) | 270 | Hedtke et al. 1986 |
| Bluegill, *Lepomis macrochirus* | Dowicide EC-7 (93.7% PCP) | 7.6-8.6 | 12 wk | Reduced growth and larval drift | 40 | Zischke et al. 1985 |

Table 6. (Continued)

| Species | Chemical* | pH | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Largemouth bass, *Micropterus salmoides* | - | 7.0 | <4 hr | Threshold opercular rhythm response | 47<br>50 | Morgan 1976, 1977 |
| Largemouth bass (4.1 g), *Micropterus salmoides* | PCP (99%) | 7.2 | 7 days | Reduced growth rate and food conversion efficiency | 50.4 | Mathers et al. 1985 |
| Mozambique tilapia (2.0 g), *Tilapia mossambica* | PCP | - | 24 hr | LC90 | 800 | Lemma and Yau 1974 |
| Leopard frog (tadpole), *Rana pipiens* | NaPCP | 7.6 | 9.5 hr | LC100 | 800 | Goodnight 1942 |
| African clawed toad (3-4 wk), *Xenopus laevis* | - | - | 48 hr | LC50 | 260 | Slooff 1982; Slooff and Baerselman 1980 |
| African clawed toad (<2 d), *Xenopus laevis* | PCP | - | 100 days | Reduced survival and growth | 32-100 | Slooff and Canton 1983 |
| | | | SALTWATER SPECIES | | | |
| Photoluminescent bacterium, *Photobacterium phosphoreum* | PCP | - | 5 min | 50 % reduction in light output | 80 | Curtis et al. 1982 |
| Photoluminescent bacterium, *Photobacterium phosphoreum* | PCP | - | 5 min | 50 % reduction in light output | 924 | Ribo and Kaiser 1983 |
| Microfungal populations in microcosms | PCP | 10-17*** | 8 wk | Successional change in microfungal species composition | 140 | Cook et al. 1980 |
| Golden brown alga, *Monochrysis lutheri* | NaPCP | 28.9*** | 12-15 days | Decreased cell numbers | 270.6 | Woelke 1965 |
| Diatom, *Skeletonema costatum* | PCP | 25*** | 7 days | EC50 (cell division) | 2,000 | Erickson and Freemen 1978 |

Table 6. (Continued)

| Species | Chemical* | Salinity (g/kg) | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Diatom, *Thalassiosira pseudonana* | PCP | 25 | 7 days | EC50 (cell division) | 500 | Erickson and Freeman 1978 |
| Diatom, *Thalassiosira pseudonana* | PCP | 26-29 | 24 hr | EC50 (cell division) | 250 | Erickson 1981 |
| Diatom, *Thalassiosira pseudonana* | PCP | 26-29 | 48 hr | EC50 (cell division) | 300 | Erickson 1981 |
| Dinoflagellate, *Glenodinium halii* | PCP | 25 | 7 days | EC50 (cell division) | 1,000 | Erickson and Freeman 1978 |
| Microflagellate, *Isochrysis galbana* | PCP | 25 | 7 days | EC50 (cell division) | 250 | Erickson and Freeman 1978 |
| Sea grass, *Thalassia testudinum* | PCP | 30 | 40 hr | EC50 (reduced oxygen evolution) | 740 | Walsh et al. 1982 |
| Giant kelp, *Macrocystis pyrifera* | PCP | - | 4 days | Photosynthesis inhibition | 2,660 | Lammering and Burbank 1960; reported in Bulkema et al. 1979 |
| Giant kelp, *Macrocystis pyrifera* | PCP | - | 2 days | Photosynthesis inhibition | 1,000 | Lammering and Burbank 1960; reported in Bulkema et al. 1979 |
| Nematodes, (Meiobenthic communities) | Dowicide G-ST | - | 9-13 wk | Decrease in biomass and density; shift in species composition | ≥161 | Cantelmo and Rao 1978b,c |
| Polychaete worm, *Nereis virens* | PCP | 32-35 | 48 hr | Significant decrease in coelomic fluid osmolality, coupled with mortality | 720 | Carr and Neff 1981 |
| Polychaete worm, *Nereis virens* | PCP | 32-35 | 14 days | BCF = 280 | - | Carr and Neff 1981 |

Table 6. (Continued)

| Species | Chemical[a] | Salinity (g/kg) | Duration | Effect | Concentration (µg/L)[aa] | Reference |
|---|---|---|---|---|---|---|
| Polychaete worm, *Nereis virens* | PCP | 32-35 | 2 mo | Significant increase in ascorbic acid levels and significant decrease in glycogen reserves | 100 | Carr and Neff 1981 |
| Polychaete worm, *Ophryotrocha diadema* | PCP | 33 | 37 days | Apparent reduction in reproduction | ≥98 | Hooftman and Vink 1980 |
| Polychaete worm, *Ophryotrocha diadema* | PCP | - | 41 days | EC50 (reproduction) | 23 | Adema and Vink 1981 |
| Polychaete worm, *Ophryotrocha diadema* | PCP | - | 48 days | Apparent reduction in reproduction | ≥11 | Adema and Vink 1981 |
| Polychaete worm (adult), *Arenicola cristata* | Dowicide G-ST | 22-24 | 6 days | Reduced feeding activity | ≥80 | Rubinstein 1978 |
| Japanese littleneck, *Tapes philippinarum* | PCP | - | 120 days | Lethal | 100 | Tomiyama et al. 1962 |
| Japanese littleneck, *Tapes philippinarum* | PCP | - | 24 hr | BCF = 6 to 189 depending on tissue | - | Kobayashi et al. 1969 |
| Common Atlantic slippershell (larva), *Crepidula fornicata* | PCP | - | 7 days | LC50 | 460 | Adema and Vink 1981 |
| Blue mussel (larva), *Mytilus edulis* | NaPCP | 28 | 48 hr | 22.1% abnormal larvae | 369.5 | Dimick and Breese 1965; Woelke 1972 |
| Blue mussel (larva), *Mytilus edulis* | NaPCP | 24 | 48 hr | 69.1% abnormal larvae | 369.5 | Dimick and Breese 1965; Woelke 1972 |

Table 6. (Continued)

| Species | Chemical* | Salinity (g/kg) | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Blue mussel, *Mytilus edulis* | PCP | - | 14 days | LC50 | 750 | Adema and Vink 1981 |
| Eastern oyster (embryo), *Crassostrea virginica* | PCP | - | 48 hr | 100% abnormal larvae | 250-5,000 | Davis and Hidu 1969 |
| Eastern oyster (larva), *Crassostrea virginica* | PCP | - | 14 days | 100% mortality | 100-500 | Davis and Hidu 1969 |
| Eastern oyster (adult), *Crassostrea virginica* | NaPCP | 20.3 | 192 hr | EC50 (growth) | 76.50 | Schimmel et al. 1978 |
| Quahog clam, *Mercenaria mercenaria* | NaPCP | 28-30 | 18 wk | Reduced resistance to bacterial infection | 459.9 | Anderson et al. 1981 |
| Quahog clam, *Mercenaria mercenaria* | NaPCP | 28-30 | 8 wk | BCF = 100 | - | Anderson et al. 1981 |
| Quahog clam, *Mercenaria mercenaria* | NaPCP | 28-30 | 18 wk | BCF = 54 | - | Anderson et al. 1981 |
| Copepod, *Pseudodiaptomus coronatus* | NaPCP | 18 | 96 hr | Significant increase in feeding rate | 74.82 | Hauch et al. 1980 |
| Brown shrimp (adult), *Penaeus aztecus* | NaPCP | 26.5 | 96 hr | BCF = 0.2165 (geometric mean of 4 values) | - | Schimmel et al. 1978 |
| Grass shrimp (adult), *Palaemonetes pugio* | NaPCP | 10 | 12 days | Histological changes (gill necrosis; loss of microvilli and epithelial rupture of midgut and hepatopancreas; and mitochondria compartmentalization) | 923.7 | Doughtie and Rao 1978; Rao and Doughtie 1984 |

Table 6. (Continued)

| Species | Chemical* | Salinity (g/kg) | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Grass shrimp (adult), *Palaemonetes pugio* | NaPCP | 24.3 | 96 hr | BCF = 1,506 (geometric mean of 4 values) | - | Schimmel et al. 1978 |
| Grass shrimp (post molt), *Palaemonetes pugio* | NaPCP | - | 13 hr | 100% mortality, 3 hrs after molt | 4,618 | Cantelmo et al. 1978 |
| Grass shrimp (adult), *Palaemonetes pugio* | NaPCP | 10 | 9 days | 50% reduction in limb regeneration | 436.9<br>521.9 | Rao et al. 1978,1979, 1981 |
| Grass shrimp (adult), *Palaemonetes pugio* | NaPCP | 10 | 96 hr | Significant increase in exuvial dry weight | 923 | Brannon and Conklin 1978 |
| Grass shrimp (adult), *Palaemonetes pugio* | NaPCP | - | 24-36 hr | Significant increase or decrease in oxygen consumption followed by death | ≥9.237 | Cantelmo et al. 1978 |
| Grass shrimp (adult, new molt), *Palaemonetes pugio* | PCP | 10 | 1 hr | BCF = 150 | - | Rao et al. 1981 |
| Grass shrimp (adult, intermolt), *Palaemonetes pugio* | PCP | 10 | 1 hr | BCF = 30 | - | Rao et al. 1981 |
| Longnose killifish, (juvenile), *Fundulus similis* | NaPCP | 22.9 | 96 hr | BCF = 27.03 (geometric mean of 4 values) | - | Schimmel et al. 1978 |
| Striped mullet, *Mugil cephalus* | NaPCP | 25.5 | 96 hr | BCF = 7,446 (geometric mean of lowest two values) | - | Schimmel et al. 1978 |

Table 6. (Continued)

| Species | Chemical* | Salinity (g/kg) | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Striped mullet, *Mugil cephalus* | PCP | 33 | 1-120 hr | Elevation of plasma cortisol concentration, hyperglycemia, depletion of liver glycogen, increase in liver ascorbate concentration | 100-200 | Thomas et al. 1981 |
| Winter flounder, *Pseudopleuronectes americanus* | PCP | - | 15 days | Elevated levels of acid-soluble thiol in liver | 50 | Thomas and Wofford 1984 |
| Benthic macrofauna | PCP | 27 | 5 wk | Significant reduction in species richness and faunal numbers | 55 | Tagatz et al. 1983 |
| Benthic macrofauna | PCP | 16.7 | 9 wk | Significant reduction in species richness and faunal numbers | 76 | Hansen and Tagatz 1980; Tagatz et al. 1977,1980 |
| Benthic macrofauna | PCP | 16.7 | 9 wk | No significant effects on colonization | 7 | Tagatz et al. 1977,1980 |
| Benthic macrofauna | PCP | 18 | 1 wk | Significant reduction in species richness and total faunal numbers | 140<br>141 | Tagatz et al. 1981 |
| Benthic macrofauna | Dowicide G-ST | 22 | 13 wk | Significant reduction in total faunal numbers | 15.8 | Hansen and Tagatz 1980; Tagatz et al. 1978,1980 |

Table 6. (Continued)

| Species | Chemical* | Salinity (g/kg) | Duration | Effect | Concentration (µg/L)** | Reference |
|---|---|---|---|---|---|---|
| Benthic macrofauna | Dowicide G-ST | 22 | 13 wk | No significant effect on colonization | 1.8 | Hansen and Tagatz 1980; Tagatz et al. 1978, 1980 |

* PCP = pentachlorophenol; NaPCP = sodium pentachlorophenate. Percent purity is given in parentheses when available.

** Results are expressed as pentachlorophenol. If the concentrations were not measured and the published results were not reported to be adjusted for purity, the published results were multiplied by the purity if it was reported to be less than 97%.

** Salinity (g/kg), not pH.

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