UNITED STATES GEOLOGICAL SURVEY

Chlordane, DDT, PCB's, and Other Selected Organic Compounds in Asiatic Clams and Yellow Bullhead in the Potomac River Basin, 1992

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ABSTRACT

Chlordane, DDT (dichlor-diphenyl-trichloroethane), and PCB's (polychlorinated biphenyls) were the most widespread organic contaminants detected during a 1992 survey of aquatic biological tissues in the Potomac River Basin. On the basis of existing U.S. Food and Drug Administration criteria, no new threats to human health were discovered, although chlordane concentrations may pose a threat to fish-eating wildlife. Chlordane exceeded the National Academy of Sciences and National Academy of Engineering recommended maximum concentration for the protection of fish-eating wildlife at two sites.

The survey, conducted by the U.S. Geological Survey's National Water-Quality Assessment Program, sampled Asiatic clams (Corbicula fluminea) and yellow bullhead (Ameiurus natalis) at 16 sites to determine the occurrence and distribution of 29 hydrophobic organic compounds. Thirteen of these organic compounds were detected in the survey. Sites with the greatest number of compounds detected include the Potomac River near Alexandria, Va., with 6 compounds detected in Asiatic clam tissue, and Accotink Creek near Annandale, Va., with 11 compounds in yellow bullhead tissue.

Chlordane was detected at six sites, with maximum concentrations of 31.1 µg/kg (micrograms per kilograms) in Asiatic clam tissue and 127 µg/kg in yellow bullhead whole-fish tissue. DDT was detected at five sites, with maximum concentrations of 12.9 µg/kg in Asiatic clam tissue and 7.6 µg/kg in yellow bullhead whole-fish tissue. PCB's were detected at nine sites, with maximum concentrations of 162 µg/kg in Asiatic clam tissue and 146 µg/ kg in yellow bullhead whole-fish tissue.

INTRODUCTION

The Potomac River Basin is one of 20 study units in the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program that began investigations in 1991. The NAWQA Program is designed to assess the Nation's water quality through an integrated approach using physical, chemical, and biological measurements.

A basinwide survey was conducted as part of NAWQA's integrated assessment of water quality within the Potomac River Basin. Biotic tissues and streambed sediments were sampled at 22 sites to describe the occurrence and distribution of selected trace elements and hydrophobic organic compounds (fig. 1). Sites were selected that represent the major physical settings, drainage basins, different land uses, and areas of known contamination. The drainage areas for the sampling sites ranged from about 20 to nearly 12,000 square miles (table 1).

Biotic tissues from 16 sites were sampled in 1992 during low streamflow conditions (table 1). Streambed sediment was collected at all 22 sites and biotic tissues at 16 sites (table 1). Asiatic clams (*Corbicula fluminea*) were collected at 14 of the 16 sites and yellow bullhead (*Ameiurus natalis*) at 7 sites. Both Asiatic clam and yellow bullhead were collected at 5 sites (table 1).

Biotic tissues were analyzed for 24 trace elements and 29 organic compounds. Streambed-sediment samples were analyzed for 45 trace elements and 200 organic compounds. Trace element and streambed sediment data are not included in this report. These data are available at the USGS office at Baltimore, Maryland.

The organic compounds analyzed for in biotic tissues were aldrin, dacthal (DCPA), dichlor-diphenyl-trichloroethane (DDT) and its metabolites, dieldrin, endrin, heptachlor, heptachlor epoxide, hexachlorocyclopentadiene, hexachlorobenzene (HCB), hexachlorobutadiene, mirex, polychlorinated biphenyls (PCB's), pentachloroanisol (PCA), and isomers of chlordane, hexachlorocyclohexane (HCH), and methoxychlor. For the purposes of this report, chlordane is defined as the sum of cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane, and DDT is

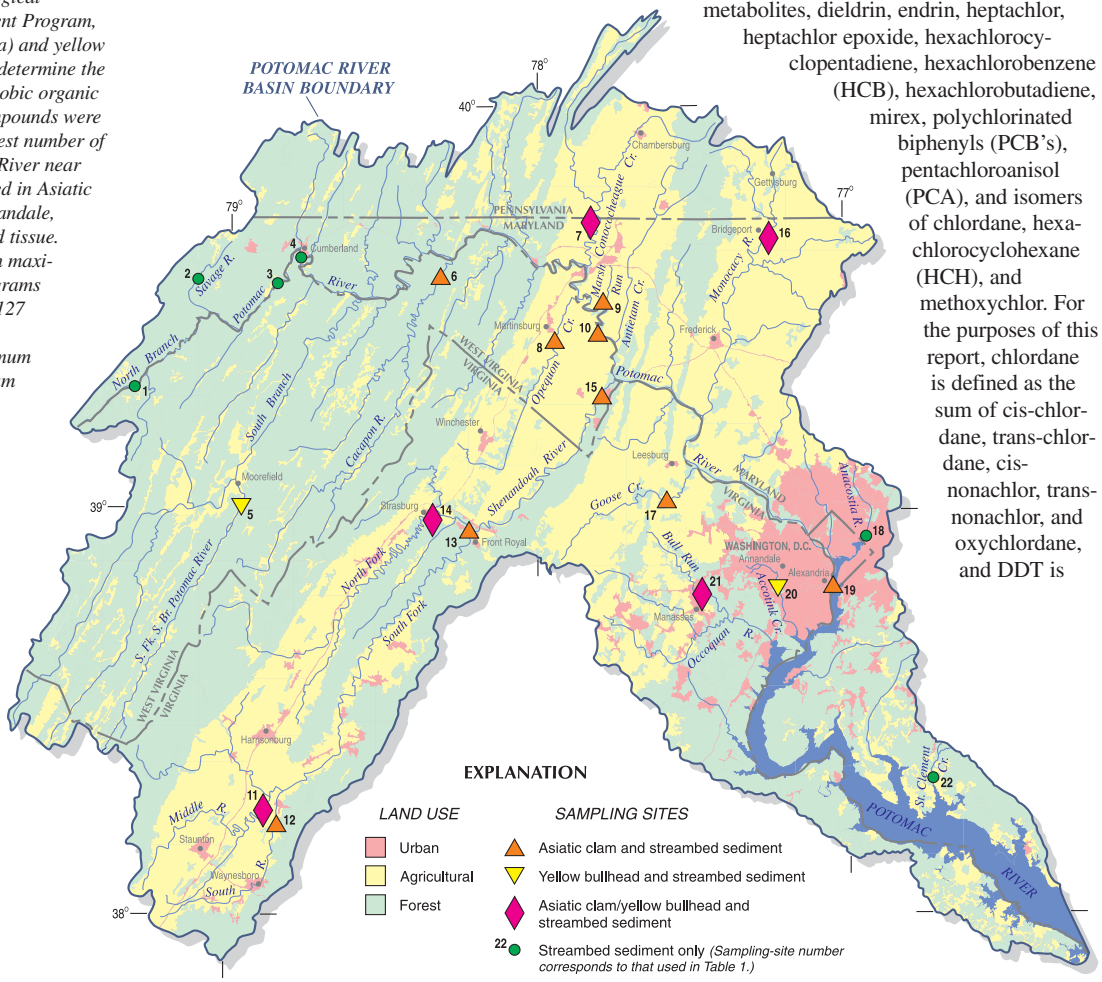


Figure 1. *Generalized land use and location of sites where Asiatic clams, yellow bullhead, or streambed sediment were sampled in the Potomac River Basin, 1992.*

Table 1. Concentrations of chlordane, DDT, and PCB's in Asiatic clam and yellow bullhead whole-fish tissue at sites where sediment was sampled in the Potomac River Basin, 1992.

[Abbreviations: USGS, U.S. Geological Survey; (µg/kg), micrograms per kilogram (wet weight); <, less than; ––, no data available; do., ditto]

SAMPLING-SITE NO. (Fig. 1)	USGS STATION NO.	SAMPLING-SITE NAME	DRAINAGE AREA (square miles)	TISSUE TYPE SAMPLED	CHLORDANE [1] (µg/kg)	DDT [1] (µg/kg)	PCB's (µg/kg)
1	01595000	N. Br. Potomac R. at Steyer, Md.	73	None sampled	----	----	----
2	01596500	Savage R. near Barton, Md.	49.1	do.	----	----	----
3	01600000	N. Br. Potomac R. at Pinto, Md.	596	do.	----	----	----
4	01603000	N. Br. Potomac R. near Cumberland, Md.[2]	875	do.	----	----	----
5	01608000	S. Fk. S. Br. Potomac R. near Moorefield, W.Va.[2]	283	Yellow bullhead	[3]<5.0	[3]<5.0	[4]<50.0
6	01611500	Cacapon R. near Great Cacapon, W.Va.	677	Asiatic clam	<5.0	<5.0	<50.0
7	01614500	Conococheague Cr. at Fairview, Md.[2]	494	do.	<5.0	<5.0	<50.0
				Yellow bullhead	9.6	<5.0	91.0
8	01616500	Opequon Cr. near Martinsburg, W.Va.	272	Asiatic clam	<5.0	7.9	<50.0
9	01617800	Marsh Run at Grimes, Md.	18.9	do.	<5.0	<5.0	<50.0
10	01618000	Potomac R. at Shepherdstown, W.Va.	5,936	do.	<5.0	<5.0	140
11	01625000	Middle R. near Grottoes, Va.	375	do.	<5.0	<5.0	<50.0
				Yellow bullhead	53.2	<5.0	120
12	01627500	South R. at Harriston, Va.	212	Asiatic clam	<5.0	<5.0	<50.0
13	01631020	S. Fk. Shenandoah R. below Cabin Run at Front Royal, Va.	1,647	do.	<5.0	<5.0	162
14	01634000	N. Fk. Shenandoah R. near Strasburg, Va.	768	do.	<5.0	<5.0	<50.0
				Yellow bullhead	<5.0	<5.0	146
15	01636500	Shenandoah R. at Millville, W.Va.[2]	3,040	Asiatic clam	<5.0	<5.0	148
16	01639000	Monocacy R. at Bridgeport, Md.[2]	173	do.	8.8	5.1	<50.0
				Yellow bullhead	<5.0	6.9	<50.0
17	01644000	Goose Cr. near Leesburg, Va.	332	Asiatic clam	<5.0	<5.0	<50.0
18	01651010	Anacostia R. near Bladensburg, Md.	130	None sampled	----	----	----
19	01652588	Potomac R. near Alexandria, Va.	11,880	Asiatic clam	31.1	12.9	154
20	01654000	Accotink Cr. near Annandale,Va.[2,5]	23.5	Yellow bullhead	127	7.6	90.0
21	01657000	Bull Run near Manassas, Va.[5]	147	Asiatic clam	21.9	<5.0	<50.0
				Yellow bullhead	113	6.4	75.0
22	01661050	St. Clement Cr. near Clements, Md.	18.5	None sampled	----	----	----

[1] Chlordane concentrations are sums of cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane. DDT concentrations are sums of o,p'-DDT, p,p'-DDT, o,p'-DDD, p,p'-DDD, o,p'-DDE, and p,p'-DDE.

[2] Fixed sites: Sites where additional water-quality and ecological samples have been collected by the National Water-Quality Assessment Program.

[3] Method reporting limit for chlordane and DDT.

[4] Method reporting limit for PCB's.

[5] Sites where the concentration of chlordane in yellow bullhead whole-fish tissue exceeded the National Academy of Sciences/National Academy of Engineering recommended maximum whole-fish tissue concentration for the protection of fish-eating wildlife (100 µg/kg).

defined as the sum of o,p'-DDT, p,p'-DDT, o,p'-DDD, and p,p'-DDD, o,p'-DDE, p,p'-DDE.

Three of the organic compounds, chlordane, DDT, and PCB's, were of particular interest because they were detected most frequently during this survey. In addition, chlordane and PCB's were detected at the highest concentrations in the Potomac River Basin and are considered toxics of concern to the Chesapeake Bay (U.S. Environmental Protection Agency, 1991b). These compounds can have potential negative effects on humans and wildlife. Chlordane, DDT, and PCB's are considered probable carcinogens in humans (U.S. Environmental Protection Agency 1991a, 1992, 1994) and are linked to adverse effects in wildlife, such as eggshell thinning in several families of birds, caused by DDT (National Academy of Sciences, National Academy of Engineering, 1973; U.S. Environmental Protection Agency, 1992). The use of chlordane has been banned since 1988, DDT since 1973, and PCB's since 1988 (U.S. Environmental Protection Agency, 1992).

Purpose and Scope

The purpose of this report is to address three questions concerning the biotic tissue component of the 1992 basinwide survey of organic contaminants within the Potomac River Basin:

(1) At which of the 22 sites and in what biotic tissue types sampled were chlordane, DDT, PCB's, and other selected organic compounds detected?

(2) Of the sites and biotic tissue types where chlordane, DDT, PCB's and other selected organic compounds were detected, what were their concentrations?

(3) How does the concentration detected compare to established standards for the protection of human health and fish-eating wildlife?

Also for biotic tissues, descriptions of methods, sample collection, and laboratory analyses are presented.

The report focuses on organic contaminants in biotic tissues and details three selected compounds, chlordane, DDT, and PCB's, from the 1992 basinwide survey of contaminants within the Potomac River Basin. The report presents less-detailed information concerning other organic compounds analyzed in biotic tissues during the basinwide survey. Also, general information concerning the basinwide survey is presented, including information on the occurence of organic compounds in streambed sediment.

Methods

Biotic tissues were collected and analyzed using methods developed by the NAWQA Program (Crawford and Luoma, 1994) and the USGS National Water Quality Laboratory (NWQL) (Leiker and others, 1995). The following is general information on collection, laboratory methods, and data-analysis techniques used during the 1992 basinwide survey of contaminants in biotic tissues in the Potomac River Basin. All tissue types sampled were handled and processed using specific procedures to prevent contamination of the samples. Detailed information on sample collection and analysis can be found in Crawford and Luoma (1994) and Leiker and others (1995).

Asiatic clams were collected by hand or rake at the 14 sites sampled (see photograph). The Asiatic clams were allowed to depurate (expel gut contents) for 24 hours following collection. They were then measured, weighed, and shipped frozen to the NWQL in

Collection of Asiatic clams using a clam rake at Bull Run near Manassas, Va. (sampling-site 21, fig.1).

Arvada, Colorado for analysis. As many as 250 Asiatic clams were composited to obtain a sample of at least 50 grams (1.8 ounces) for analysis of organic compounds (Crawford and Luoma, 1994).

Yellow bullhead were collected using electrofishing techniques (see photograph). The samples were comprised of five or more whole fish for analysis of organic compounds. The fish had their sex identified, were weighed, measured, and shipped frozen to the NWQL for analysis. Additional information, such as external parasites or deformities, was recorded (Crawford and Luoma, 1994).

Collection of yellow bullhead using a backpack electrofisher at Accotink Creek near Annandale, Va. (sampling-site 20, fig.1).

Organic compound analyses were performed on extracts from homogenized Asiatic clam and yellow bullhead whole-fish samples. Asiatic clam tissue was homogenized after removal from the shell. Organic compounds were extracted by Soxhlet extraction using methylene chloride (Leiker and others, 1995). Lipids were removed by gel permeation chromatography and fractionated using alumina/silica adsorption chromatography. Extracts were analyzed by two dissimilar fused-silica gas-chromatographic, capillary columns with electron-capture detection. The method reporting limits are 5 µg/kg (micrograms per kilogram) for chlorinated compounds and 50 µg/kg for PCB's (Leiker and others, 1995).

On the basis of laboratory performance information and comparison to other laboratories, the NWQL's method of analysis of chlorinated pesticides in biotic tissue provided acceptable levels of accuracy and precision for most method compound concentrations. NWQL results for chlordane and DDT concentrations in U.S. Environmental Protection Agency (USEPA) quality-control samples were within the acceptable range established by USEPA. The precision of chlordane and DDT concentrations is within one standard deviation (Leiker and others, 1995). DDT is defined as the sum of p,p'-DDT, p,p' -DDD, and p,p'-DDE in USEPA quality-control samples.

On the basis of concentrations for duplicate samples, the data results by NWQL from U.S. Fish and Wildlife Service (USFWS) round-robin samples were within one standard deviation of the mean for all method compounds. When duplicates were not averaged, about 80 percent of concentration data for individual round-robin samples were within one standard deviation of the mean. One-hundred percent of the concentration data were within two standard deviations of the mean for all method compounds (Leiker and others, 1995).

However, some of the DDT method compounds o,p'-DDD and p,p'-DDD "may present a problem in analysis" (Leiker and others, 1995). The NWQL considered a relative standard deviation (RSD) of 23 percent to be an acceptable level of performance. o,p'-DDD and p,p'-DDD, however, had RSD greater than 23 percent. Method performance data indicated that o,p'-DDT and p,p'-DDT underwent thermal degradation to o,p'-DDD and p,p'-DDD inside the gas chromatography injection port, explaining RSD's greater than 23 percent (Leiker and others, 1995). A performance evaluation mix (PEM) was not analyzed during the NWQL's method-performance phase when developing analysis methods. This type of problem is identified and corrected by examining the results of the PEM standard that was analyzed after every fifth environmental sample (Leiker and others, 1995).

In this report, chlordane, DDT, and PCB concentrations are presented in detail and compared to two standards: (1) the U.S. Food and Drug Administration (FDA) action level in edible shellfish tissue for the protection of human health and (2) the National Academy of Sciences and National Academy of Engineering (NAS/NAE) recommended maximum concentration in whole fish for the protection of fish-eating wildlife. The FDA action level was applied to organic compound concentrations in Asiatic clams, and the NAS/NAE maximum recommended concentration level was applied to yellow bullhead whole fish-tissue concentrations (U.S. Food and Drug Administration, 1992; Nowell and Resek, 1994). In addition, dieldrin and heptachlor epoxide were compared to FDA action levels and NAS/NAE recommended concentrations. None of the other organic compounds detected had established guidelines or standards.

FDA action levels and NAS/NAE recommended maximum concentrations are routinely reported in milligrams per kilogram (mg/kg). Because the Asiatic clam and yellow bullhead whole-fish tissue concentrations were reported in micrograms per kilogram by the NWQL, the FDA action levels and NAS/NAE recommended maximum concentrations were converted to micrograms per kilogram for ease of comparison to tissue-concentration data in this report.

The FDA action levels for the protection of human health are 300 µg/kg for chlordane, 5,000 µg/kg for DDT, and 2,000 µg/kg for PCB's (U.S. Food and Drug Administration, 1992; Nowell and Resek, 1994). For comparison to FDA action levels, chlordane isomer and DDT metabolite concentrations less than 20 µg/kg are not included in determining total chlordane and DDT concentrations (Nowell and Resek, 1994). Due to the capability of NWQL to analyze reproducible concentrations at very low levels, chlordane isomer and DDT metabolite concentrations less than 20 µg/kg were included in total chlordane and DDT determinations in this report. The NAS/NAE recommended maximum concentration for chlordane is 100 µg/kg, 1,000 µg/kg for DDT, and 500 µg/kg for PCB's (National Academy of Sciences, National Academy of Engineering, 1973; Nowell and Resek, 1994).

When calculating chlordane concentrations for comparison to NAS/NAE recommended maximum concentration for the protection of fish-eating wildlife, residues of aldrin, HCH, dieldrin, endosulfan, endrin, heptachlor, heptachlor epoxide, lindane, and toxaphene are typically summed with chlordane residues (Nowell and Resek, 1994). For consistency in this report, only chlordane isomer concentrations used to calculate the FDA action levels were summed. Most of the other compounds not used to calculate the sum of chlordane either were not detected or were found at concentrations near the method reporting limit of 5 µg/kg. The exclusion of these compounds from the sum of chlordane was not considered to greatly affect the interpretation.

CHLORDANE, DDT, PCB's, AND OTHER SELECTED ORGANIC COMPOUNDS IN BIOTIC TISSUES

Thirteen of 29 organic compounds analyzed in biotic tissue were detected during this survey. Chlordane, DDT, and PCB's were the most widespread organic compounds detected. Chlordane was detected at six sites, DDT at five sites, and PCB's at nine sites. Five other organic compounds were reported. DCPA and p,p-methoxychlor were detected at one site each. β-HCH, dieldrin, and heptachlor epoxide were detected in biotic tissues from three sites. The Potomac River near Alexandria, Va. (site 19, fig. 1), had six organic compounds detected, the highest number detected in Asiatic clam tissues. Accotink Creek near Annandale, Va. (site 20, fig. 1), had 11 organic compounds detected, the highest number detected in yellow bullhead whole-fish tissue. In this section, frequency of detection and range in concentration are presented for chlordane, DDT, and PCB's. Also, information concerning geographic distribution and tissue type is presented.

CHLORDANE

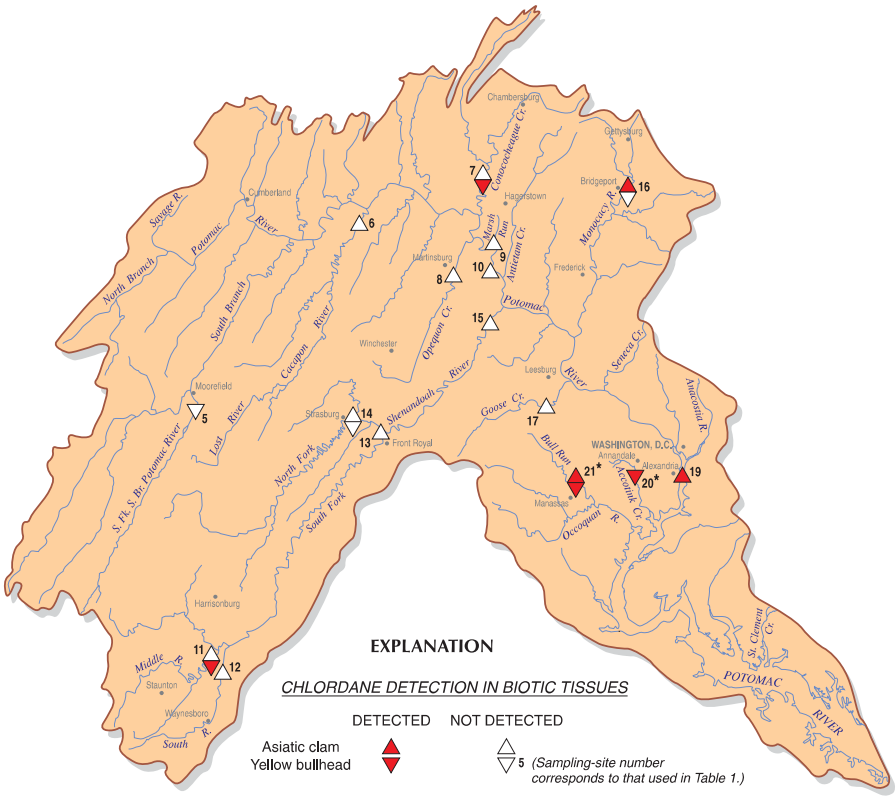
Chlordane was detected at concentrations greater than the method reporting limit of 5 µg/kg in tissue from 6 of 16 sites (fig. 2). Chlordane was detected in tissues from Conococheague Creek (site 7) and the Monocacy River (site 16) in Maryland, the Middle River (site 11), Accotink Creek (site 20), and Bull Run (site 21) in Virginia, and the Potomac River (site 19) in Washington, D.C. Chlordane was detected in both Asiatic clam and yellow bullhead whole-fish tissue from only one of five sites sampled for both tissue types (site 21). Chlordane was detected in streambed sediment at five of the six sites where chlordane was detected in tissues. Site 16, the Monocacy River at Bridgeport, Md., did not have chlordane detected in sediments sampled.

Asiatic clams

Chlordane was detected in Asiatic clam tissue from 3 of 14 sites where Asiatic clams were sampled (sites 16, 19, 21) (fig. 2). At these sites, concentrations of chlordane in Asiatic clams ranged from 8.8 to 31.1 µg/kg (tables 1 and 2). Concentrations of chlordane in Asiatic clam tissue did not exceed the FDA action level of 300 µg/kg for the protection of human health. Site 19, the Potomac River near Alexandria, Va., had the highest concentration of chlordane in Asiatic clam tissue (31.1 µg/kg), which is about 10 times less than the FDA action level (tables 1 and 2).

Yellow bullhead

Chlordane was detected in yellow bullhead whole-fish tissue from four of seven sites where yellow bullhead were sampled (sites 7, 11, 20, and 21) (fig. 2). At these sites, concentrations of chlordane in yellow bullhead ranged from 9.6 to 127 µg/kg (tables 1 and 2). Sample concentrations from Accotink Creek near Annandale, Va. (site 20), and Bull Run near Manassas, Va. (site 21), exceeded the NAS/NAE recommended maximum concentration of 100 µg/kg for the protection of fish-eating wildlife (fig. 2, tables 1 and 2).



* Chlordane concentrations in yellow bullhead whole-fish tissue exceeded the National Academy of Sciences and National Academy of Engineering recommended maximum concentration for the protection of fish-eating wildlife.

Figure 2. *Spatial occurrence of chlordane in Asiatic clam and yellow bullhead whole-fish tissue in the Potomac River Basin, 1992.*

DDT

DDT was detected in concentrations greater than the method reporting limit of 5 µg/kg in biotic tissues from 5 of 16 sites (fig. 3). DDT was detected in tissues from Opequon Creek in West Virginia (site 8), the Monocacy River (site 16) in Maryland, Accotink Creek (site 20) and Bull Run (site 21) in Virginia, and the Potomac River (site 19) in Washington, D.C. DDT was detected in both Asiatic clam and yellow bullhead whole-fish tissue from one of the five sites sampled for both tissue types (site 16). DDT was detected in streambed sediment at all 5 sites where DDT was detected in tissues.

Asiatic clams

DDT was detected in Asiatic clam tissue from 3 of 14 sites where Asiatic clams were sampled (sites 8, 16,and 19) (fig. 3). At these sites, concentrations of DDT in Asiatic clams ranged from 5.1 to 12.9 µg/kg (tables 1 and 3). Concentrations of chlordane in Asiatic clam tissue did not exceed the FDA action level of 5,000 µg/kg for the protection of human health. Site 19, the Potomac River near Alexandria, Va., had the highest concentration of DDT in Asiatic clam tissue (12.9 µg/kg), which was more than 100 times less than the FDA action level (tables 1 and 3).

Yellow bullhead

DDT was detected in yellow bullhead whole-fish tissue from 3 of 7 sites where yellow bullhead were sampled (sites 16, 20, 21)(fig. 3). At these sites, concentrations of DDT in yellow bullhead ranged from 6.4 to 7.6 µg/ kg (tables 1 and 3). Concentrations of DDT in yellow bullhead whole-fish tissue did not exceed NAS/NAE recommended maximum concentration of 1,000 µg/kg for the protection of fish-eating wildlife. Site 20, Accotink Creek near Annandale, Va., had the highest concentration in yellow bullhead whole-fish tissue, which was more than 100 times less than the maximum recommended concentration for the protection of fish-eating wildlife (tables 1 and 3).

PCB's

PCB's were detected in concentrations greater than the method reporting limit of 50 µg/kg in biotic tissues from 9 of 16 sites (fig. 4). PCB's were detected in tissues from the Middle River (site 11), the North Fork Shenandoah River (site 14), the South Fork Shenandoah River (site 13), Accotink Creek (site 20), and Bull Run (site 21) in Virginia, the Shenandoah River (site 15) in West Virginia, Conococheague Creek (site 7) and the Potomac River (site 10) in Maryland, and the Potomac River (site 19) in Washington, D.C. PCB's were detected in yellow bullhead whole-fish tissue only, at the sites sampled for both Asiatic clams and yellow bullhead (fig. 4). PCB's were detected in streambed sediment at all 9 sites where PCB's were detected in tissues.

Asiatic clams

PCB's were detected in Asiatic clam tissue from 4 of 14 sites where Asiatic clams were sam-

Table 2. Summary of chlordane concentrations in Asiatic clam and yellow bullhead whole-fish tissue.

[Abbreviations: (µg/kg), micrograms per kilogram; FDA, U.S. Food and Drug Administration; NAS/NAE, National Academy of Sciences, National Academy of Engineering]

Tissue Type	Number of sampling sites	Number of sites where detected	Minimum detected concentration, (µg/kg)	Maximum detected concentration, (µg/kg)	Standards	Number of sites exceeding standard concentration
Asiatic clam	14	3	8.8	31.1	FDA action level for the protection of human health (300 µg/kg)	0
Yellow bullhead	7	4	9.6	127	NAS/NAE recommended maximum concentration for the protection of fish-eating wildlife (100 µg/kg)	**2**

pled (sites 10, 13, 15, and 19; fig. 4). At these sites, concentrations of PCB's in Asiatic clams ranged from 140 to 162 µg/ kg (tables 1 and 4). Concentrations of PCB's in Asiatic clam tissue did not exceed the FDA action level of 2,000 µg/kg for the protection of human health. Site 13, the South Fork Shenandoah River below Cabin Run at Front Royal, Va., had the highest concentration of PCB's in Asiatic clam tissue (162 µg/kg), which was more than 10 times less than the FDA action level (tables 1 and 4).

Yellow Bullhead

PCB's were detected in yellow bullhead whole-fish tissue from five of seven sites where yellow bullhead were sampled (sites 7, 11, 14, 20, and 21; fig. 4). At these sites, concentrations of PCB's in yellow bullhead ranged from 75 to 146 µg/kg (tables 1 and 4). Concentrations of PCB's in yellow bullhead whole-fish tissue did not exceed the NAS/NAE recommended maximum concentration of 500 µg/kg for the protection of fish-eating wildlife. Site 14, the North Fork Shenandoah River near Strasburg, Va., had the highest concentration in yellow bullhead whole-fish tissue (146 µg/kg), which was at least three times less than the maximum recommended concentration for the protection of fish-eating wildlife (tables 1 and 4).

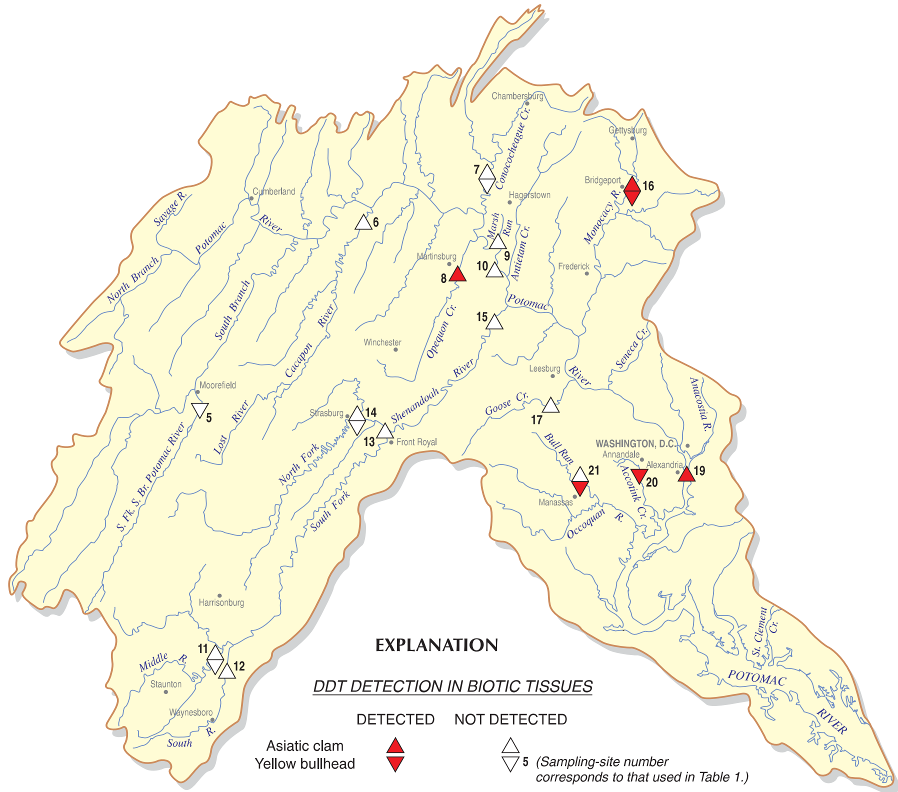


Figure 3. *Spatial occurrence of DDT in Asiatic clam and yellow bullhead whole-fish tissue in the Potomac River Basin. 1992.*

Other selected organic compounds

Five of the other 17 organic compounds analyzed in biotic tissues were detected at concentrations greater than the method reporting limit of 5 µg/kg in Asiatic clam or yellow bullhead whole-fish tissues. DCPA and p,p-methoxychlor were detected in tissues from one site. β-HCH, dieldrin, and heptachlor epoxide were detected in tissues from three sites. Only dieldrin and heptachlor epoxide had FDA action levels and NAS/NAE recommended maximum concentrations.

DCPA was detected in yellow bullhead whole fish tissues from Accotink Creek (site 20) in Virginia at 5.9 µg/kg. p,p-methoxychlor was detected at 17.4 µg/kg in Asiatic clam tissues from the Monocacy River in Maryland (site 16). β-HCH was detected in Asiatic clam tissues from the Monocacy River in Maryland (site 16) at 5.8 µg/kg and at 5.2 µg/kg in Asiatic clam tissue from Goose Creek in Virginia (site 17). In yellow bullhead whole-fish tissue, β-HCH was detected in samples from Accotink Creek (site 20) in Virginia at 5.9 µg/kg.

Dieldrin was detected only in yellow bullhead whole-fish tissues, at 12.4 µg/kg from Bull Run (site 21) and at 13.8 µg/kg from Accotink Creek (site 20) in Virginia and at 6.8 µg/kg from Conococheague Creek (site 7) in Maryland. Dieldrin concentrations were at least five times less than the NAS/NAE recommended maximum concentration of 100 µg/kg for the protection of fish-eating wildlife.

Heptachlor epoxide was detected in Asiatic clam tissues from Opequon Creek in West Virginia (site 8) at 7.8 µg/kg. The concentration of heptachlor epoxide was more than 10 times less than the FDA action level of 300 µg/kg for the protection of human health. Heptachlor epoxide was also detected in yellow bullhead whole-fish tissues from the Middle River (site 11) and Accotink Creek (site 20) in Virginia at 7.9 and 15.8 µg/kg, respectively. Concentrations of heptachlor epoxide were at least six times less than the NAS/NAE maximum concentration of 100 µg/kg for the protection of fish-eating wildlife.

Table 3. Summary of DDT concentrations in Asiatic clam and yellow bullhead whole-fish tissue.

[Abbreviations: (µg/kg), micrograms per kilogram; FDA, U.S. Food and Drug Administration; NAS/NAE, National Academy of Sciences, National Academy of Engineering]

Tissue Type	Number of sampling sites	Number of sites where detected	Minimum detected concentration, (µg/kg)	Maximum detected concentration, (µg/kg)	Standards	Number of sites exceeding standard concentration
Asiatic clam	14	3	5.1	12.9	FDA action level for the protection of human health (5,000 µg/kg)	0
Yellow bullhead	7	3	6.4	7.6	NAS/NAE recommended maximum concentration for the protection of fish-eating wildlife (1,000 µg/kg)	0

IMPLICATIONS

No new threats to human health were discovered on the basis of the 1992 survey of organic contaminants in Asiatic clams and the established FDA action levels. Chlordane, DDT, and PCB concentrations were less than FDA action levels at the 14 sites where Asiatic clams were sampled within the Potomac River Basin. Of the five other organic compounds detected, only dieldrin and heptachlor epoxide had established FDA action levels, and concentrations of these compounds did not exceed those standards. All organic compounds detected were at least 10 times less than the established FDA standards.

Although all compounds detected in Asiatic clam tissues were substantially less than established FDA action levels, two sampling sites were located on streams with known contamination problems. One site, the Shenandoah River below Cabin Run near Front Royal, Va. (site 13), is located in an area with a human health advisory for PCB's. This site had the highest concentration of PCB's in Asiatic clams. The human health advisory includes reaches of the North Fork, the South Fork and the main-stem Shenandoah River in Virginia due to a historical source of PCB contamination (Emily Jones, Commonwealth of Virginia, Department of Game and Inland Fisheries, written and oral commun., 1996). The other site, the Potomac River near Alexandria, Va. (site 19), is located within Washington, D.C. A human health advisory exists for Washington, D.C. waters, "due to PCB's and other compounds" (Hamid Karimi, District of Columbia Department of Consumer and Regulatory Affairs, written commun., 1994). This site had six organic compounds detected in Asiatic clams, the highest number detected in

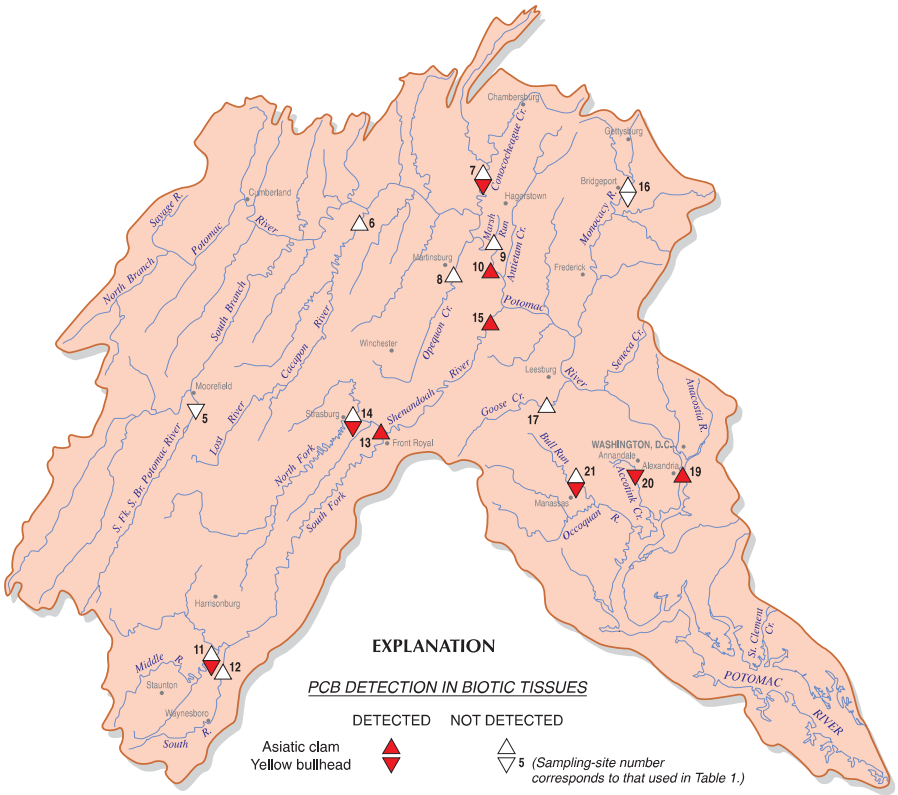


Figure 4. *Spatial occurrence of PCB's in Asiatic clam and yellow bullhead whole-fish tissue in the Potomac River Basin, 1992.*

Asiatic clam samples. Site 19 had the highest concentration of chlordane and DDT, although not necessarily significantly higher than other sites. Site 19 also had the second highest PCB concentration detected in Asiatic clam tissues. Both the Virginia and Washington, D.C. human health advisories are based on fish-tissue samples. Because both advisories are based on analyses of fish tissue, the data are not directly comparable to Asiatic clam concentrations.

Concentrations of chlordane in biotic tissues from two of the seven sites sampled may indicate the potential for harm to fish-eating wildlife, on the basis of the survey of contaminants in yellow bullhead whole-fish tissues and established NAS/NAE recommended maximum concentrations. Chlordane was the only compound that exceeded the established NAS/NAE recommended maximum concentration in whole fish-tissues. Chlordane exceeded the NAS/NAE standards in samples from Accotink Creek near Annandale, Va. (site 20), and Bull Run near Manassas, Va. (site 21).

There may be greater potential risk to fish-eating wildlife at Accotink Creek (site 20) and Bull Run (site 21) than indicated by concentrations of chlordane alone. Two other compounds, dieldrin and heptachlor epoxide, were also detected in tissues from these sites. Concentrations of dieldrin and heptachlor epoxide typically are included in the sum of chlordane for comparison to the NAS/NAE recommended maximum concentration. Their inclusion in the sum of chlordane may indicate concentrations even higher than those for chlordane alone and the possibility of greater potential risk to wildlife at these two sites. In addition, site 20 had 11 organic compounds detected in yellow bullhead, more compounds detected than from any other site. The other compounds detected in tissues from the site were β-HCH, DCPA, DDT, and PCB's. Bull Run near Manassas, Va. (site 21), had eight organic compounds detected in yellow bullhead, the second highest detection rate at a site. The other compounds detected in samples from this site were DDT and PCB's.

Table 4. Summary of PCB concentrations in Asiatic clam and yellow bullhead whole-fish tissue.

[Abbreviations: (µg/kg), micrograms per kilogram; FDA, U.S. Food and Drug Administration; NAS/NAE, National Academy of Sciences, National Academy of Engineering]

Tissue Type	Number of sampling sites	Number of sites where detected	Minimum detected concentration, (µg/kg)	Maximum detected concentration, (µg/kg)	Standards	Number of sites exceeding standard concentration
Asiatic clam	14	4	140	162	FDA action level for the protection of human health (2,000 µg/kg)	0
Yellow bullhead	7	5	75	146	NAS/NAE recommended maximum concentration for the protection of fish-eating wildlife (500 µg/kg)	0

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REFERENCES

Crawford, J. K., and Luoma, S. N., 1994, Guidelines for the studies of contaminants in biotic tissues for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 92-494, 69 p.

Leiker, T.J., Madsen, J.E., Deacon, J.R., and Foreman, W.T., 1995, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory determination of chlorinated pesticides in aquatic tissue by capillary-column gas chromatography with electron-capture detection: U.S. Geological Survey Open-File Report 94-710, 42 p.

National Academy of Sciences, National Academy of Engineering, 1973, Water quality criteria, 1972: Ecological Research Series EPA-R3-73-03, p. 594

Nowell, L.H., and Resek, E.A., 1994, National standards and guidelines for pesticides in water, sediment, and aquatic organisms— Application to water-quality assessments: Reviews of Environmental Contamination and Toxicology, v.40, 221 p.

U.S. Environmental Protection Agency, 1991a, Fact sheet—National primary drinking water standards: U.S. Environmental Protection Agency, EPA 570/9-91/012FS, 8 p.

—— 1991b , Chesapeake Bay Program, 1991, Chesapeake Bay toxics of concern list: U.S. Environmental Protection Agency, 112 p.

—— 1992, National study of chemical residues in fish—Volume II: U.S. Environmental Protection Agency, EPA 823-R-92-008b, 263 p.

—— 1994, National primary drinking water standards: U.S. Environmental Protection Agency, EPA 810-F-94-001A, 8 p.

U.S. Food and Drug Administration, 1992, Action levels for poisonous or deleterious substances in human food and animal feed (8/92): Department of Health and Human Services, Washington, D.C., 16 p.

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