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*Chemical Analysis of Sediments and Fish
from the
Mahoning River, Lawrence County, Pennsylvania*



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CHEMICAL ANALYSIS OF SEDIMENTS AND FISH
FROM THE
MAHONING RIVER, LAWRENCE COUNTY, PENNSYLVANIA

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PREFACE

The U.S. Fish and Wildlife Service (Service) has been concerned with environmental contaminants since the late 1940's, when researchers began investigating the impacts of synthetic organic pesticides, such as DDT, on fish and wildlife resources. Publication of Rachel Carson's Silent Spring focused national attention on the biological and ecological effects of massive use of persistent chemical compounds.

Since the early 1980's, the Service has been working to improve its field operation capabilities to address and enhance the quality of fish and wildlife resources impacted by environmental contaminants. Service field offices seek to identify contaminant threats to fish and wildlife and recommend actions to eliminate those threats. The results of the Service's monitoring, field assessment, and research initiatives indicate that a broad spectrum of contaminants are adversely affecting fish and wildlife throughout the United States. Aberrations such as backbone deformation, liver tumors, alteration of enzyme activity and function, and reduced nesting success are being detected with increasing regularity in research and field studies of natural populations. Service biologists are alert to the fact that these observations may signify chemical contamination of the environment.

The following report details the Service's investigations into a sediment contamination situation in the Pennsylvania section of the Mahoning River.

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INTRODUCTION

In July, 1988, the Ohio Department of Health issued a swimming, wading and fish consumption advisory for the Mahoning River between Warren, Ohio and the Pennsylvania border. The advisory was based on analysis of sediments along the river bottom and river banks showing high concentrations of polycyclic aromatic hydrocarbons (PAH's). Fish from the river were analyzed and found to contain low levels of mirex, phthalate esters and PCBs. The Pennsylvania Department of Environmental Resources requested our assistance in determining whether similar levels of sediment and fish contamination have affected the Pennsylvania reach of the river.

The Mahoning River originates approximately ten miles southeast of Alliance, Ohio. It flows northwest into Alliance and then northeast into Warren, Ohio. From Warren, it flows generally southeast through the metropolitan Youngstown area and across the Ohio/Pennsylvania border approximately one half mile southeast of Lowellville, Ohio. It continues its southeasterly flow through Pennsylvania for approximately nine miles until joining with the Shenango River to form the Beaver River slightly over one half mile south of New Castle, PA. Sediment and fish samples were taken by the Service and PA DER, respectively, along the Pennsylvania stretch of the Mahoning River in order to determine if contamination pervaded in this section to the same degree as in the Ohio reaches.

METHODS

Field Methods

Ten sediment samples were collected on June 3 and 4, 1991. Two samples were collected on June 3 from Hickory Run, a tributary which flows into the Mahoning River just upstream of its confluence with the Shenango River. These two samples were believed to be typical of uncontaminated conditions and could therefore be used for comparison to the Mahoning River samples. On June 4, eight samples were taken from various points along the Pennsylvania section of the Mahoning River. Figure 1 provides a map of all sampling stations. Table 1 describes the location of each station in detail. Sample station numbers were assigned in the order in which the samples were collected.

Because we were interested in determining the "worst-case" degree of chemical contamination in Mahoning River sediments, our sampling was deliberately biased to seek out fined-grained sediments. Sediments were collected from depositional areas at the edge of the river, such as downstream of a projecting log or gravel bar. Samples were obtained from several different spots in each depositional zone by using a stainless steel ponar dredge which was carefully pushed into the sediments by hand to remove the top 1 to 4 inches of sediments. The water depth over the sediments ranged from 1 to 6 inches. (At one station where the water was too deep to obtain a sample from the bottom, a soil sample was taken from the river bank a few inches above the water line.) The sediments were combined in a stainless steel bucket. Leaves, stones, and other extraneous material were removed to the extent possible, and the entire sample was "homogenized" by stirring with a stainless steel spoon. Two separate aliquots were removed from the homogenized sediments and placed in two separate, chemically-cleaned glass jars. (One of the aliquots would later be sent to the laboratory responsible for organics analysis, and the other to the laboratory responsible for metals, total organic carbon, and grain size analyses). The samples were labeled and placed on ice until the end of the day, when they were transferred to a freezer.

All sediment sampling equipment was decontaminated between samples by scrubbing with soap and water, followed by the following sequential rinses: deionized water, acetone, deionized water, nitric acid, and deionized water.

Fish samples were collected during the same two-day period by the Pennsylvania Department of Environmental Resources and the Pennsylvania Fish and Boat Commission, using backpack electrofishing equipment. Collection locations are shown in Figure 1. Samples were composites of two to five fish, and were prepared either as whole fish samples or as scaled, skin-on fillets from both sides of each fish. For some of the large carp, only right-side fillets were retained; Appendix A contains the fish collection data sheets describing the exact preparation method for each sample, as well as the size of each fish.

Chemical Analysis

The Environmental Trace Substances Research Center in Columbia, Missouri analyzed the fish and sediment samples for trace elements, and the sediments for total organic carbon and grain size. The Mississippi State Chemical Laboratory at Mississippi State University, Mississippi State, Mississippi, analyzed the sediment samples for organochlorines and polycyclic aromatic hydrocarbons. Both laboratories were under contract to the U.S. Fish and Wildlife Service under rigorous quality assurance/quality control conditions.

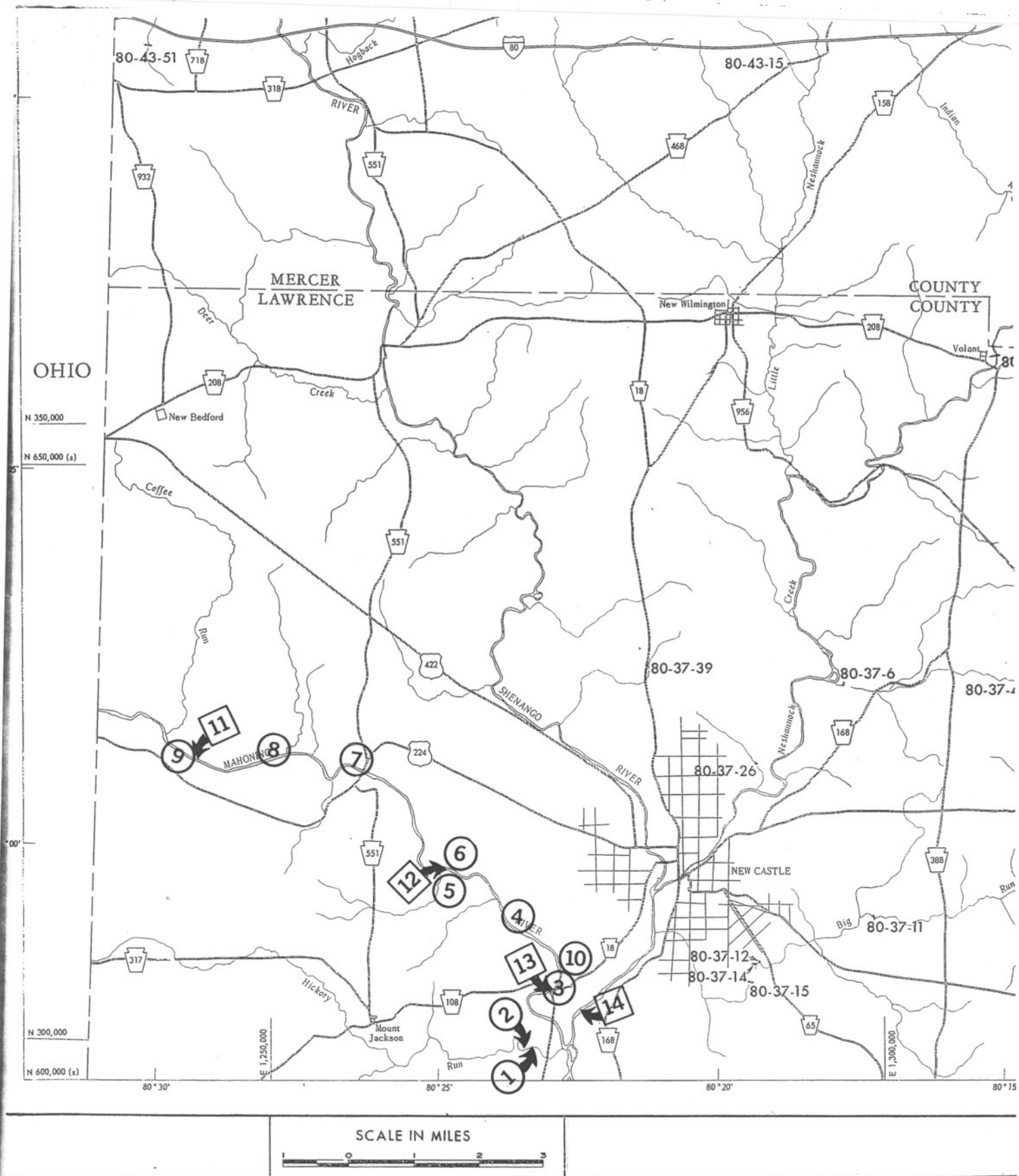


Figure 1. Collection location for fish and sediment samples taken from the Mahoning River, Shenango River, and Hickory Run, June 3-4, 1991. Circles represent sediment samples; squares represent fish samples. (Base map from PA "Water Resources Planning Inventory No.1," PA Dept. of Forests and Water, 1970.)

Table 1. Description of sediment sample locations and date of collection.

Station Number	Collection Date	Description of Station Location
1	6-3-91	Hickory Run, right bank, approximately 0.7 mile upstream of confluence with Mahoning River.
2	6-3-91	Hickory Run, left bank, approximately 100 feet upstream of station No. 1.
3	6-4-91	Mahoning River, left bank, at intersection of Rts. 18 and 108, just upstream of "Cone & Shake" ice cream stand.
4	6-4-91	Mahoning River, right bank, 150 feet upstream of new Rt. 60.
5	6-4-91	Mahoning River, right bank, 150 feet upstream of Covert's Bridge.
6	6-4-91	Mahoning River, left bank, 150 feet upstream of Covert's Bridge (approximately 100 feet upstream of power line).
7	6-4-91	Mahoning River, left bank, 100 feet upstream of Edinburg bridge.
8	6-4-91	Mahoning River, left bank, approximately 1 mile downstream of Churchill Road bridge.
9	6-4-91	Mahoning River, right bank, approximately 75 feet upstream of Churchill Road bridge (road with St. Lawrence Church). At downstream tip of small island near right bank.
10	6-4-91	Mahoning River, right bank, approximately one half mile upstream of Station No. 3., near Valley View Cemetery in Mahoningtown. Samples from bank surface (about 1" deep) several inches above water line.

RESULTS

Sediments

Tables 2 through 4 contain the results of the grain size, total organic carbon, metals, organochlorine, and polycyclic aromatic hydrocarbon (PAH) analysis for the sediment samples.

An examination of the data in Table 2 reveals that we were not entirely successful in obtaining fine-grained, highly organic sediment samples. Most of our samples consisted primarily of sand. The samples with the lowest sand content were from Stations 3 and 7 on the Mahoning River; field notes described both of these samples as having a deep black color, an oily appearance, and a strong petroleum odor.

Table 3 provides the results of the inorganic analysis for the sediment and soil samples. Sediment samples 3 and 7 generally contained higher concentrations of elements than any of the other sediment samples, as would be expected due to their higher silt/clay content. Concentrations of many elements were an order of magnitude higher in the Mahoning River samples when compared to the two Hickory Run "reference" samples: chromium, copper, iron, mercury, molybdenum, nickel, lead, and zinc. When compared to the "heavily polluted" guidelines established by the U.S. Environmental Protection Agency (1977; see Appendix B) for the classification of Great Lakes sediments, most or all of the Mahoning River samples exceeded the guidelines for chromium, copper, iron, manganese, nickel, lead, and zinc. Three of the samples (including the river bank sample #10) exceeded the EPA heavily polluted guideline for mercury. Most of the Mahoning River arsenic concentrations also exceeded the EPA heavily polluted level of 8 ppm, although one of the Hickory Run samples also exceeded this level. The same Hickory Run sample also exceeded the EPA heavily polluted guideline for barium, and most of the Mahoning River samples (with the exception of river bank sample #10) contained barium concentrations close to the Hickory Run sample. The Ohio EPA (Estenik, 1988) had reported that sediments from Ohio portions of the Mahoning were highly contaminated with chromium, copper, iron, lead, zinc, arsenic, cadmium, manganese and mercury.

We compared the Mahoning River results to concentrations of elements in samples collected by this office from Presque Isle Bay on Lake Erie in 1990. Presque Isle Bay is considered to be relatively contaminated, and has been designated by the International Joint Commission as a Great Lakes "Area of Concern." Several Mahoning River samples contained higher concentrations of chromium, copper, mercury, manganese, lead, nickel, and zinc than the Presque Isle Bay samples. In addition, all of the Mahoning River samples contained higher iron concentrations than were found in Presque Isle Bay, and molybdenum, which was absent in Presque Isle Bay, was found in all of the Mahoning River samples at concentrations up to 40 ppm.

Zinc concentrations in the Mahoning River were even higher than we observed in sediments collected from the Red Clay Creek in Chester County, Pennsylvania, downstream of a known source of zinc contamination. The highest zinc concentration we observed in Red Clay Creek watershed sediments was 1110 ppm dry weight; in contrast, zinc at Station 7 on the Mahoning River reached 3590 ppm.

Table 4 presents the results of analysis for organochlorine compounds and polycyclic aromatic hydrocarbons (PAH's). The only organochlorines detected were PCBs in most of the Mahoning River samples, and dieldrin in the Mahoning River bank sample; neither of these compounds was found in Hickory Run. PCBs reached a high of 7.06 ppm dry weight at Station 7 on the

Table 2. Percent moisture, total organic carbon, sand, silt and clay in nine sediment samples and one soil sample (MR 91-10) collected June 3 and 4, 1991 from the Mahoning River and Hickory Run.

Sample Identification Number	Percent Moisture	Total Organic Carbon (%)	Percent Sand	Percent Silt	Percent Clay
MR91-1	25.7	<0.1	95.2	3.7	1.1
MR91-2	40.3	1.2	67.0	27.1	5.9
MR91-3	60.4	3.8	41.1	53.4	5.5
MR91-4	36.2	3.2	76.9	18.4	4.6
MR91-5	27.0	0.9	95.2	4.2	0.5
MR91-6	26.2	1.3	92.2	7.0	0.8
MR91-7	57.9	14.7	48.8	50.1	1.1
MR91-8	27.4	0.8	95.8	3.5	0.7
MR91-9	30.3	2.6	92.3	6.6	1.1
MR91-10	55.0	---	---	---	---

--- = analysis not conducted

Table 3. Concentrations of elements in nine sediment samples and one soil sample (#10) collected June 3-4, 1991, from Hickory Run and the Mahoning River. All values in ppm dry weight. See Table 2 for percent moisture, sand, silt and clay. * indicates concentrations exceeding "heavily polluted" guidelines established for the classification of Great Lakes sediments (U.S. Environmental Protection Agency, 1977). + indicates concentrations exceeding the highest concentrations found in sediments collected from Presque Isle Bay on Lake Erie in 1990 (U.S. Fish and Wildlife Service, 1991). Information on the EPA classifications is found in Appendix B.

Sample Number	MR91-1	MR91-2	MR91-3	MR91-4	MR91-5	MR91-6	MR91-7	MR91-8	MR91-9	MR91-10
Sample Location	Hickory Run		Mahoning River							
Sample Type	Sediments									Soil
Ag	<2.0	<2.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Al	4620	7350	12900	6190	6230	4890	13100	4050	5630	15100
As	7.1	8.8*	42*+	18.0*	10.0*	9.0*	32.8*	4.4*	12.0*	38.4*
B	<2.0	<2.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Ba	41.5	114*	297*+	74.8*	96.4*	79.2*	143*	57.8	98.8*	216*
Be	0.37	0.57	1.6	0.7	0.9	0.6	1.0	0.6	0.8	1.0
Cd	<0.3	0.5	4.0	<1.0	<1.0	<2.0	5.0	<2.0	<2.0	6.0
Cr	6.1	9.9	98.0*	53.0	77.0*	91.0*	380*+	110*+	110*+	550*+
Cu	5.9	13.0	169*	87.0*	90.0*	106*	307*+	132*	112*	437*+
Fe	18600	24400	18600	200000*+	212000*+	263000*+	249000*+	346000*+	249000*+	178000*+
Hg	0.02	0.045	1.05*+	0.37	0.16	0.14	1.2*+	0.14	0.30	1.4*+
Mg	827	1910	2880	1230	3020	1560	3460	1450	2250	4130
Mn	295	377	1920*+	1450*+	1640*+	1640*+	2220*+	2110*+	1810*+	1830*+
Mo	<1.0	<1.0	10.0	10.0	20.0	20.0	40.0	25.0	20.0	28.0
Ni	8.9	16.0	110*	47.0	68.0*	63.0*	200*+	82.0*	73.0*	280*+
Pb	10.0	20.0	330+	83.0*	74.1*	86.0*	910*+	110*	140*	860*+
Se	0.3	0.73	1.7	0.5	0.6	0.5	1.7	0.4	0.61	2.4+
Sr	18.0	78.6	116+	14.0	43.0	26.0	63.6	22.0	54.3	63.8
Th	<4.0	<4.0	<20.0	<20.0	20.0	<20.0	<20.0	<20.0	<20.0	<20.0
V	9.3	13.0	25.0	13.0	10.0	13.0	30.0	10.0	12.0	31.0
Zn	45.1	96.7	1750*+	338*	421*	324*	3590*+	361*	479*	4840*+

Table 4. Concentrations of organochlorine compounds and PAH's in nine sediment samples and one soil sample collected June 3-4, 1991 from the Mahoning River and Hickory Run. All values in ppm dry weight; dry weight concentrations were derived from the wet weight concentrations reported by the laboratory using the following equation: dry weight = wet weight/(1-%moisture/100). ND = not detected. Lower level of detection = 0.05 for toxaphene and PCBs; 0.01 for all other compounds.

Sample Number	MR91-1	MR91-2	MR91-3	MR91-4	MR91-5	MR91-6	MR91-7	MR91-8	MR91-9	MR91-10
Sample Location	Hickory Run		Mahoning River							
Sample Type	Sediments									Soil
% Moisture	26.0	61.0	66.2	57.6	36.2	33.4	66.0	37.4	41.8	58.0
Total PCB's	ND	ND	0.77	ND	0.38	ND	7.06	0.42	0.57	4.8
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.02
Naphthalene	ND	0.03	0.86	0.35	0.92	0.44	1.24	0.26	0.91	1.81
Fluorene	ND	0.05	0.21	0.19	0.69	0.24	0.59	0.35	1.29	0.88
Phenanthrene	0.11	0.44	3.85	1.46	3.8	1.44	6.2	2.4	6.5	8.8
Anthracene	0.01	0.05	1.27	0.50	1.00	0.62	2.15	0.69	1.9	4.1
Fluoranthene	0.19	0.56	5.6	2.8	4.7	2.1	17.4	2.7	8.6	31.0
Pyrene	0.15	0.33	7.7	2.22	4.2	1.5	16.8	1.9	6.2	31.0
1,2-benzanthracene	0.07	0.13	2.90	1.06	1.9	0.65	6.2	0.77	2.4	10.0
Chrysene	0.07	0.18	0.80	1.16	1.7	0.69	4.4	0.81	1.9	10.7
Benzo(b)fluoranthene	0.04	0.36	2.40	1.27	2.2	0.78	4.7	0.91	2.8	8.1
Benzo(k)fluoranthene	0.03	0.05	0.59	0.52	0.74	0.30	2.35	0.35	1.10	4.1
Benzo(e)pyrene	0.26	0.72	2.37	3.30	1.6	2.3	7.4	2.4	6.2	52.4
Benzo(a)pyrene	0.05	0.28	2.72	2.08	1.7	1.29	4.7	1.42	1.9	8.3
1,2,5,6-dibenzoanthracene	0.03	0.44	2.19	0.26	0.69	0.42	1.88	0.37	1.43	2.6
Benzo(g,h,i) perylene	0.07	0.67	3.85	0.90	1.52	0.74	3.2	0.67	2.4	6.7

The following organochlorine compounds were not detected: HCB, α -BHC, Γ -BHC, β -BHC, δ -BHC, α -chlordane, oxychlordane, heptachlor epoxide, Γ -chlordane, t-nonachlor, toxaphene, o,p'-DDE, p,p'-DDE, dieldrin, o,p'-DDD, endrin, cis-nonachlor, o,p'-DDT, p,p'-DDT, p,p'-DDD, mirex, 8-monohydromirex, 2,8-dihydromirex, (cis)5,10-dihydromirex, (trans) 5,10-dihydromirex, and 10-monohydromirex.

Mahoning River, and were found in the river bank sample at 4.8 ppm. All of the reported PAH's were found at low concentrations in the two Hickory Run samples; however, the same compounds were consistently found at concentrations at least one order of magnitude higher in the Mahoning River sediments. The river bank sample was consistently the most contaminated of the Mahoning River samples.

Table 5 compares the concentrations of selected PAHS in Mahoning River sediments we collected in Pennsylvania to those reported from Ohio portions of the river in 1986 (Estenik, 1988). PAH concentrations in the Pennsylvania samples were similar to those found between River Miles 17.68 and 36.7 in Ohio, but much lower than concentrations between River Miles 12.36 and 16.7 in Ohio.

Table 6 provides further insight into the severity of the Mahoning River PAH contamination, providing a comparison of our sample results to results from reference areas, areas with epizootics of neoplasia in fish, and from Presque Isle Bay. The Mahoning River sediments were somewhat more contaminated than those from Presque Isle Bay, and contained PAH concentrations an order of magnitude greater than the reference areas. Of the seven PAH's selected for comparison, five were found in Mahoning River samples at concentrations similar to the lowest levels found in areas with fish neoplasia.

Fish

Tables 7 and 8 provide the fillet and whole fish residue concentrations of various elements, and of organochlorine pesticides and PCBs, respectively. Aluminum results for these samples should be considered questionable, as the samples were wrapped in aluminum foil for storage. Table 9 compares the results for our whole fish samples with data from the National Contaminant Biomonitoring Program (NCBP; Schmitt et al., 1990; Schmitt and Brumbaugh, 1990). The NCBP analyzed seven elements (arsenic, cadmium, copper, mercury, lead, selenium and zinc) and organochlorine chemicals in whole freshwater fish samples collected from over 100 stations nationwide. The Mahoning River whole carp and white sucker samples exceeded the NCBP's 85th percentile concentrations for several elements. One of the Mahoning River carp samples contained a high cadmium burden compared to the NCBP values. All of the Mahoning River whole fish samples were extremely high in copper, two of the carp samples were high in lead, and all three carp samples were high in zinc. The Shenango River carp sample also exceeded the NCBP 85th percentile value for copper and zinc.

When compared to NCBP geometric mean values, chlordane-related compounds were somewhat elevated in several of the fish samples. However, PCBs far exceeded the NCBP geometric mean in all of the samples, including those from the Shenango River. None of the fillet carp concentrations exceeded the FDA Action Level of 2.0 ppm. Dieldrin was present in a whole white sucker sample from the Mahoning River at 0.04 ppm, equal to the NCBP geometric mean.

One carp sample collected by the Ohio EPA in 1986 from the Ohio portion of the Mahoning River contained mirex at 0.44 ppm (Estenik, 1988). Mirex was not detected in any of our fish samples.

Table 5. Concentrations of selected PAH compounds (ppm dry weight) in sediment samples collected in the Pennsylvania portion of the Mahoning River in 1991 compared to PAH concentrations in sediments collected by the U.S. Environmental Protection Agency from three Mahoning River areas in Ohio in 1986 (Estenik, 1988).

Element	Mean and Range	Pennsylvania River Mile 0.0 - Ohio Border (1991)	Ohio River Mile 12.36 - 16.7 (1986)	Ohio River Mile 17.68 - 23.72 (1986)	Ohio River Mile 26.9 - 36.7 (1986)
Naphthalene	Mean	0.71	7877	5.46	5.5
	Range	(0.26 - 1.24)	(1.3 - 38000)	(0 - 25.0)	(0 - 21.0)
Phenanthrene	Mean	3.7	2596	33.9	14.3
	Range	(1.4 - 6.5)	(5.4 - 18000)	(0 - 250)	(0 - 34.0)
Anthracene	Mean	1.2	260	6.23	4.6
	Range	(0.5 - 2.2)	(0.6 - 1200)	(0 - 31.0)	(0 - 14.0)
Fluoranthene	Mean	6.3	1239	32.4	15.1
	Range	2.1 - 17.4	(0.4 - 9500)	(0.8 - 180)	(0.8 - 53.0)
Pyrene	Mean	5.8	381	22.9	11.6
	Range	(1.5 - 16.8)	(2.9 - 1700)	(0.8 - 120)	(0.8 - 38.0)
Chrysene	Mean	1.6	289	10.1	6.8
	Range	(0.7 - 4.4)	(0 - 1700)	(0 - 33.0)	(0 - 14.0)
Benzo(b)fluoranthene	Mean	2.2	176	3.35	5.4
	Range	(0.8 - 4.7)	(0 - 900)	(0 - 11.0)	(0 - 24.0)
Benzo(a)pyrene	Mean	2.3	500	6.13	5.8
	Range	(1.3 - 4.7)	(0 - 3400)	(0 - 25.0)	(0 - 16.0)

Table 6. Concentrations of selected PAHs in Mahoning River sediments compared to concentrations from Presque Isle Bay (U.S. Fish and Wildlife Service, 1991), areas with epizootics of neoplasia in fish (*), and reference locations (R). All values in ppm dry weight. (Adopted from Baumann, 1989).

Great Lakes/Fresh Water	Phenanthrene	Fluoranthene	Pyrene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene
Smokes Creek*	0.93	7.6	2.0	18	1.9	0.73	1.6
Union Ship Canal*	7.5	33	24	14	11	3.4	6.4
Buffalo River*	23	28	38	9.5	6.5	3.4	6.8
Black Rock Canal*	3.4	9.9	11	2.7	3.8	2.4	3.4
Black River*	390	220	140	51	---	---	3
Lake Ontario (R)	NA	0.28	0.056	0.22	NA	NA	---
Buckeye Lake (R)	0.04	0.11	0.072	0.028	---	---	0.014
Presque Isle Bay	1.599	2.567	2.175	1.082	1.018	0.791	0.873
Mahoning River	3.7	6.3	5.8	1.6	2.2	0.85	2.3

NA = Data not available

Table 7. Concentrations of elements (ppm dry weight) and percent moisture in ten fish samples collected June 3-4, 1991 from the Mahoning and Shenango Rivers. Sample numbers 11-14 correspond to collection stations shown in Figure 1. See Appendix A for field data sheets.

Sample Type	FILLET				WHOLE FISH					
Location	Mahoning River		Shenango River	Mahoning River				Shenango River		
Species	Carp					White Sucker	Rockbass and Pumpkinseed		Carp	
Sample Number	11F	12F	13F	14F	11W	12W	13C	13W	14B	14W
Percent Moisture	78.8	75.7	77.9	76.1	70.8	74.8	77.9	73.4	78.6	73.8
Ag	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Al	<3.0	<3.0	<3.0	6.0	170	416	568	200	42.0	380
As	<0.2	<0.2	<0.2	<0.2	0.3	0.5	0.5	0.2	<0.2	0.4
B	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Ba	0.33	0.2	0.32	0.2	3.8	8.1	6.6	3.4	2.1	5.7
Be	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cd	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	<0.3	<0.3	<0.2	<0.3
Cr	<1.0	<1.0	1.0	<1.0	2.0	7.7	7.0	3.0	1.0	3.0
Cu	1.4	1.7	1.8	1.9	6.0	24.4	12.0	7.5	2.4	6.5
Fe	68.0	73.0	66.0	56.0	4100	16300	16000	7020	131	981
Hg	0.36	0.23	0.40	0.36	0.14	0.14	0.16	0.17	0.30	0.15
Mg	1030	900	967	927	952	1120	1150	1080	1160	932
Mn	0.94	1.1	1.2	1.1	39.2	129	109	63.6	15.0	49.3
Mo	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	1.0	1.0	<1.0	<1.0
Ni	<1.0	<1.0	<1.0	<1.0	2.0	4.7	4.8	3.0	<1.0	2.0
Pb	<4.0	<4.0	<4.0	<4.0	<4.0	4.0	5.0	<4.0	<4.0	<4.0
Se	1.5	1.8	2.1	1.6	1.5	1.8	2.2	1.6	2.0	1.4
Sr	1.5	1.1	1.6	0.92	22.0	25.2	25.5	18.0	13.5	15.7
Th	<7.0	<7.0	<7.0	<7.0	<7.0	<7.0	<7.0	<7.0	<7.0	<7.0
V	<0.3	<0.3	<0.3	1.3	0.8	1.8	2.5	2.8	2.3	3.1
Zn	94.8	91.6	74.3	69.5	286	353	227	75.2	75.0	172

Table 8. Organochlorine and PCB residues (ppm wet weight), percent moisture, and percent lipids in ten fish samples collected June 3-4, 1991 from the Mahoning and Shenango Rivers. Sample numbers 11-14 correspond to collection stations shown in Figure 1. ND = not detected. Lower level of detection = 0.05 for toxaphene and PCBs; 0.01 for all other compounds. See Appendix A for field data sheets.

Sample Type	FILLET				WHOLE FISH					
Location	Mahoning River		Shenango River	Mahoning River				Shenango River		
Species	Carp							White Sucker	Rock bass and Pumpkinseed	Carp
Sample Number	11F	12F	13F	14F	11W	12W	13C	13W	14B	14W
Percent Moisture	79.2	76.6	78.4	77.0	71.8	77.0	77.6	74.0	79.0	74.4
Percent Lipid	1.72	4.00	2.14	3.98	9.68	4.74	2.84	7.76	2.26	7.42
Oxychlordane	ND	0.01	ND	ND	0.02	0.01	ND	0.01	0.01	0.01
Heptachlor epoxide	ND	0.02	ND	ND	0.03	0.01	ND	0.02	ND	0.01
Γ-chlordane	ND	0.02	0.01	0.02	0.03	0.01	0.01	0.02	ND	0.02
t-nonachlor	ND	0.04	0.03	0.04	0.05	0.03	0.02	0.03	0.04	0.04
PCB's (Total)	0.91	1.2	1.3	1.3	1.8	1.4	1.20	1.7	2.0	1.5
σ-chlordane	0.01	0.03	0.02	0.03	0.05	0.02	0.02	0.03	0.02	0.03
p,p'-DDE	0.04	0.09	0.03	0.02	0.05	0.14	0.02	0.03	0.03	0.03
Dieldrin	ND	0.01	ND	ND	ND	0.02	0.02	0.04	0.01	ND
p,p'DDD	0.01	0.03	0.02	0.01	0.05	0.02	0.01	0.02	ND	0.01

The following compounds were not detected: HCB, α-BHC, Γ-BHC, β-BHC, δ-BHC, toxaphene, o,p'-DDE, o,p'-DDD, endrin, cis-nonachlor, o,p'-DDT, p,p'-DDT, mirex, 8-monohydromirex, 10-monohydromirex, 2,8-dihydromirex, (cis)5,10-dihydromirex, and (trans)5,10-dihydromirex.

Table 9. Concentrations of selected elements and organochlorine chemicals in Mahoning River whole fish samples, compared to National Contaminant Biomonitoring Program (NCBP) results for 1984. Shaded values equal or exceed the NCBP values. All values in ppm wet weight. (Concentrations of elements in fish samples from Table 7 were converted to wet weight).

Element	Mahoning River				Shenango River		NCBP 1984	
	Carp			White Sucker	Rock Bass and Pumpkinseed	Carp	85th Percentile	Geometric Mean
Sample Number	11W	12W	13C	13W	14B	14W		
As	0.1	0.1	0.1	0.1	ND	0.1	0.27	
Cd	ND	0.1	ND	ND	ND	ND	0.05	
Cu	1.8	6.1	2.7	2.0	0.5	1.7	1.0	
Hg	0.04	0.04	0.04	0.05	0.1	0.04	0.17	
Pb	ND	1.0	1.1	ND	ND	ND	0.22	
Se	0.4	0.5	0.5	0.4	0.4	0.4	0.73	
Zn	84.	89.	50.	20.	16.1	45.	34.2	
oxychlordane	0.02	0.01	ND	0.01	0.01	0.01		0.01
Γ -chlordane	0.03	0.01	0.01	0.02	ND	0.02		0.02
α -chlordane	0.05	0.02	0.02	0.03	0.02	0.03		0.03
heptachlor epoxide	0.03	0.01	ND	0.02	ND	0.01		0.01
t-nonachlor	0.05	0.03	0.02	0.03	0.04	0.04		0.03
PCBs (Total)	1.8	1.4	1.2	1.7	2.0	1.5		0.39
p,p'-DDE	0.05	0.14	0.02	0.03	0.03	0.03		0.19
Dieldrin	ND	0.02	0.02	0.04	0.01	ND		0.04
p,p'-DDD	0.05	0.02	0.01	0.02	ND	0.01		0.06

CONCLUSIONS

The results of chemical analysis of sediments collected from the Pennsylvania portion of the Mahoning River show somewhat lower concentrations of PAHs than were documented in a 1986 study of Ohio reaches of the river. Nevertheless, the concentrations are elevated compared to reference areas, and may be within the range of contamination generally associated with a high risk for fish neoplasia. If our one bank soil sample is any indication, bank contamination with PCBs, PAHs and other contaminants may be severe in some areas. Certainly, the degree of sediment contamination varies from one location to another.

Fish collected from the Mahoning River and the Shenango River contain a variety of organic and inorganic contaminants at concentrations far above "background" concentrations.

APPENDIX A
FIELD DATA SHEETS
(FISH SAMPLES)

FIELD DATA SHEET
Tissue Sampling - Commonwealth of Pennsylvania

Station # _____ Water Body: Shenando R Date: 6/4/91

Location: 200 yds downstream from Cherry St Bridge (at RR bridge, approx. 0.9 mi above mouth).

County: LAWRENCE Municipality: TAYLOR Twp

Collector: Hasse Agency: PA DER Coll.# _____

Method: Electrofishing (X) Seine () Gill Net () Rotenone ()
Angling () Other ():

Reason: _____

	SPECIES	TL-MM	WT-G	*CONDITION
1.	Carp	555	5Lb-4oz	Couple rub spils Lower jaw
2.	Carp	464	3Lb-7oz	Good
3.	Carp	455	3Lb-4oz	"
4.	Carp MR91-14F	427	2Lb-12oz	Fungus on Caudal Fin
5.	Carp	435	2Lb-14oz	Good
* 6.	Carp	410	2Lb-4oz	Good
* 7.	Carp MR91-14W	275	14oz	Good
* 8.	Rock Bass	155	82 grams	Anchor worms on body (Parasites)
* 9.	Rock Bass	165	100 grams	Anchor worms on body
* 10.	Pumpkinseed	127	56 grams	Anchor worms on body
*Note tumors, lesions, & general condition (if needed).				
* 11.	Pumpkinseed	120	46 grams	Good
Tissue Type: Whole Fish (X) Skinless Fillet () Skin-on Fillet (X) and Scaled (Y or N) (Y)				
Blood () Organ ():				
Other ():				

Comments (water/weather conditions, man-hours expended, problems etc.)

Weather - Sunny/Clear - Low 70's

Electrofished - 25 min

River: Clear

* whole fish samples

Note: 5 carp fillets (right side only) packaged together
Also (2) whole carp wrapped as one packet, and the rock bass wrapped together as one pkt (whole fish)

FIELD DATA SHEET
Tissue Sampling - Commonwealth of Pennsylvania

Station # _____ Water Body: MAHONING RIVER Date: 6/4/91
Location: 100 yds downstream from Route 108 bridge
(lower station)
County: Lawrence Municipality: N. Beaver Twp
Collector: HASSE Agency: PA DEE Coll.# _____
Method: Electrofishing (X) Seine () Gill Net () Rotenone ()
Angling () Other ():

Reason: _____

	SPECIES	TL-MM	WT-G	*CONDITION
1.	Carp	700	666-602	Sores - Back side old wounds healed over - T.S.L. sores
2.	Carp	505	466-402	Rub spots on lower part of head
3.	Carp	475	366-602	Good
4.	Carp	402	266-602	Sores on lower part of head left
5.	Carp	432	266-402	Small sore at base of Pectoral
6.	Carp	412	266	
7.	Carp	345	166-502	Reddish area between Pectoral fins
8.	White Sucker	237	152 gm	Good
9.	white sucker	280	238 gm	Missing upper part of caudal fin
10.	Note tumors, lesions, & general condition (if needed).			

Tissue Type: Whole Fish (X) Skinless Fillet () Skin-on Fillet (X)
Scaled (Y or N) (Y)
Blood () Organ ():
Other ():

Comments (water/weather conditions, man-hours expended, problems etc.)

* packaged separately ^{as} whole fish samples
** " " " " " "

Electrofished for 20 minutes
clear/sunny 70's
River - Turbid

MR91-13F
Right-side Fillets only
MR91-13W
Whole fish samples
858 lbs
(14 oz.)

FIELD DATA SHEET
Tissue Sampling - Commonwealth of Pennsylvania

Station # _____ Water Body: Mahoning River Date: 6/3/91
Location: 100 yds downstream from bridge T372 @ Coverts
(middle station)

County: Lawrence Municipality: Union twp

Collector: Hasse Agency: PA DFR Coll.# _____

Method: Electrofishing (☒) Seine () Gill Net () Rotenone ()
Angling () Other ():

Reason: _____

MR
91-12F
2 lb 14oz skin-on fillets
MR
91-12F
2 lb 13oz whole fish

SPECIES	TL-MM	WT-G	*CONDITION
1. <u>Carp</u>	<u>398.0</u>	<u>11lb 14oz</u>	<u>small sores ventral tail fin wear</u>
2. <u>Carp</u>	<u>434.0</u>	<u>21lb 8oz</u>	<u>Good</u>
3. <u>Carp</u>	<u>445.0</u>	<u>21lb 10oz</u>	<u>sore on ventral surface</u>
4. Carp	410.0	21lb 2oz	Good fish accid. dropped - thrown away
5. <u>Carp</u>	<u>400.0</u>	<u>11lb 14oz</u>	<u>Good</u>
*6. <u>Carp</u>	<u>274.0</u>	<u>12oz</u>	<u>fungus on caudal fin</u>
*7. <u>Carp</u>	<u>305.0</u>	<u>15oz</u>	<u>Good</u>
*8. <u>Carp</u>	<u>225</u>	<u>11lb 2oz</u>	<u>anal fin wear</u>
9. _____	<u>12:07</u>	_____	_____
10. _____	_____	_____	_____

*Note tumors, lesions, & general condition (if needed).

Tissue Type: Whole Fish (☒) Skinless Fillet () ^{and} Skin-on Fillet (☒)
Scaled (Y or N) (☒)
Blood () Organ ():
Other ():

Comments (water/weather conditions, man-hours expended, problems etc.)

Shock time 20 min

* Fish packed whole

weather clear/partly cloudy
temp mid 70's

River : turbid

FIELD DATA SHEET
Tissue Sampling - Commonwealth of Pennsylvania

Station # _____ Water Body: Mahoning River Date: 6/3/91

Location: 150 yds downstream from T324 bridge
near Robinson (upper station)

County: Lawrence Municipality: Mahoning

Collector: Hasse Agency: PADER Coll.# _____

Method: Electrofishing (X) Seine () Gill Net () Rotenone ()
Angling () Other ():

Reason: _____

MR91
-11F
✓
2321g
516 202.
Skin-on fillets

MR
91-
11W
✓
3 whole fish
1302.
216

SPECIES	TL-MM	WT-G	*CONDITION
1. <u>Carp</u>	<u>468.0</u>	<u>2 lbs 2oz</u>	<u>Good</u>
2. <u>Carp</u>	<u>504.0</u>	<u>4.0 lbs</u>	<u>sores/parasites on belly</u> <u>lower caudal fin worn</u>
3. <u>Carp</u>	<u>528.0</u>	<u>4 lbs 4oz</u>	<u>sores/parasites on belly</u> <u>pelvic fin deformed (left side)</u>
4. <u>Carp</u>	<u>505.0</u>	<u>3 lbs 9oz</u>	<u>Good</u>
5. <u>Carp</u>	<u>424.0</u>	<u>2.0 lbs</u>	<u>sore/parasite on belly</u>
6. <u>Carp</u>	<u>368.0</u>	<u>1 lbs 9oz</u>	<u>Good</u>
7. <u>Carp</u>	<u>332.0</u>	<u>1 lbs 4oz</u>	<u>old wound left side</u>
8. _____	_____	_____	_____
9. _____	_____	_____	_____
10. _____	_____	_____	_____

*Note tumors, lesions, & general condition (if needed).

Tissue Type: Whole Fish (✓) Skinless Fillet () Skin-on Fillet (✓)
and
Scaled (Y or N) (Y)

Blood () Organ ():

Other ():

Comments (water/weather conditions, man-hours expended, problems etc.)

Shocked 25 min
Weather clear, partly sunny
Temp mid 70's

* Fish packed
whole

River: turbid

APPENDIX B

EPA (1977) POLLUTION CLASSIFICATION GUIDELINES

Table B-1. U.S. Environmental Protection Agency 1977 Guidelines for the pollutional classification of Great Lakes harbor sediments. All values in ppm dry weight. Source: U.S. EPA, Region V. Chicago, IL. April 1977.

	Nonpolluted	Moderately Polluted	Heavily Polluted
Lead	<40	40 - 60	>60
Zinc	<90	90 - 200	>200
Iron	<17,000	17,000 - 25,000	>25,000
Nickel	<20	20 - 50	>50
Manganese	<300	300 - 500	>500
Arsenic	<3	3 - 8	>8
Cadmium	Lower limits not established		>6
Chromium	<25	25 - 75	>75
Barium	<20	20 - 60	>60
Copper	<25	25 - 50	>50
Mercury	>1 unacceptable for open lake disposal		>1
Total PCBs			>10