Table 2.5-7
PCB Levels from Waste Water Treatment Plants, Michigan

City	Effluent (1971-72) (ppb) Aroclor 1254	Effluent (1971) (ppb) Aroclor 1242	Effluent (1971) (ppb) Aroclor 1254	Sludge (1971) (ppb) Aroclor 1242	Sludge (1971) (ppb) Aroclor 1254
Adrian	0.41-14.00				
Albion	0.44		0.34		1.5
Ann Arbor	<0.10-0.14		0.25		1.1
Battle Creek	0.16-0.92		<0.10		2.8
Bay City	5.70-340.00	3.20		352.0	
Benton Harbor St. Joseph	0.31-0.99		0.20		13.8
Brighton	0.38				<0.1
Charlotte	0.61		0.34		6.8
Constantine	0.85		0.46		2.1
Detroit	0.88-3.00	2.15	32.1		
Dexter	<0.10		0.23		3.2
E. Lansing	0.35-0.69		0.18		4.6
Escanaba	0.29				5.9
Essexville	0.21-0.28		0.10		3.9
Flint	<0.10-1.30		<0.10		6.3
Flushing	0.52				
Gladstone	0.19	0.44			4.1
Grand Haven	<0.50		<0.10		4.1
Grand Rapids	0.37-0.68	1.05			11.8
Holland	0.42-0.79	<0.10			0.8
Houghton-Hancock	<0.10	0.18			5.5
Iron Mountain-Kingsford	0.55-1.20	0.69			9.5
Ironwood	0.16		0.29		5.2
Jackson	<0.10	<0.10			3.0
Kalamazoo	0.19-1.30	1.12	23.3		
L'Anse	<0.10		0.31		4.4
Lansing	0.13-0.23	0.22			5.3
Manistique	<0.20	0.63			1.5
Marquette	0.35	0.29			2.8
Marshall	<0.10	0.15			3.9
Menominee	0.35	0.57			4.2
Midland	0.13-0.40	<0.10			2.9
Milford	<0.10		2.20		
Monroe	0.33-0.60	<0.10			3.3
Mt. Clemens	1.40-10.00		2.90	175.0	
Mt. Pleasant	<0.10	0.29			6.5
Muskegon	0.28	0.83			12.7
Muskegon Heights	0.37	0.18			11.0
Niles	0.68	0.48			7.8
Norway	0.40	<0.10			<0.1

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Table 2.5-7 (cont.)

City	Effluent (1971-72) (ppb) Aroclor 1254	Effluent (1973) (ppb) Aroclor 1242	Effluent (1973) (ppb) Aroclor 1254	Sludge (1973) (ppb) Aroclor 1242	Sludge (1973) (ppb) Aroclor 1254
Ontonagon	<0.10				
Owosso	<0.10	0.12			2.0
Parchment	<0.10				
Pontiac (Auburn Rd)	<0.10-0.61		0.60		
Pontiac (E. Blvd)	0.15-1.30		0.54		
Portage	1.90				
Port Huron	0.28-0.52		1.80		
Saginaw	0.74-3.80		0.77		5.0
St. Ignace	<0.20	0.31			1.5
South Haven	<0.10				
Swartz Creek	<0.10				
Three Rivers	<0.30	<0.10			4.1
Trenton	0.14-1.10	<0.10			<0.1
Warren	0.10-0.16	<0.10			<0.1
Wayne County (Wyandotte)	0.17-0.64	0.40		2.01	
Wyoming	0.44-0.55	0.22			
Ypsilanti	0.21-0.22		0.31		2.0
Ypsilanti Twp #1	<0.10-0.12	<0.10			<0.1
Ypsilanti Twp #2	0.16-0.19	<0.10			<0.1
Cadillac		0.53			<0.1
Howell					15.0
Sault Ste. Marie		0.73			2.4
Traverse City		<0.10			1.8

SOURCE: Monitoring for Polychlorinated Biphenyls in the Aquatic Environment, Michigan Water Resources Commission, May 1973

2.5.2.3 Wisconsin

Samples from sewage treatment facilities in Wisconsin were collected in March 1970. The PCB concentrations identified in the effluents ranged from 0.04 to 0.25 ppb and are presented in Table 2.5-8.[9]

In 1971 11 municipal sewage treatment plants in eleven southeastern Wisconsin cities were sampled as shown in Figure 2.5-8. Table 2.5-9 shows the results of this study and indicates that six of the eleven sewage plants had effluents ranging from 0.1 to 0.5 ppb of Aroclor 1254 while two sites were greater than 1.0 ppb for the same Aroclor. However Portage had 42 ppb of Aroclor 1248 in the effluent with 5.2 ppm in the digester sludge.

It is interesting to note that even though Port Washington is not as highly industrialized as Grafton the effluents from both cities contained approximately the same concentrations of PCB's ranging from 0.12 to 0.23 ppb.

Since the concentrations for Cedarburg were so high a special 24 hour study was conducted. The concentrations in raw sewage began to increase at the beginning of the working day from 0.54 ppb to a maximum of 3.1 ppb at 4:00 p.m. Table 2.5-10 presents the readings taken. The concentration in the final effluent appears to begin increasing from 0.33 ppb at midnight to a maximum of 0.77 ppb at 2 p.m. The concentration of PCB's in the effluent is approximately 30 percent of that in the influent. The concentration of PCB's in the sludges is approximately 1,000 times higher than in the fluid wastes. These data demonstrate that the time of sampling waste effluents is of importance in mass transport estimates.[1]

MONS 047282

Table 2.5-8
Concentrations of PCBs in Outfalls into the
Milwaukee River on March 26, 1970

Location	Aroclor	PCB Concentration (ppb)
West Bent STP effluent	1254	0.25
Fredonia STP effluent	1254	0.12
Tributary at Fredonia	1260	0.04
Saukville STP effluent	1260	0.13
Chemical plant effluent, Saukville	1242	2.50
Grafton STP effluent	1254	0.04

SOURCE: Veith, G.D., and G.F. Lee, Water Research, 5, 1107-1115, (1971)

Table 2.5-9
PCB Concentrations in the Effluents from 11 Southeastern
Wisconsin Sewage Treatment Plants, 1971

City	PCB Concentrations (ppb)	Estimated Mass Transport (in lb/day)
Beaver Dam	0.05	0.0002
Port Washington	0.12-0.22	0.0027
Grafton	0.07-0.23	0.0008-0.0015
Cedarburg	0.28-1.1	0.0027-0.018
Racine	0.60-0.83	0.142
Burlington	0.08-0.14	0.0017
Lake Geneva	2.2-2.8	0.018
Walworth	0.17-0.34	
Beloit	3.89-11.75	0.0038-0.0052
Ft. Atkinson	1.24-2.48	
Portage	32-42	0.0015

SOURCE: Dube, D.J. Polychlorinated Biphenyls in Effluents from Sewage Treatment Plants in Southeastern Wisconsin

MONS 047283

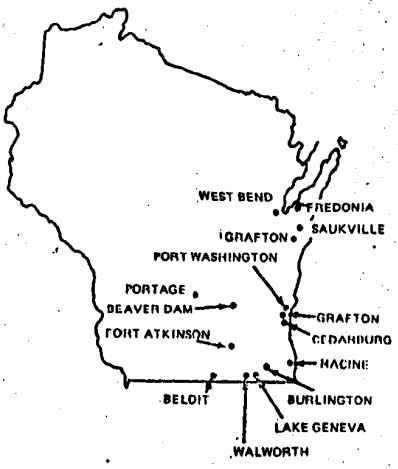


FIGURE 2.5-8 WISCONSIN CITIES WHERE MUNICIPAL SEWAGE TREATMENT PLANTS WERE SAMPLED IN 1971

MONS 047284

Table 2.5-10
A 24-hour Survey of PCB's in the Cedarburg Treatment Plant on April 15, 1971

Time	Flow (in gal/min)	PCB Concentrations (in ppb)[1] In the Influent	In the Effluent	In the Primary Trickling Filter
0:00	1480	0.30	0.33	-----
1:00	1360	----	----	0.19
2:00	1300	0.20	0.10	-----
4:00	1250	0.13	0.35	-----
6:00	1200	----	0.16	-----
8:00	2000	0.54	0.39	-----
10:00	2100	0.40	0.50	-----
12:00	1900	1.7	0.23	0.69
14:00	1900	1.5	0.77	-----
16:00	1850	3.1	0.70	-----
17:00	1900	----	----	0.25
20:00	1950	0.30	0.22	-----
21:00	1800	----	----	0.14
22:00	1650	0.36	0.34	-----

[1]The Chromatograms of the samples most closely resembled the chromatogram of Aroclor 1254.

SOURCE: Dube, D.J. Polychlorinated Biphenyls in Effluents from Sewage Treatment Plants in Southeastern Wisconsin

2.5.2.4 Ohio

Very little information is available from the Ohio River. The values reported are given in Table 2.5-11.

Table 2.5-11
PCB Levels from Sewage Treatment Plants, Ohio, 1971

Collection Site	Aroclor Detected	Concentration (ppb)
Dayton	1254	17
Hamilton	1248	10
Middleton	-----	N.D.

SOURCE: Polychlorinated Biphenyls and the Environment, Inter-departmental Task Force on PCB's, May 1972

2.5.2.5 California

In 1970 over a billion gallons of waste water entered the sea each day from urban sewage systems in California. Since two kilograms of PCB output per day are equivalent to one ton per year, outfalls of 9 sewage treatment plants discharging waste to the sea in California were sampled in an effort to identify potential PCB sources. The samples were all taken from sewage outfalls at sites closest to the points of entry into the sea as shown in Figure 2.5-9. The highest output was reported in Los Angeles County which is one of the most industrialized areas in the state. Table 2.5-12 shows the PCB levels identified in the samples collected.[5]

The only other available data were collected in early 1975 on sludge as part of the California Compliance Monitoring Survey for Chlorinated Hydrocarbons.[6] The results obtained are listed in Table 2.5-13.

Only one plant was sampled in both studies, the Hyperion Plant in Los Angeles. The 1970 sludge samples had 78.5 and 98.1 ppb concentrations while the 1975 readings ranged from 1,000-1,400 ppb.

MONS 047287

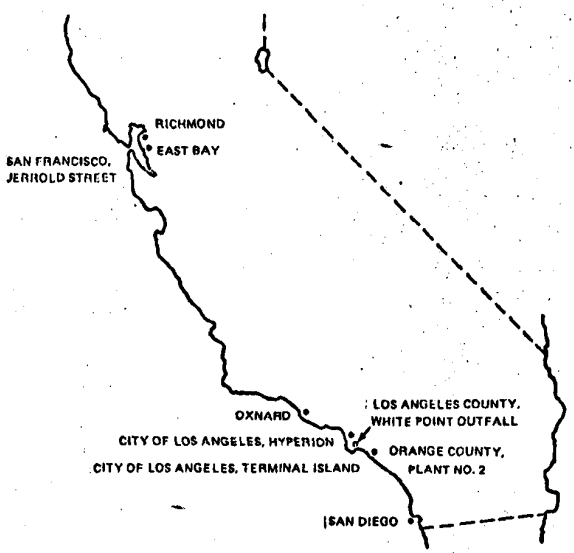


FIGURE 2.5-9 LOCATIONS OF TREATMENT PLANTS SAMPLED, CALIFORNIA

MONS 047288

Table 2.5-12
PCB Compounds in Urban Sewage Outfalls in California - 1970

Sampling Station	Description	Flow	PCB Type	PCB ppb	PCB est. kg/day
Richmond	Serves most of Richmond including one of the most heavily industrialized regions of the Bay Area.	21.5	——	N.D	——
EBMUD East Bay Municipal Utility District	Discharges primary treated waste water and digested sludge into San Francisco Bay.	155	1260	3.1-3.8	2.0
San Francisco (Southeast Sewage Treatment Plant)	Serves the industrial area of San Francisco.	31.5	1260	3.8-5.8	0.6
Oxnard	Serves Oxnard.	10.0	——	N.D	——
Hyperion Waste Water (City of Los Angeles) Sludge	Mostly domestic sources.	340 5	1254 1254	0.16-0.37 78.5-92.1	0.4 1.6
White Point	Serves Long Beach, Torrance and other heavily industrialized areas of Los Angeles County.	350	1242, 1254	76	100
Terminal Island	Serves Wilmington and Terminal Island seas. Processes mostly industrial waste.	9.3	1242	5.8-12.8	0.35
Orange County (plant #2)	Serves most of Orange County.	130	1242	0.21-0.64	0.18
San Diego	Serves San Diego and surrounding communities.	80		N.D	

SOURCE: Schmidt, T.T., R.W. Risebrough and F. Gress, Bulletin of Environmental Contamination and Toxicology 6, 235-243, (1971)

MONS 047289

Table 2.5-13
PCB Levels in Sludge, California, 1975

Location	Description	Polychlorinated Biphenyls (ppm) Aroclor 1254	Aroclor 1260	Aroclor 1242
Orange County Sewage Treatment Plant	Fountain Valley Digester Sludge	----	----	38-40
Hyperion Sewage Treatment Plant	Los Angeles, Digester Sludge	1.0-1.4	----	----
Fort Ord Sewage Treatment Plant	Secondary Digester Sludge	0.2-0.4	----	----
Treasure Isle Sewage Treatment Plant	Sludge	0.4-0.6	----	----
Travis Air Force Base, Sewage Treatment Plant	Digester Sludge	0.6-0.8	----	----
Mather Air Force Base	Sacramento Primary Digester Sludge	0.4-0.6	----	----
McClellan Air Force Base	Secondary Sludge	----	4.5-5.5	----
Beale Air Force Base	Primary Digester	0.3-0.5		

SOURCE: Unpublished Data, USEPA National Field Investigation Center, August 1975

MONS 047290

REFERENCES, Section 2.5

1. Duke, D.J. Polychlorinated Biphenyls in Effluents from Sewage Treatment Plants in Southeastern Wisconsin

2. Nadeau, R.J., and R.P. Davis, Investigation of Polychlorinated Biphenyls in the Hudson River, USEPA Region II

3. Polychlorinated Biphenyls and the Environment, Interdepartmental Task Force on PCB's, May 1972

4. Monitoring for Polychlorinated Biphenyls in the Aquatic Environment, Michigan Water Resources Commission, May 1973

5. Schmidt, T.T., R.W. Risebrough and F. Gress, Bulletin of Environmental Contamination and Toxicology 6, 235-243, (1971)

6. Unpublished Data, USEPA National Field Investigation Center, August 1975

7. Unpublished Report, Contract 68-01-2978, USEPA, Office of Toxic Substances; July 1975

8. USEPA, Pesticide Monitoring Programs: Lake Michigan and Tributaries in Illinois, EPA 600/3-74-002

9. Veith, G.D., and G.F. Lee, Water Research, 5, 1107-1115, (1971)

MGNS 047291

2.6 Data from Localized Monitoring Efforts - Cities

2.6.1 Jacksonville, Florida

Samples of ambient air, water, soils and bottom sediments were collected in the vicinity of Jacksonville, Florida, on September 10, October 6-7 and November 20-21, 1975, for PCB analysis.[1]

Figure 1 illustrates the sampling locations in the Jacksonville area. The outlined area on Figure 2.6-1 circumscribes a municipal sewage sludge disposal site which has been used for the past several years by the City of Jacksonville.

AIR DATA

Air samples were collected at the fire station off Fort Caroline Road using a high-volume sampler equipped with polyurethane foam as the collection medium. Measured PCB concentrations are reported in Table 2.6-1 for the 24-hour period of November 20-21, 1975. The levels measured throughout this period ranged from 4 to 9 ng/m^3, with the lowest levels being observed during the early morning period. Chromatograms indicated the presence of the lower substituted PCB components of Aroclors 1221 and 1016. Quantitation of the PCB levels was performed after perchlorination to decachlorobiphenyl.

WATER, BOTTOM SEDIMENT AND SLUDGE DATA

The analytical data for water, bottom sediment and sludge are summarized in Table 2.6-2 for the sampling points shown on Figure 2.6-1. PCB content of bottom sediments range from 10 to 572 ppb, surface water concentrations ranged from the analytical detection limit of 20 ppt to 285 ppt, expressed as decachlorobiphenyl. The highest sediment concentration (572 ppb) was observed near the cooling water discharge of the Jacksonville Electric Authority Southside Generating Station. This may be related to use of PCB-containing materials at the generating station. Intermediate concentrations were observed in sections of the St. John's River which is surrounded by urban and industrial development. Drainage creeks from the municipal sewage sludge landfill area had bottom sediments of lower concentration. Inspection of gas chromatographic elution patterns indicates the presence of Aroclor 1260 in these sediment samples.

A concentration level of 720 ppb was measured for fresh sludge taken from the Monterey sewage treatment plant. Two-year-old sludge, taken from the landfill area, had a concentration level of 119 ppb.

MONS 047292

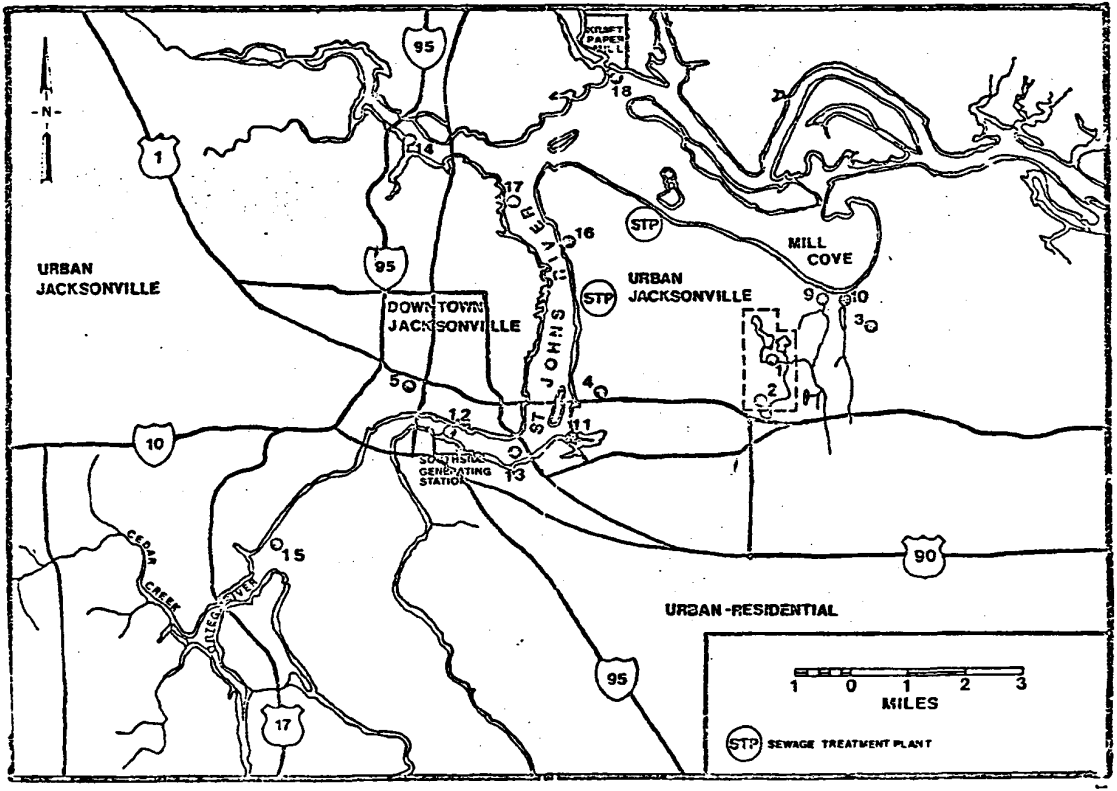


FIGURE 2.6-1 SITE MAP OF JACKSONVILLE, FLORIDA, VICINITY SHOWING SAMPLE LOCATIONS.

MONS 047293

Table 2.6-1
PCB in Ambient Air in the Vicinity of Jacksonville, Florida

Date	Period	Concentration (ng/m^3)*
11/20/75	1200-1600	9
11/20/75	1200-1800	8
11/20/75	1800-2400	9
11/20/75	2000-2400	7
11/21/75	2400-0600	4
11/21/75	0600-1200	6

* Reported as decachlorobiphenyl.

Table 2.6-2
PCB Analysis of Environmental Samples
in the Jacksonville, Florida, Area.

Sample Site	Sample Type	Site Description	Concentration (ppb)*
1	Sludge	Monterey sewage treatment plant	720
2	Soil	SW section of sludge landfill; about two years old	119
3	Soil	Air collection site	68
9	Sediment	Unnamed Stream into Mill Cove	10
10	Sediment	Ginhouse Creek	21
11	Sediment	Arlington River Mouth	74
11	Water	Arlington River Mouth	0.260
12	Sediment	Generating Station Discharge	572
13	Sediment	St. John's River	142
14	Sediment	Trout River	167
14	Water	Trout River	0.020
16	Water	Jacksonville College Pier	0.285
17	Water	St. Joseph's River	0.103
18	Water	Broward River Mouth	0.020

*Reported as decachlorobiphenyl.

SOURCE: Unpublished Report. Contract 68-01-2978, Office of Toxic Substances, EPA, December 1975.

MONS 047294

REFERENCES, Section 2.6

1. Unpublished Report. Contract 68-01-2978, Office of Toxic Substances, EPA, December 1975.

MONS 047295

3.0 Behavior of PCB's in the Environment

In general, PCB environmental movement is dependent on stability, solubility and volatility. These properties will control their transport via air, soil, water and/or sediment depending on the partition coefficient in each phase.

Ceneral discussions on the thermal, photochemical and chemical properties of PCB's have recently been published by Hutzinger, Safe and Zitko[5]. Various transport mechanisms have received considerable attention[9,14]. Current air data indicates that the predominant movement of PCB's in the atmosphere is not attached to particulates as is the case with DDT, but rather as the free unbound molecular species.

Some of the complexities of the behavior of PCB's in the environment include the following characteristics which are discussed in subsequent sections: (a) the complexity of the composition of different Aroclor products, (b) the difficulty in definition of water solubility and adsorption properties due to the complexity of the mixtures, and (c) the variability of the volatilization process depending on the starting mixture and point of release. By coupling these areas, the focus will be on those PCB properties that influence environmental sample collection, control their distribution in environmental samples and present potential difficulties in environmental sampling.

3.1 Composition of Aroclor Products

PCB's have been manufactured in the United States by the Monsanto Industrial Chemicals Company, and marketed under the trademark Aroclor with a numerical designation[8]. Table 3-1 provides an overview of the major Aroclors produced with their associated chlorine content. These Aroclor products are mixtures of different isomers. A typical analysis of the currently produced products and the associated chlorobiphenyl composition is shown in Table 3-2. In addition, the number of potential isomers making up the chlorobiphenyl component are also indicated. From this chemical analysis, Aroclor 1221 can be considered primarily as a monochlorobiphenyl and is the only Aroclor with a significant biphenyl concentration; Aroclor 1016 and 1242 are primarily trichlorobiphenyls, with the 1016 having a lower penta and hexa content than the 1242 product; Aroclor 1254 is primarily a pentachlorobiphenyl product. The composition of the different isomers could be quite different for each product.

3.2 Water Solubility of PCB's

The water solubility of various Aroclor products and some chlorobiphenyl isomers has been measured by different investigators. A limited set of reported values are shown in Table 3-3. The solubility for all three monochlorobiphenyl isomers is listed and range from 1190-5900 ppb. The solubilities for all of the higher chlorobiphenyl isomers have not been measured and only representative compounds are listed to

show the range of values possible and the component solubilities for Aroclor 1221; for the dichlorobiphenyls, the 2,4-, 2,2'-, 2,4'-, 4,4'-dichloro isomer is listed out of a possible 12 isomers and range in solubility from 80-1880 ppb; for the trichlorobiphenyls, only the 2,2',5-trichloro is listed out of a possible 24 isomers; for the tetrachlorobiphenyls only the 2,2',5,5'-tetrachloro is listed out of a possible 42 isomers. These values indicate that PCB's have low solubilities and the solubility decreases with the number of chlorine atoms present in the isomer, i.e., the lower isomers containing chlorine show the highest solubility. Factors that contribute to the variability of the results include adsorption to particulate matter or wall surfaces and the slow equilibration process.

Studies by Haque et. al.,[9] show that equilibration of Aroclor 1254 in water required approximately two months to reach complete equilibrium, with the major portion being achieved in a week. These studies also included various types of adsorbent surfaces ranging from sand to highly organic soil samples. The adsorption increased strongly with the organic content of the adsorbent studied. Starting with an original concentration of Aroclor 1254 at 56 ppb, the addition of 100 grams of sand or silica gel had very little effect on the final PCB concentration. However, by adding a high organic content soil, the final PCB concentration was reduced by approximately 85%.

Studies by Eichelberger[1] on the behavior of PCB's in river water over a 16 week period indicated that the levels of recovery of 10 ppb spiked Aroclor 1242 samples were 87, 76, 73, 60, 53 and 43 percent for zero time, 1, 2, 4, 8 and 16 weeks respectively. Losses were attributed to irreversible adsorption on either the walls of the sample container or the silt contained in the sample.

3.3 Interactions of PCB's with Soils

The behavior of PCB's in soil is a complex process dependent on a number of factors which include surface properties and composition. Soil composition can be identified by characterizing the percentage of sand, silt, clay and organic carbon. Depending on the surface properties, soils can act as an effective barrier to PCB migration in landfill sites and as an effective sink to PCB's deposited via aerial fallout. Once the PCB's are adsorbed, factors that would influence PCB movement are leaching when water is added to the soil and re-evaporation under normal atmospheric conditions.

In a series of experiments directed at understanding the leaching properties for various soils that could be encountered at different landfill sites, different types of soils were studied[10]. These experiments percolated water through a column packed with soil coated with Aroclor 1016 and monitored the effluent water. Breakthrough of the PCB's was found to be related to the clay content of the soil. Soils with the higher clay content retained the PCB's. The isomer distribution in the

effluent reflected the different water solubility and adsorption properties characteristic of the Aroclor 1016 isomers. The less chlorinated isomers were more readily leached. Results from these experiments are shown in Figure 3-1, where an Aroclor 1016 and 1221 standard solution is compared with the leached mixture. The resulting isomer distribution is slightly changed from the starting Aroclor 1016 and has a closer resemblance to the isomer pattern of Aroclor 1221. In the worst case, less than 0.05% of the total Aroclor 1016 available was leached under conditions equivalent to forty years of annual rainfall.

Adsorption and evaporation studies[5] with Aroclor 1254 on different soils show that due to the few adsorption sites in sand, sand surfaces adsorb relatively small amounts when compared to the other types of soils. Consequently the vaporization loss from a sand surface will be significantly higher than soil surfaces where it is more tightly bound. The less chlorinated isomers show a greater loss than those isomers of high chlorine content.

3.4 Evaporation of PCB's from Water

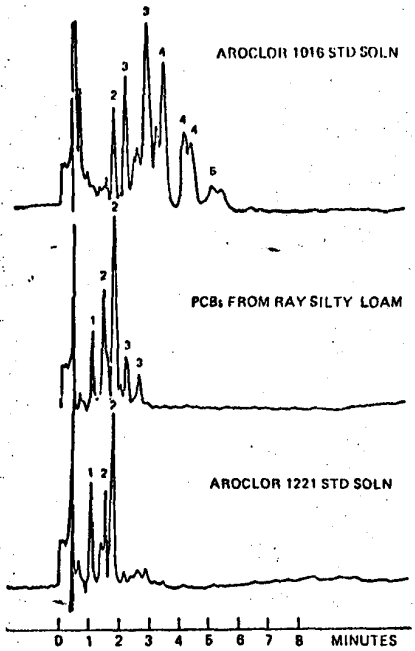
The transfer of PCB's from water to the air environment may be significantly faster than expected when considering that these compounds have a high molecular weight, low solubilities and low vapor pressures[6,7]. On examination, these compounds exhibit very high activity coefficients in aqueous solution resulting in high equilibrium vapor partial pressures and consequently high evaporation rates. The rates are relatively insensitive to temperature. For different Aroclor products, the evaporation process is complex depending on the chlorobiphenyl isomers present, leading to different isomer concentrations in each phase with time. The calculated half-lives for Aroclor 1242 and 1254 for a water depth of one meter are 12.1 and 10.3 hours respectively. Using the half-life values, if a monitoring station is located one hour downstream from a source of Aroclor 1242, by the time the water reaches the station, approximately one twentieth of the initial levels may have been evaporated. Where the water body is turbulent, the evaporation rate will be increased significantly.

3.5 Environmental Sampling Guidelines

Based on these limited studies, the following guidelines and precautions are suggested:

(1) laboratory measurements of field samples should be made as soon as possible;
(2) concentration levels of field samples measured in the laboratory will be lower than actual concentrations;
(3) concentration levels in water may be much lower in some areas depending on the type of suspended particulate matter;
(4) samples collected at plant outfalls will be non-equilibrium samples;

MONS 047298



SOURCE: MIEURE, J.P., O. HICKS, R.G. KALEY AND V.W. SAEGER, "CHARACTERIZATION OF POLYCHLORINATED BIPHENYLS," NATIONAL CONFERENCE ON POLYCHLORINATED BIPHENYLS, CHICAGO, ILL., NOVEMBER 19-21, 1975

FIGURE 3-1

(5) sampling methods should be employed which reduce the problem of irreversible adsorption on container walls;
(6) soil samples will have an enriched high chlorobiphenyl isomer concentration;
(7) leached water and air samples will have an enriched lower chlorobiphenyl isomer concentration;
(8) true identification of the specific Aroclor released into the environment becomes more difficult with time.

MONS 047300

Table 3-1
AROCLOR PRODUCTS
Produced by Monsanto

Currently in Production	Discontinued	Percent Chlorine
1221		21
	1232	32
1016		41
1242		42
	1248	48
1254		54
	1260	60
	1262	62
	1268	68

Table 3-2
COMPOSITION OF SOME AROCLORS

Chlorobiphenyl Composition	Number of Isomers	Chlorobiphenyl Percent Distribution of some Aroclors 1221	1016	1242	1254
$C_{12}H_{10}$		11	<0.1	<0.1	<0.1
$C_{12}H_9Cl$	3	51	1	1	<0.1
$C_{12}H_8Cl_2$	12	32	20	16	<0.5
$C_{12}H_7Cl_3$	24	4	57	49	1
$C_{12}H_6Cl_4$	42	2	21	25	21
$C_{12}H_5Cl_5$	46	<0.5	1	8	48
$C_{12}H_4Cl_6$	42	ND	<0.1	1	23
$C_{12}H_3Cl_7$	24	ND	ND	<0.1	6
$C_{12}H_2Cl_8$	12	ND	ND	ND	ND

ND = None detected, <0.1%

Table 3-3
SOLUBILITY OF AROCLORS AND CHLOROBIPHENYLS IN WATER

Aroclor Products	Solubility (ppb)	Media	References
1016	225-250	distilled water	10
1221	200	distilled water	8
1242	200	distilled water	9
1254	300-3000	fresh water	12
1254	300-1500	salt water	12
1254	50	distilled water	9
1254	56	distilled water	3
1254	40	distilled water	8
Chlorobiphenyl Compounds			
2-chlorobiphenyl*	5900		5
3-chlorobiphenyl	3500		5
4-chlorobiphenyl*	1190		5
2,4-dichlorobiphenyl	1400		5
2,4-dichlorobiphenyl	637		2
2,2'-dichlorobiphenyl*	1500		5
2,4'-dichlorobiphenyl*	1880		5
4,4'-dichlorobiphenyl*	80		5
2,2',5-trichlorobiphenyl	248		2
2,2',5,5'-tetrachlorobiphenyl	46		11
2,2',5,5'-tetrachlorobiphenyl	26		2

*These are the major chlorobiphenyl compounds in Aroclor 1221; the other major constituent is biphenyl which has a solubility in water of 4600 ppb.

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MONS 047303

4.0 Occurrence of PCB's in Food

Some of the earliest findings of PCB's in foods occurred during the fall of 1969 in coho salmon and milk from West Virginia which was traced back to the misuse of a transformer fluid containing PCB's for defoliant spraying adjacent to dairy pasturage. In 1971 PCB's were found in poultry from North Carolina. Contaminated fish meal was implicated as the causative agent. The contamination was traced back to a leak in heat exchange equipment using PCB's. The fish meal samples examined contained from 14 to 30 ppm of PCB's. Follow-up sampling of eggs showed that 71 of 224 eggs contained residues in excess of 0.5ppm ranging from 0.6 to 4.2.ppm.[2]

The Food and Drug Administration conducts a comprehensive food surveillance program yearly to determine pesticide residues, PCB's, heavy metals and other contaminants in the dietary intake of consumers in the United States and to target emerging problems and trends. The FDA has analyzed all raw agricultural commodities sampled under the pesticide surveillance program for PCB's since 1969. PCB's have been encountered most frequently in fish, both freshwater (catfish, chub, and smelt) and saltwater (porgies, sea trout, bonita and sardines), with trace levels in shellfish. Table 4-1 presents the results of this program from July 1970 to September 1971.[2]

The total diet studies for FY 70 and FY 71 showed composite samples containing PCB residues up to 0.36 ppm. The positive readings were found in meat, fish, poultry, dairy and the grain and cereal composites. The 0.36 ppm value was found to be caused by migration of PCB's from the grayboard container and dividers to packaged shredded wheat.[2]

The FY 73 study included thirty market basket samples from representative areas of the United States consisting of the total 14-day diet of a 15-20 year old male in the region of collection including about 117 individual food items.[1]

These 117 food items are separated after any necessary preparation into twelve food group composites for analysis:

I	Dairy Products
II	Meat, Fish and Poultry
III	Grain and Cereal Products
IV	Potatoes
V	Leafy Vegetables
VI	Legume Vegetables
VII	Root Vegetables
VIII	Garden Fruits
IX	Fruits
X	Oils, Fats and Shortening
XI	Sugar and Adjuncts
XII	Beverages (including drinking water)

MONS 047304

Most of the PCB levels identified in 1973 were trace amounts resulting in a daily intake of only 1 µg/day. The most frequent occurrences were in the meat-fish-poultry and grain-cereal products groups with 33% and 17% positive analyses. It has been suggested that environmental contamination may be the source in the first group and lingering recycled paper contamination in the second group.

Of 30 composites examined for each commodity group PCB residues were only determined in five of the groups as follows:

Group	Frequency
Dairy Products	3
Meat, Fish and Poultry	10
Grain and Cereal Products	5
Potatoes	1
Oils, Fats and Shortening	1

The range for all 20 positives was trace to 0.073 ppm. In fact 19 of the 20 readings were only trace amounts with the 0.073 ppm composite appearing in the Grain and Cereal Products group.[1]

Data for 1974 are not available yet. However preliminary information is that there were only 14 positive readings with 13 of them in the Meat, Fish and Poultry Group and the other one in the sugar and adjuncts group. The range of levels measured was trace to 0.05 ppm with the maximum levels in the Meat, Fish and Poultry group.[1]

Using the preceding figures it is estimated by FDA that the daily intake of PCB's from all twelve food group composites was 1.07 µg/day in 1973 and 0.388 µg/day in 1974.[1]

MONS 047305

Table 4-1
PCB Residues in Selected Food Commodities
July 1970 - September 1971

	Number of samples examined	Number of samples positive	Percent positive	PCB levels, ppm, low	PCB levels, ppm, high	Average
Fish	670	363	54	T	35.29	1.87
Cheese	1344	91	6	T	1.0	.25
Milk	941	69	7	T	27.8	2.27
Shell eggs	550	161	29	T	3.74	.55
Fish by-products	---	13	--	T	5.0	1.17
Total (excluding fish by-product)	3505	684	19			1.14

SOURCE: Kolbye, A.D., Jr., Environmental Health Perspectives, 85-88, April 1972.

MONS 047306

REFERENCES, Section 4.0

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MONS 047307

5.0 Exposure and Biological Accumulation of PCB's in Man

5.1 National Monitoring Programs

The National Human Monitoring Program for Pesticides is conducted by the Office of Pesticide Programs, EPA. Small samples of adipose tissue from postmortem examinations and from specimens submitted for pathological examination during therapeutic surgery are collected and analyzed for the presence of chlorinated hydrocarbon insecticides. Analysis for PCB's was begun in 1968. Summaries of the data from 1971 are reported in Table 5.1-1 and from 1972 to 1974 in Table 5.1-2.

Note that although classes are different in the two sets of results, the proportion of samples showing traces of PCB's is increasing: 50.7%, 1971; 73.99%, 1972; 75.49%, 1973; 90.93%, 1974. The increase between 1973 and 1974 is dramatic. However, the percentage of tissues which contained quantifiable (greater than 1.0 ppm) of PCBs appears to be remaining relatively constant (31.1%, 58.53%, 55.08%, 40.30%, 1971-74).

5.2 Localized Studies

There have been several localized studies showing the presence of PCB's in both human plasma and milk. A 1968 study in Charleston County, South Carolina[3], reported that of 612 plasma samples collected from healthy volunteers, 45% showed some PCB residue. Levels ranged to a maximum of 29 ppb with a mean plasma residue of 2.12 ppb. This study also tested for the significance of several factors on PCB levels, concluding only that residues were more frequent and higher in whites and urban residents. A follow-up study conducted in 1972[1] in the Charleston area sampled plasma and scalp hair specimens from 37 refuse burners and 54 controls. PCB residues were not detected in hair samples, but 81% of the refuse burners (compared with only 11% of the controls) had detectable PCB residues in plasma. Median levels for those with detectable amounts in plasma were 2.6 ppb for the refuse workers and 3.7 ppb for the controls, with maximums of 14.1 ppb and 20.2 respectively.

A 1971-72 study[5] of 40 human milk samples in Colorado discovered PCB residues in 20% of the samples in ranges from 40 to 100 ppb. A 1971 study of 47 lactating women in Texas[2] reported an absence of PCB residues both in milk from all subjects and in serum from 28 subjects. A minor study of blood samples from nine cachectic patients and 15 healthy nonpatients from Missouri and surrounding states[4] reported detectable PCB residues in all patients (mean 48 ppb, range 10-100 ppb) and none detectable in the nonpatients. No conclusions were drawn.

Table 5.1-1
PCB Concentrations in Human Adipose Tissue, 1971

Sample Size	Absent		Trace to Below 1 ppm		1-2 ppm		2 ppm	
	Number	%	Number	%	Number	%	Number	%
637	314	49.3	125	19.6	165	25.9	33	5.2

SOURCE: Yobs, Anne R., Environmental Health Perspectives, 1, 79-81 April 1972.

Table 5.1-2
PCB Concentrations in Human Adipose Tissue, 1972-1974

	Sample Size	Absent		Below 1 ppm		1-3 ppm		73 ppm	
		Number	%	Number	%	Number	%	Number	%
1972	4102	1067	26.01	634	15.46	2079	50.68	322	7.85
1973	1277	313	24.51	513	40.17	378	29.60	70	5.48
1974	1047	95	9.07	530	50.62	371	35.43	51	4.87

SOURCE: Kutz, F.W., Project Officer, National Human Monitoring Program for Pesticides, Office of Pesticides Programs, U.S. EPA, Washington, DC.

MONS 047309

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MONS 047310

6.0 Environmental Trends

There are few data bases or environmental studies which provide an adequate basis for sound analytic determinations of national trends in environmental levels of PCB's. Such a data base would be a result of a system of studies involving consistent sampling across media, i.e., statistical samples taken at the same locations at representative time periods, analyzed according to standard protocols, taken over a period of time long enough to establish a trend. Some studies do show consistent sampling within specific media, e.g., the Great Lakes Environmental Contaminant Survey, but the literature is full of snapshot studies with neither predecessor nor successor, and baseline studies which have not been followed by any further work. Thus, whether due to funding, modification of priorities or personnel changes, long-term consistency and coordination have not been achieved. As a result, the conclusions drawn in this section represent qualitative judgements drawn from the large mass of generally uncoordinated PCB studies analyzed.

Even recognizing all the faults of the available data base, the sheer mass of data supports the conclusion that there is widespread contamination of the environment by PCB's. There are regional variations, but effects are consistent across all media (e.g., water, sediment, fish, birds), generally showing greater concentrations of PCB's in highly developed areas and in areas of industrial activity. Over the past five years of increasing recognition of and attention to the problems of PCB's, the situation has shown no improvement nationally. Conscious efforts have, however, resulted in substantial improvement in some localized instances.

PCB contamination of the nation's waterways was termed widespread by the USGS over the period 1971-1972; more recent data from the USGS up to 1975 has shown no reduction in either levels or in geographical dispersion. Although sampling stations in the USGS data base are not expected to be representative of the U.S. and the data suffers from multiple observations at some stations and spot readings at others, over the period 1971-1975 states which had reported PCB's in sediment continued to do so while six of the 23 states which had shown no contaminated samples in 1973 did report some contamination in 1974. Sediment concentrations are imperfect indicators of current contamination levels and whole water measurements would be better. However, the currently practiced analytical protocol for water measurements, which limits detectability to 0.1 ppb, leads to a preponderance of zero readings in whole water which mask the very real problem of PCB contamination in the nation's waters. In almost all cases in which samples of both whole water and bottom sediment were taken simultaneously and the sediment had a non-zero PCB level, concentration in the water was reported as zero ppb. This occurred even when the concentration in bottom sediment was as high as 4000 parts per billion! Were water measurements to be taken at the parts per trillion level as some recent studies have done, whole water readings would certainly show PCB contamination, to an extent similar to that shown by sediment readings.

MONS 047311

The results of the U.S. Fish and Wildlife Service's fish monitoring activities show that stations which have reported high concentrations in the past continue to do so, and that the higher concentrations are associated with river systems having significant industrial activity. Such results are consistent with those for water and sediment from the USGS water quality file. The fish data, however, shows a decline in both the proportion of composites with some PCB residues and the proportion with residues in excess of 0.5 ppm in the 1970-73 sampling program. Levels of detection are generally lower in 1973 than in previous years. While there are cautionary notes (see section 2.1.5), some improvement in PCB contamination appears evident, although mostly at those stations with prior low contamination levels.

Water is recognized as being a major sink and transport mechanism for PCB's and, therefore, residue levels in water and fish are significant. Yet other media confirm the stability and breadth of contamination over the nation. Data on human adipose tissue show a steady climb over the years 1971-74 in the percent showing traces of PCB's. Soil monitoring shows that sixty percent, i.e., 3 of 5 cities sampled each year since the National Soils Monitoring Program started have had at least one positive PCB sample. Bird monitoring conducted as part of the U.S. Bureau of Fish and Wildlife's portion of the National Pesticides Monitoring Program shows residue levels in black ducks and mallards increasing between 1969 and 1972 in the Atlantic and Mississippi flyways and slightly decreasing in the Central and Pacific Flyways. PCB residues in starlings for 1970, 1972 and 1974 appear to be decreasing, yet PCB residues have been found in all samples each year, underscoring the ubiquitous nature of PCB's throughout the country.