# QUALITY CRITERIA FOR WATER




U.S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

MONS 058556

*NOTICE*

*This document is a preliminary draft. It has not been formally released by EPA and should not at this stage be construed to represent Agency policy. It is being circulated for comment on its technical accuracy and policy implications.*

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## POLYCHLORINATED BIPHENYLS

CRITERION:

.001 ug/l for freshwater and marine aquatic life and for consumers thereof.

INTRODUCTION:

Polychlorinated biphenyls (PCB's) are a class of compounds produced by the chlorination of biphenyls and are registered under the trade name, Aroclors (R). The degree of chlorination determines their chemical properties, and generally their composition can be identified by the numerical nomenclature, e.g., Aroclor 1242, Aroclor 1254, etc. The first two digits represent the molecular type and the last two digits the average percentage by weight of chlorine (NTIS, 1972).

Except Aroclor 1016

Identification of PCB'S in the presence of organochlorine pesticides such as DDT and DDE has been difficult in the past because of their similar chromatographic characteristics (Risebrough, et al., 1968). In PCB analysis today, the interference of organochlorine hydrocarbons is overcome by sequential column chromatography on Florisil and silica gel (Armour and Burke, 1970; FDA, 1971). Gas-liquid chromatography with highly sensitive and selective detectors has been employed successfully in the detection of PCB's at low levels (Nebecker and Puglisi, 1971).

PCB compounds are slightly soluble in water (50 mg/l at 25° C) soluble in fats, oils, and organic solvents, and resistant to both heat and biological degradation (NTIS, 1972). Typically, the specific gravity, boiling point, and melting point of PCB's increase with their chlorine content. PCB's are relatively non-flammable, have useful cooling,



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insulating, and dielectric properties, and principally are used in the electrical industry in capacitors and transformers.

RATIONALE:

Exposure to PCB's is known to cause skin lesions (Schwartz and Peck, 1943) and to increase liver enzyme activity that may have a secondary effect on reproductive processes (Risebrough, 1969; Street, et al., 1968; Wasserman, et al., 1970). It is not clear whether the effects are due to the PCB's or their contaminants, the chlorinated dibenzofurans, which are highly toxic (Bauer, et al., 1961; Schultz, 1968; Varrett, 1970). While chlorinated dibenzofurans are a by-product of PCB production, it is not known whether they are also produced by the degradation of PCB's (NAS, 1974).

Studies of the Milwaukee River revealed concentrations in ambient water of 2.0 to 2.8 ug/l and residues in fish as high as 405 ug/g PCB (Veith and Lee, 1971). Open water Lake Michigan PCB concentrations have been reported to be less than 0.01 ug/l and near-shore waters were found to have less than 0.1 ug/l; mean residues in coho salmon were about 15 ug/g (Veith, 1973). Veith (1973) found that goldfish, Carassius auratus, in the lower Milwaukee River, Wisconsin, accumulated Aroclor 1248 approximately $0.7 \times 10^5$ to $2 \times 10^5$ times depending upon the liquid content. From both laboratory and river system studies, many aquatic organisms appear to bioconcentrate PCB mixtures containing 3, 4, 5, and 6 chlorine atoms per molecule approximately $3 \times 10^3$ to $2 \times 10^5$ times the concentration in the water. Tissue residues in fathead minnows, Pimephales promelas, ranged from 0.7 ug/g of Aroclor 1248 in control fish to 1036 ug/g of Aroclor 1254 in fish held for 8 months in water containing 4.0 ug/l



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of Aroclor 1254. The latter case indicates a bioconcentration factor of $2.3 \times 10^5$.

On the basis of the FDA action level of 5 ug/g in fish tissue, and both laboratory and field derived bioconcentration levels for fathead minnows, Pimephales promelas, and goldfish, Carassius auratus, in the range of $0.7 \times 10^3$ to $2.3 \times 10^5$, an ambient water concentration of no more than 0.022 ug/l would be permissible. However, lake trout from the Great Lakes larger than 12 inches in length generally contain more than 5 ug/g of PCB's and chub from the Great Lakes generally contain PCB's in amounts approaching or slightly exceeding 5 ug/g. Since monitoring data on the Great Lakes consistently indicate concentrations equal to or less than .01 ug/l, a criterion of less than 0.01 ug/l for all fishes appears necessary.

Bluegill sunfish, Lepomis macrochirus, exposed to Aroclors 1248 and 1254 exhibited a bioaccumulation factor of $7.1 \times 10^4$ (Stalling and Mayer, 1972). The bioaccumulation factor for gizzard shad, Dorosoma cepedianum, in the Saginaw River (Michigan) varied between $0.6 \times 10^5$ and $1.5 \times 10^5$ for Aroclor 1254 (Michigan Water Resource Commission, 1973). A residue level of 2 ug/g in fish consumed by commercial ranch mink has been shown to preclude survival of mink offspring (Ringer, et al., 1972). Reproduction was nearly eliminated in ranch mink fed a beef diet containing 0.64 ug/g of Aroclor 1254 (Platonow and Kalstad, 1973). This suggests that a tissue level limit of not more than 0.5 ug/g would be required to protect ranch mink, and by implication, other carnivorous mammals. These data, plus the fact that lake trout from the Great



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Lakes (in water with PCB levels equal to or less than 0.01 ug/l) already exceed the 5 ug/g FDA limit, justify a fresh water criterion of not greater than 0.001 ug/l.

Median PCB concentrations in whole fish of eight species from Long Island Sound obtained in 1970 were reported to be on the order of 1 ug/g, as were comparable concentrations found in fish off the coast of Southern California (Hays and Risebrough, 1972; Risebrough, 1969). Generally, residues in ocean fish have been below 1 ug/g (Risebrough, 1970).

Surveys of Escambia Bay (Florida) during the period September 1969 to December 1971 produced data on the pathways and effects of PCB's in the estuarine and marine environments. The sediment reservoir of Aroclor 1254 is thought to be a continuing source of PCB's to aquatic biota. The initial survey of Escambia Bay biota revealed fish, shrimp, and crabs with levels as high as 12 ug/g. Higher levels of PCB's were detected in higher trophic levels than shrimp, which could implicate a chain transfer from sediment to large animals.

From the Escambia Bay data, which include flow-through bioassays with residue analyses where possible, the following conclusions were reached: (1) all of the Aroclors tested are acutely toxic for certain estuarine organisms; (2) bioassays lasting longer than 96 hours demonstrated that Aroclor 1254 is toxic to commercial shrimp at less than 1 ug/l; (3) fish, particularly sheepshead minnows, Cyprinodon variegatus, are extremely sensitive to Aroclor 1254 with 0.1 ug/l being lethal to fry; and, (4) acute toxicity of Aroclor 1016 to estuarine organisms is similar to that of other Aroclors but it appears less toxic to fish in long-term exposures than does Aroclor 1254 (Duke, 1974; Schimmel, et al., 1974).



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Oysters, Crassostrea virginica, were sensitive to Aroclor 1260 with growth diminished by 44 percent in concentrations of 10 ug/l and by 52 percent in 100 ug/l. Approximately 10 percent of the pink shrimp, Penaeus duorarum, died in 100 ug/l, but no apparent effects on pinfish, Lagodon rhomboides, were noted at that concentration. Aroclor 1254 had no apparent effect on juvenile pinfish at 100 ug/l in 48-hour flow-through tests, but killed 100 percent of the pink shrimp. At 100 ug/l of Aroclor 1254 for 96 hours, shell growth of oysters was inhibited and was decreased 41 percent at levels of 10 ug/l. The toxicity of Aroclors 1248 and 1242 to shrimp and pinfish was similar to that of Aroclor 1254. Aroclor 1242 was toxic to oysters at 100 ug/l. Killifish, Fundulus heteroclitus, exposed to 25 ug/l of Aroclor 1221 suffered 85 percent mortality. In 96-hour bioassays, Aroclor 1016 was toxic to an estimated 50 percent of the oysters, Crassostrea virginica; brown shrimp, Penaeus aztecus; and grass shrimp, Paleomonetes pugio, at 10 ug/l; it was toxic to 18 percent of the pinfish at 100 ug/l (Duke, 1974).

Young oysters, Crassostrea virginica, exposed to Aroclor 1254 in flowing sea water for 24 weeks experienced reduction in growth rates at 4.0 ug/l, but apparently were not affected by 1.0 ug/l. Oysters accumulated as much as 100,000 times the test-water concentration of 1.0 ug/l. General tissue alterations in the vesicular connective tissue around the diverticula of the hepatopancreas were noted in the oysters exposed to 5.0 ug/l. No significant mortality was observed in oysters exposed continuously to 0.01 ug/l of Aroclor 1254 for 56 weeks (Duke, 1974).

Blue crabs, Callinectes sapidus, apparently were not affected by 20 days' exposure to 5.0 ug/l of Aroclor 1254. Pink shrimp exposed under



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similar conditions experienced a 72 percent mortality. In subsequent flow-through bioassays, 51 percent of the juvenile shrimp were killed by Aroclor 1254 in 15 days and 50 percent of the adult shrimp were killed at 3.0 ug/l in 35 days. From pathological examinations of the exposed pink shrimp, it appears that Aroclor 1254 facilitates or enhances the susceptibility to latent viral infections. Aroclor 1254 was lethal to grass shrimp, Paleomonetes pugio, at 4.0 ug/l in 16 days, to amphipods at 10 ug/l in 30 days, and to juvenile spot, Leiostomus xanthurus, at 5.0 ug/l after 20 to 45 days. Sheepshead minnows, Cyprinodon variegatus, were the most sensitive estuarine organisms to Aroclor 1254 with 0.3 ug/l lethal to the fry within 2 weeks. Aroclor 1016, in two different 42-day flow-through bioassays, caused significant mortalities of pinfish at 32 ug/l and 21 ug/l. Pathological examination of those exposed to 32 ug/l revealed several liver and pancreatic alterations. Sheepshead minnows in 28-day Aroclor 1016 flow-through bioassays were not affected by concentrations of 10 ug/l or less, but died at 32 and 100 ug/l (Duke, 1974). The bioaccumulation factors determined by the flow-through bioassays are:

| Aroclor | Organism | Time | Accumulation Factors (as a multiplier of test water concentrations) |
|---|---|---|---|
| 1254 | Oyster (Crassostrea virginica) | 30 days | $1.01 \times 10^5$ |
| 1254 | Blue crab (Callinectes sapidus) | 20 days | $4 \times 10^3$ |
| 1254 | Grass shrimp (Paleomonetes pugio) | 7 days | $3.2 \times 10^3$ to $11 \times 10^3$ |
| 1254 | Spot (Leiostomas xanthurus) | 14-28 days | $37 \times 10^3$ |



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| | | | |
|---|---|---|---|
| 1254 | Pinfish (Lagodon rhomboides) | 35 days | $21.8 \times 10^3$ |
| 1016 | Pinfish (Lagodon rhomboides) | 42 days | $11 \times 10^3$ to $24 \times 10^3$ |
| 1016 | Sheepshead minnow (Cyprinodon variegatus) | | $2.5 \times 10^3$ to $8.1 \times 10^3$ |

Based upon an accumulation factor of 100,000 in the oyster, it is necessary to limit the marine water concentration of PCB's to a maximum of 0.01 ug/l to protect the human consumer. Data on the toxicity of Aroclor 1254 to sheepshead minnow fry mentioned earlier (Schimmel, et al., 1974), however, indicating lethality at 0.1 ug/l, justify lowering the latter concentration by a factor of 0.01 to obtain a marine criterion of 0.001 ug/l. This level is further supported by the evidence cited earlier suggesting that a food tissue level of 0.5 ug/g, or 0.1 times the FDA level for human consumption, is necessary to protect carnivorous mammals.

Evidence is accumulating that PCB's do not contribute to shell thinning of bird eggs (NAS, 1974). Dietary PCB's produced no shell thinning in eggs of mallard ducks (Heath, et al., 1972). PCB's may increase susceptibility to infectious agents such as viral diseases (Friend and Trainer, 1970), and increase the activity of liver enzymes that degrade steroids, including sex hormones (Risebrough, et al., 1968; Street, et al., 1968). Laboratory studies have indicated that PCB's with their derivatives or metabolites, cause embryonic death of birds (Voss and Koeman, 1970).



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