ENVIRONMENTAL LEVELS OF PCB's

Doris J. Ruopp
Vincent J. DeCarlo
U.S. Environmental Protection Agency
Washington, D.C. 20460

ABSTRACT

Since the 1966 discovery in Sweden that chlorinated biphenyls were widely dispersed in the environment their environmental levels have been the subject of many studies with the results indicating that PCB's can have adverse ecological and toxicological effects. However, a well planned national approach to environmental sampling has not been attempted thus hindering making a national assessment of the PCB problem. This paper reviews the levels that are currently being found in the environment.

INTRODUCTION

Since the 1966 discovery in Sweden that chlorinated biphenyls were widely dispersed in the environment, their levels have been the subject of many studies both abroad and in the United States. Extensive laboratory and environmental measurements indicate that PCB's can have adverse ecological and toxicological effects, are very resistant to environmental degradation and are being discharged by many different sources.

This paper will focus on the current PCB data base in an effort to assess the PCB levels in the environment on a national basis.

ENVIRONMENTAL PCB SOURCES

Before the PCB data base is examined, it would be of interest to review how these chemicals get into the environment. The major sources contributing to the environmental levels of PCB's are industrial effluents, manufacturing processes, consumer and industrial waste materials, sewage treatment facilities and accidental spills. Lacking extensive air and soil data from these sources, available water data are shown in Table 1. The 5 major PCB spills in 1973-75 all involved transformers. In 4 of those incidents, the PCB's were spilled on soil while in the fifth the transformer was dropped on a pier and the contents were spilled into the water. In the latter incident, 283 gallons were spilled and it was estimated that only 70-90 gallons were recovered. In all cases the material that could be recovered was drummed up and entombed at a cost approaching $2.3 million.

REVIEW OF THE PCB DATA BASE

To assess the scope and extent of PCB's in the environment, all national surveys and national data bases maintained by the U.S. Environmental Protection Agency (EPA) were examined, including STORET, the national water quality storage and retrieval system, the National Soils Monitoring Program for Pesticide Residues and the Human Monitoring Program. In addition, data from special data bases maintained by the United States Geological Survey and the open literature were also examined along with available unpublished reports. Using these data, maps were constructed showing the concentrations of PCB's in urban soils and the aquatic environment.

The data from the national surveys show that a great deal of effort has been expended and continues to be expended but that the data are very limited. On examination, all States are believed to show some level of PCB contamination. In Table 2 States which had significant levels in at least one medium are listed with their reported PCB levels for surface and ground water, bottom sediments and fish. In Table 3, a number of localized studies are listed along with the reported environmental data. In all these studies the most extensive measurements have been in fish.

TABLE 1
ENVIRONMENTAL SOURCES OF PCB's

SOURCE	EFFLUENT WATER CONCENTRATIONS (ppb)
PAPER MILLS	
Wisconsin[1]	0.1 - 18.5
WASTE PAPER MILLS	
Wisconsin[1]	18.5
INDUSTRIAL EFFLUENTS	
California[2]	0 - 76
Wisconsin[2]	.04 - 0.25
Ohio[2]	0 - 17
Michigan[3]	.1 - 7000
MUNICIPAL WASTE WATER TREATMENT PLANTS	
Michigan[3]	0.5
Wisconsin[1]	.05 - 17.0
Ohio[2]	.10 - 17
California[2]	0.16 - 76
CAPACITOR AND TRANSFORMER FACILITIES	
New York[4]	2800
Massachusetts[5]	42.5
PCB MANUFACTURING FACILITY	
East St. Louis[5]	.87
SPILLS	Variable

1. Kleinert, S. J., Environmental Status of PCB in Wisconsin, May 8, 1975, Wisconsin Department of Natural Resources.
2. PCB's and the Environmental, Report of the Interdepartmental Task Force on PCB's, National Technical Information Service, 1972.
3. Statement of Concerns of the Lake Michigan Toxic Substances Committee Related to Polychlorinated Biphenyls, June 1975. Prepared by Karl F. Bremer, USEPA, Chicago, Ill.
4. Unpublished Data - Royal J. Nadeau and Robert P. Davis, Investigation of Polychlorinated Biphenyls in the Hudson River, Hudson Falls-Ft. Edward Area, August 1974.
5. Field Sampling and Analysis of Toxic Pollutants Interim Report, Battelle, Pacific Northwest Laboratories, August 1974.

DSW 027033

STLCOPCB4010995

WATER

On the basis of the national aquatic environmental data collected in 1971-1972 and in 1974, a continuing widespread accumulation of PCB's in water, sediment and fish appears to be occurring. However, no trend analysis is possible with the available measurements. For example, whole water measurements have been taken throughout most of the country but those states reporting non zero readings are few in relation to the number of states showing zero concentrations. This is due both to the low solubility of PCB's and to the usual analytical procedure that limits detectability to the 0.1 ppb level. More meaningful water concentrations were obtained in the Lake Ontario[1] and Orange County, California[2] studies where concentrations in water at the ppt (ng/l) level were measured. At these levels, changes in PCB concentrations could be found with distance and time and could be related to other measurable parameters such as PCB concentrations in sediment, flora and fauna.

SEDIMENTS

Since PCB's are relatively insoluble, it is not surprising that bottom deposits have shown significant concentrations. Although 30 states collected samples in the 1974 study, 15 had less than 4 stations reporting and showed zero readings. Of the remaining 15, with at least 4 reporting stations, 13 showed detectable concentrations. Since the 13 states involved were not necessarily the same in both studies, only a very broad comparison may be made, i.e., five states had lower concentrations, four states were higher and four did not sample again.[3] We may conclude, then, that in those states with any monitoring effort in the 1974 study, PCB's are present in bottom deposits and the levels are not any lower than in the 1971-72 study. Considering the persistence of PCB's, a significant proportion of the nation's waters are now affected and will continue to be.

SOILS

The National Soils Monitoring Program is a small sampling effort studying only 5 urban areas each year. However, PCB's were detected in three of the five cities sampled in each of the years for which data are available, 1971-73. Of the 22 positive readings 17 of them were below 1 ppm. Of the cities sampled in 1973, Pittsfield, Mass., was of particular interest because it has a large transformer and condenser plant using large quantities of PCB's. Six different sampling sites within one mile of the plant show no detectable PCB residues. In contrast, the soil surrounding another facility in Illinois using PCB's in the manufacture of investment casting waxes was recently measured for PCB content. Samples taken in an area one-quarter mile radius around the plant ranged in value from 0.77-5.2 ppm. The PCB's identified were mixtures of Aroclor 1260 and dechlorobiphenyl. Levels up to 1.8 ppm Aroclor 1260 were found at 1-1/4 miles from the plant. Samples were collected from this facility as part of a study being conducted for the Office of Toxic Substances at sites suspected to have PCB concentrations. Other sites sampled in March of 1975 were in the vicinity of an investment casting company in Michigan and the PCB manufacturer in Illinois. Surface soil samples were collected at each site up to a distance of approximately one mile from the plant boundary, at 1/4 mile intervals in all directions. PCB's were detected in soils at both sampling locations. Concentrations ranged from the detection limit of 0.001 ppm to over 20 ppm. The distribution of all PCB's analyzed appears higher near the plant site and generally decreases with distance from the site.[4] Details of the sampling sites and the concentration levels measured are shown in Figure 1.

TABLE 2

SELECTED STATE DATA ON ENVIRONMENTAL LEVELS OF PCB's

State	Surface and Ground Water[1] µg/l	Bottom Sediment[1] µg/kg	Fish[3] ppm
AL			1.53-5.48
AR		20-2,400	1.69-3.88
CA	0.1	20-190	
CO	0.3		
CT	0.1-0.2	5-350[2]	2.16-5.34
FL	0.1-2.1	5-3,200	0.10-1.25
GA		10-1,300	0.52-1.18
IL			1.21-11.3
IA			0.35-1.41
MD	0.1	10-1,200	0.56-1.31
MA	0.2		
MI			4.00-11.7
MN	0.1-0.3		0.44-1.09
MS		50-170	
NB			0.47-4.58
NJ	0.1	3-800[2]	0.10-4.00
NY	0.1-4.0	3-13,000[2]	2.68-9.50
OH			1.73-8.07
OR		1-5-140	0.71-3.62
PA	0.2	6-700[2]	1.94-2.48
PR	0.1		
SC		30-200	0.10-7.3
TX	0.1-3.0	7.9-290	0.10- .22
UT			0.15-2.14
VA	0.1	5-80	
WV		10	0.31 1.20
WI			1.24-14.8

1. All data in this column taken from Hans J. Crump-Wiesner, Herman R. Feltz and Marvin L. Yates, A Study of the Distribution of Polychlorinated Biphenyls in the Aquatic Environment, Jour. Research U.S. Geol. Survey 1, 603 (1972, unless otherwise noted.
2. USGS Sediment data, 1974.
3. All data in this column taken from Croswell Henderson, Anthony Inglis and Wendell L. Johnson, Organochlorine Insecticide Residues in -Fish Fall 1969 National Pesticide Monitoring Program, Pesticide Monitoring Journal 5, 1(1971).

DSW 027034

STLCOPCB4010996

TABLE 3
SELECTED PCB STUDIES

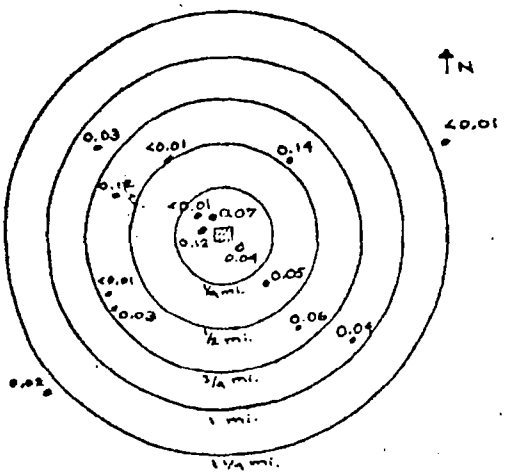
	Fish (ppm)	Water (µg/l)	Sediment (µg/kg)	Plankton (ppm)
LAKES				
Lake Ontario[1, 2]	0.14 - 9.17	0.035 - 0.097	43 - 245	3.4 - 11.8
Lake Erie[3, 4]	0.2 - 7.8			
Lake Superior[5]	0.3 - 5.6			
Lake Huron[6]	0.16 - 11.0			
Lake Michigan[6, 9]	0.1 - 165.3		3.72 - 636	
Cayuga Lake[10]	3.4 - 9.7			
Lake St. Clair[16]	tr - 3.8	0.1 - 0.2		
RIVERS				
Iowa				
Mississippi River[11]	0.9 - 5.5			
Texas				
Brazos River[12]		0.1 - 0.5		
Utah				
Green River[12]		0.1		
New York				
Hudson[13]	7 - 350	1.0 - 2800	6.6 - 6,700,000	
Michigan				
Saginaw River[6, 14]	6.9 - 165.3	0.1 - 0.21		
Kalamazoo River[7, 15]	<0.01 - 164.56	0.1 - 0.45	100 - 560	
Portage Creek[7]		0.1 - 0.48	10 - 475,400	
Wisconsin				
Milwaukee[8]		.02 - 2.17		
MARINE ENVIRONMENT				
Atlantic Ocean[17, 18]	0.038 - 0.190	0.0009 - 0.0036		
Bay of Fundy[19]	0.07 - 1.54			
Gulf of Mexico/Caribbean Sea[20, 21]	0.032 - 0.059			0.157 - 1.055
Southern California[22]	0.04 - 6.6	0.0015 - 0.019		

1. Clarence L. Haile, Gilman Veith, G. Fred Lee and William C. Boyle, Chlorinated Hydrocarbons in the Lake Ontario Ecosystem, EPA-660/3-75-002, June 1975, U.S. E.P.A., Corvallis, Oregon.
2. Klaus L. Kaiser, Mirex, An Unrecognized Contaminant of Fishes from Lake Ontario, Science 18, 523 (1974).
3. Richard L. Carr, Charles E. Finsterwalder and Michael J. Schibi, Pesticides Monitoring Journal 6:23 (1972).
4. John R. M. Kelso and Richard Frank, Organochlorine Residues, Mercury, Copper and Cadmium in Yellow Perch, White Bass and Smallmouth Bass, Long Point Bay, Lake Erie, Trans. Amer. Fish. Soc., 103:577 (1974).
5. Unpublished data. Gilman D. Veith and G. E. Glass, PCB's and DDT in Fish from Western Lake Superior, U.S. E.P.A., Duluth, Minnesota.
6. Unpublished Data - John L. Hesse, Bureau of Water Management, Michigan Department of Natural Resources, June 1973.
7. Unpublished data - State of Michigan Water Resources Commission, Polychlorinated Biphenyl Survey of the Kalamazoo River and Portage Creek in the Vicinity of the City of Kalamazoo, 1972.
8. Gilman D. Veith and Fred G. Lee, Chlorobiphenyls in the Milwaukee River, Water Research, 1971.
9. Unpublished data - Schacht 1974, EPA 600/3-74-002.
10. Carl A. Bache, James W. Serum, William D. Youngs and Donald J. Lisk, Polychlorinated Biphenyl Residues: Accumulation in Cayuga Lake Trout with Age, Science 177:1191 (1972).
11. Lauren C. Johnson and Robert L. Morris, Chlorinated Insecticide Residues in the Eggs of Some Freshwater Fish, Bulletin of Environmental Contamination and Toxicology 11:503 (1974).
12. Jean A. Schulze, Douglas B. Manigold and Freeman L. Andrews, Pesticides in Selected Western Streams 1968-1971, Pesticides Monitoring Journal 7:73 (1973).
13. Unpublished data - Royal J. Nadeau and Robert P. Davis, Investigation of Polychlorinated Biphenyls in the Hudson River (Hudson Falls - Ft. Edward Area, August 1974.
14. Unpublished data - John L. Hesse, Monitoring for Polychlorinated Biphenyls in the Aquatic Environment, May 1973.
15. Unpublished data - Michigan Water Resources Commission, Evaluation of the Aquatic Environment, of the Kalamazoo River Watershed, May 1972.
16. Michigan Department of Agriculture, Bureau of Consumer Protection, 1973 Great Lakes Environmental Contaminants Study.
17. T. F. Bidleman and C. E. Olney, Chlorinated Hyrdocarbons in the Sargasso Sea Atmosphere and Surface Water, Science 183:516, 1973.
18. George R. Harvey, Helen P. Miklas, Vaughan T. Bowen and William G. Steinhauer, Observations on the Distribution of Chlorinated Hydrocarbons in Atlantic Ocean Organisms, Journal of Marine Research 32:103 (1973).
19. V. Zitko, O. Hitzinger and P.M.K. Choi, Contamination of the Bay of Fundy - Gulf of Maine Area with Polychlorinated Biphenyls, Polychlorinated Terphenyls, Chlorinated Dibenzodioxins and Dibenzofurans, Environmental Health Perspectives, 1:47 (1972).
20. C. S. Giam, A. R. Hanks, R. L. Richardson, W. M. Sackett and M. K. Wong, DDT, DDE, and Polychlorinated Biphenyls in Biota from the Gulf of Mexico and Caribbean Sea - 1971. Pesticides Monitoring Journal 6:139 (1972).
21. C. S. Giam, M. K. Wong, A. R. Hanks, W. M. Sackett and R. L. Richardson, Chlorinated Hydrocarbons in Plankton from the Gulf of Mexico and Northern California, Bulletin of Environmental Contamination and Toxicology 9:376 (1973).
22. The Ecology of the Southern California Bight: Implications for Water Quality Management, Southern California Coastal Water Research Project, 1500 East Imperial Highway, El Segundo, 1973.

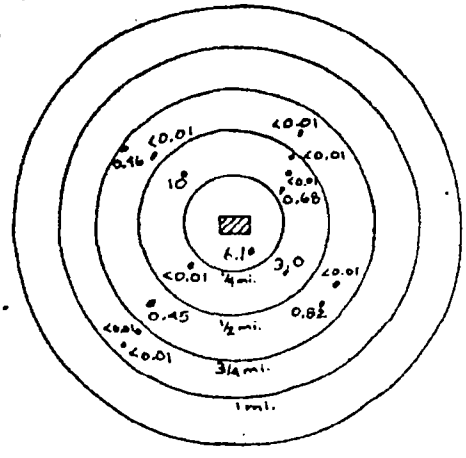
DSW 027035

STLCOPCB4010997

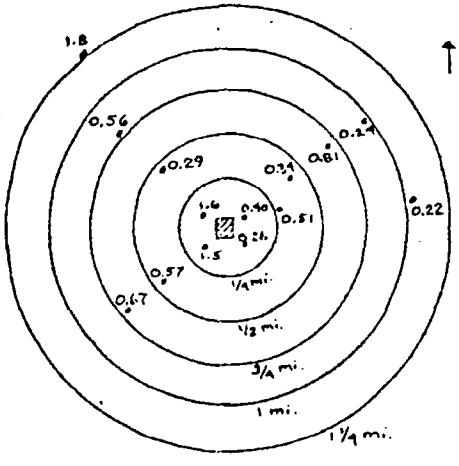
Figure 1
Concentration of PCB's in Soil with Distance
(ppm)



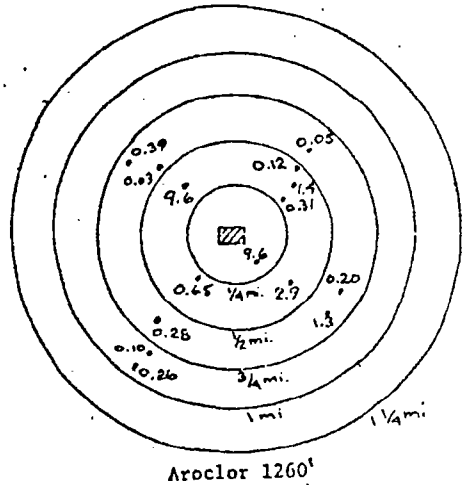
Aroclor 1260
Investment Casting Company



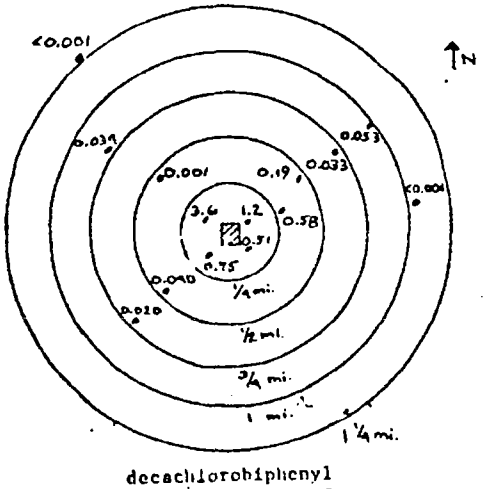
Aroclor 1242
PCB Manufacturer



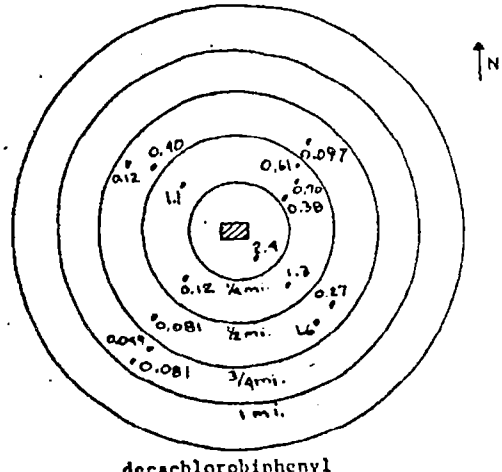
Aroclor 1260
Investment Casting Wax Manufacturer



Aroclor 1260
PCB Manufacturer



decachlorobiphenyl
Investment Casting Wax Manufacturer



decachlorobiphenyl
PCB Manufacturer

DSW 027036

STLCOPCB4010998

AIR

PCB measurements in air along with the related transport studies are practically nonexistent. Harvey and Steinhauer[5] have reported levels ranging from 3.9 - 5.3 ng/m3. Air measurements by Bidleman and Olney for Rhode Island ranged from 2.1-9.4 ng/m3 and from 0.21 - 0.65 ng/m3 at Bermuda.[6] Snow melt water data from Wisconsin ranged from zero to 0.24 ppb. The suggestion has been made that atmospheric fallout may be the most significant source of PCB discharge to the waters of the state of Wisconsin.[7]

FISH

Fish have been studied on a nationwide basis by the Department of the Interior since 1967. In the 1969 study, PCB levels were identified in fish from 35 states.[8] Data from the nationwide sampling programs, 1970-1973, are currently being prepared but were not available for this report. Consequently, nationwide fish data are not available any more currently than 1969, with the exception of the isolated studies listed in Table 3. The 1969 national study showed PCB levels generally within the FDA 5 ppm guideline. In the Great Lakes area, PCB levels in fish from Lake Michigan were so high, 7.6-10.9 ppm, that FDA seized shipments of coho salmon in May 1975.[9]

Although transport mechanisms are not well known and would vary through different ecosystems, it is interesting to consider the Lake Ontario Ecosystem Study summarized in Table 4. From this study an estimate of biomagnification is possible giving a sediment to fish ratio of 1:120. The FDA guideline of 5 ppm in the edible portion of fish corresponds to a sediment concentration of 41 ppb - a figure exceeded in all 13 states reporting through USGS in 1974.

HUMANS

With PCB's so widespread across various media as they are, it is expected that levels would be identified in humans as well. The Human Monitoring Program, in 1972, found that 3035 out of 4102 samples from 31 States showed levels ranging from less than 1 ppm to more than 3 ppm. In 1973, 964 out of 1277 samples from 28 States again showed levels in the same range. In both years approximately 75% of the adipose tissue analyzed contained some polychlorinated biphenyls. Unfortunately we do not know age, occupation or residential histories of the cases involved so it is difficult to trace the levels back to the potential sources.

CONCLUSIONS

Although there are many national and state groups collecting environmental PCB data, limitations in the current data base prevent one from making a uniform national assessment of PCB environmental levels. It appears that if a well planned national approach to sampling were attempted, the data base could be improved in a very short period of time.

TABLE 4

LAKE ONTARIO ECOSYSTEM[1]

FISH, µg/g	
Alewife	.14 - 4.36
Smelt	1.40 - 3.49
Slimy Sculpin	1.58 - 9.17
WATER, ng/l	38 - 97
SEDIMENT, ng/g	43 - 245
NET PLANKTON, µg/g	3.4 - 11.8

1. Haile, C. L., Veith, G. D., Lee, G. F., Boyle, W. C., Chlorinated Hydrocarbons in the Lake Ontario Ecosystem (IFYGL) June, 1975.

REFERENCES

1. Haile, C.L., Veith, G.D., Lee, G.F., Boyle, W.C., Chlorinated Hydrocarbons in the Lake Ontario Ecosystem (IFYGL), June 1975.
2. McDermott, D.J., and Hansen, T.C., Inputs of DDT, PCB and Trace Metals from Harbors, Coastal Water Research Project Annual Report, 1975.
3. U.S. Geological Survey.
4. Environmental Polychlorinated Biphenyl Contamination near Sites of Manufacture and Use, Environmental Science and Engineering, Inc., 1975.
5. Harvey, G.R. and Steinhauer, W.G., Atmospheric Transport of Polychlorinated Biphenyls to the North Atlantic, Atmospheric Environment, Vol. 8, 1974.
6. Bidleman, T.F., and Olney, C.F., Chlorinated Hydrocarbons in the Sargasso Sea Atmosphere and Surface Water, Science, Vol. 183, February 1974.
7. Kleinert, S.J., Environmental Status of PCB's in Wisconsin, May 8, 1975, Wisconsin Department of Natural Resources.
8. Henderson, C., Inglis, A., Johnson, W.L., Organochlorine Insecticide Residues in Fish - Fall 1969 National Pesticide Monitoring Program, Pesticides Monitoring Journal, Vol. 5, No. 1, June 1971.
9. Bremer, Karl E., Draft copy of "Statement of Concerns of the Lake Michigan Toxic Substances Committee related to PCB's," June 1975.

DSW 027037

STLCOPCB4010999