CX. 02 3

It has been established that Lake Michigan is unique in that it contains much higher concentrations of agricultural pesticides than the other Great Lakes due, in part, to the large useage in the watershed in comparison to the flushing period for the lake and to the relatively low biomass density. Previous studies have shown that the fish from Lake Michigan approached the FDA action levels for dieldrin in 1969 and that a major fraction exceeded the action levels for DDT (Reinert, 1970). More recent data (Reinert, 1972) from carefully designed monitoring (Reinert, 1971) indicates that the average DDT concentration in Lake Michigan fish remained essentially the same between 1967 to 1970 and suggested that the levels have begun to decrease.

Although not realized in the early analyses by Reinert, other work (Veith, 1970) has shown that the concentration of PCB's (similar to Aroclor 1254) were greater than 15 ug/gm in large fish collected from Lake Michigan in 1969. Thus, it is apparently in Lake Michigan rather than the other Great Lakes that the potentially hazardous and persistent chemicals from our industrialized technology are most concentrated. It follows, then, that consideration must be given to the effect these chemicals have on the biological communities sustained by Lake Michigan and the possibility of stemming or even reversing the trend of increasing levels of organochlorine compounds in the Lake Michigan system.

Despite the comparatively high levels of DDT, dieldrin and PCB's in Lake Michigan, there is no direct evidence that the chemicals are endangering the aquatic life in the lake. The concentration of each of the chemicals appears to be below 10 ng/l in the pelagic waters and less than 100 ng/l in the nearshore waters, all of which are below the "no effect" level for the respective chemicals for most aquatic organisms. However, the lack of direct evidence of damage may simply reflect the difficulty in adequately measuring such effects in this environment.

There is considerable indirect evidence which suggests that the buildup of organochlorine compounds may be a threat to the future of the biological resources of the lake. It is beyond the scope of this introduction to review the literature concerning the pesticides and PCB's, and the reader is referred to existing comprehensive reviews (Zitko and Choi, 1971; NIH, 1972; Quinby, 1972; Task Force, 1972).

In laboratory experiments crustacea exposed to varying levels of Aroclor(R) 1254 in the water concentrate the PCB within their bodies more than 20,000 times. The tissue residues may sometimes reach an equilibrium and in Gammarus fasciatus PCB did not concentrate beyond 27,000 times despite an additional 5-week exposure to 1.6 ug/l Aroclor(R). (Saunders, 1971). In contrast, PCB residues in crayfish did not reach equilibrium after a 28 day exposure. PCB concentration factors by two estuarine fishes, Lagodon rhomboides and Leiostomus xanthurus, was similar to that described above for crustaceans -- about 10,000 to 50,000 times the exposure levels in water (Hansen, et al., 1971).

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It is important to note that these accumulations occurred at water concentrations of PCB that killed the fish in 15 to 45 days.

Also similar were the accumulation ratios of 26,000 to 56,000 for bluegills (Lepomis macrochirus) chronically exposed to 2-15 ug/l of Aroclor(R) 1248 and 1254. Fathead minnows (Pimephales promelas) chronically exposed to Aroclor(R) 1242 and 1254 for 8 months concentrated PCB's 100,000 and 200,000 times the exposure levels, respectively. Residues of 50 ug/l (whole body) resulted from exposure for 8 months to 0.3 ug/l Aroclor(R) 1254. These experiments with bluegills also indicated that the maximum levels of PCB were generally related to the concentration of PCB in the water (50,000 - 200,000 times higher) to which they were exposed (Stalling and Huckins, unpublished data, 1971).

Effects on Reproduction

PCB residues in salmon eggs are apparently related to mortality of eggs. In preliminary investigations in Sweden, Jensen, Johansson, and Olsson (1970) reported that when residues in groups of eggs ranged from 0.4 to 1.9 ug/l on a whole weight basis (7.7 to 34 ug/g on a fat basis), related mortalities ranged from 16 percent up to 100 percent.

As indicated in Table I, Aroclor 1248 was the most toxic of the eight aroclors tested to Daphnia magna in static tests, with a 3-week LC50 of 25 ug/liter. Aroclor 1254 was most toxic under continuous-flow conditions with a 3-week LC50 of 1.3 ug/liter. The Aroclors were more toxic under continuous-flow than static conditions, with 16 percent impairment of reproduction caused by 1.0 ug/liter Aroclor 1248.

The calculated 96-hour LC50 values for newly-hatched fathead minnows were 7.7 ug/l for Aroclor 1254 and 15 ug/l for 1242. Three-month-old fatheads had a 96-hour LC50 of ca. 300 ug/l for 1242. Reproduction occurred at and below 1.8 ug/l 1254 and at and below 5.4 ug/l 1242. Polychlorinated biphenyls were acutely toxic but exhibited much greater chronic toxicity at very low levels, due to their cumulative nature. Newly hatched young were the most sensitive life stage. Young fathead growth was also affected above 2.2 ug/l 1248 and none survived above 5.1 ug/l after 30 days. Young flagfish, Jordanella floridae, did not survive above 5.1 ug/l 1248 and did not grow well above 2.2 ug/l.

The ninety-six hour LC50 values for Aroclor 1242 and 1248 with Gammarus pseudolimnaeus were 73 and 29 ug/liter. Survival after 30 days was 53 percent at 8.7 ug/l 1242 and 52 percent at 5.1 ug/l 1248. Good reproduction and survival of young occurred at 2.8 ug/l 1242 and 2.2 ug/l 1248.

Abundant adult emergence of the midge Tanytarsus dissimilis did not occur above 5 ug/l 1248 or 3.5 ug/l 1254. The calculated 3-week LC 50 (50 percent reduction based on control as 100 percent) for Aroclor 1254 was 0.65 ug/l for larvae and .45 ug/l for pupae.

Application factors of 0.10 for 1242 and 0.15 for 1248 were calculated for the PCB's and Gammarus. Application factors of 0.2 for 1254 and 0.16 for 1242 were calculated for fathead minnows using newly hatched fish to obtain the 96-hour LC50.

The second generation fry from adults previously exposed to the PCB mixtures were exposed to the respective mixtures for 30 days after hatching. Preliminary data analyses indicated that 3 ug/l of Aroclor(R) 1248 caused no mortality but a 20 percent reduction in the weight of the fry. Similarly, Aroclor(R) 1260 caused no mortality when the fry were exposed to 2.1 ug/l; however, the weight of the fry was reduced by 33 percent.

The residue data from the trout exposed for 27 weeks indicate that approximately 0.55 ug/l of Aroclor(R) 1254 will result in 5 ug/gm of the PCB mixture in the fish (whole fish basis). The concentration in the fillet of fish exposed to 0.84 ug/l Aroclor(R) 1254 was 1 ug/gm. The lipid content of the fillet portion of the trout was less than two percent.

Dietery exposure to PCB seems to be less of a direct hazard to fish than exposure in water. Coho salmon (Oncorphynchus kisutch) fed Aroclor(R) 1254 in varying amounts up to 14,500 ug/kg body weight per day accumulated whole body residues which were only 0.9 to 0.5 of the level in the food after 240 days of dietary exposure. Growth rates were not affected. However, all fish exposed to the highest treatment died after 240 days exposure; and thyroid activity was stimulated in all except the group treated at the lowest concentration (Mehrle and Grant, unpublished data, 1971).

The massive trout and salmon stocking program in Lake Michigan has produced an unparalleled sport fishery and provides a valuable protein source for human food as well as animal feeds. Essential to the establishment and maintenance of this fishery is the successful reproduction of the adult fish. However, Reinert (1970) has previously pointed out that DDT and dieldrin levels in eggs are similar to those which inhibited reproduction in the studies of Burdick et al. (1964) and Macek (1968). In addition, Jensen et al. (1970) have shown that 15 ug/gm of PCB's (lipid basis) in salmon eggs produced 50 percent mortaility and complete mortality can be expected when the eggs contain 25 ug/gm PCB's (lipid basis). All of these data concerning the effects of organochlorine compounds on reproduction were obtained individually, and little is known of possible combined effects when the tissue contains mixtures of the toxicants.

Even though the continued stocking of fish may maintain a food resource in spite of possible adverse effects of the residues on reproduction in Lake Michigan fish, many fish contain body burdens which make the fish unfit as a food resource for humans. The U.S. Food and Drug Administration has established a tolerance level of 5 ug/gm, 5 ug/gm and 0.3 ug/gm for DDT, PCB's and dieldrin, respectively, in food to be sold for human consumption. Since the lake supports a sizeable commercial fishery in addition to the sport fishery, the presence of these chemicals below the "no effect" level in water may still endanger these industries due to the large partition

coefficient for lipid/water systems. Indeed, numerous catches of commercial fish being shipped to markets have been seized, and tons of large salmon have been withdrawn from state give-away programs in Michigan because the DDT and PCB residues exceeded the 5 ug/gm concentration.

Concern has also arisen with respect to the impact the organochlorine compounds in the Lake Michigan biota (principally fish) is having on other animals which use this food supply. Most notably is the effect of Lake Michigan fish on mink reproduction in the North Central states. Before DDT and dieldrin levels in these fish were well documented, Hartsough (1965) indicated that Lake Michigan fish were suspected as the factor leading to poor mink reproduction. Aulerich et al. (1970) clearly demonstrated the fish had been the cause of the reproductive failure. Aulerich and Rinber (1970) found that DDT and DDD did not have significant adverse effects on mink. Furthermore, dieldrin was lethal at 2.5 ug/gm in the food for extended periods but did not appear to effect reproduction at twice this level during the gestation period. Aulerich et al. (1971) concluded that coho salmon per se did not cause reproduction problems but that the disorder is associated with other species of fish and "appears to be dependent upon the species of fish and its environment." Finally, after the earlier reports that PCB's were present in Lake Michigan fish, Ringer et al. (1972) demonstrated that 10 ug/gm of Aroclor 1254 in coho salmon produced 71 percent mortality in mink and that a mixture of 10 ug/gm PCB's and 0.5 ug/gm dieldrin in coho feed produced 100 percent mortality. No kits were born alive when the diet contained 5 ug/gm or greater Aroclor 1254 alone. This evidence clearly indicates that the biological resources of Lake Michigan may seriously endanger other species even though the levels of toxicants are not sufficiently great to produce a dramatic effect within the aquatic communities.

Equally important is the coincidence of high levels of chlorinated hydrocarbon in herring gull and other bird populations with reproductive failures and subsequent population decline. Ratcliffe (1970) and Anderson (1970) have clearly shown that major changes in eggshell thickness have occurred since 1945 and that the phenomenon may be a major factor in the decline, if not extinction, of many species of birds. In general, egg shell thinning of 10 to 15 percent (relative to pre-1940 eggs) may produce an effect in the population, 15 to 20 percent is associated with readily observable egg breakage, and 50 percent thinning has been associated with virtually total reproductive failure (Risebrough et al., 1970: Keith et al., 1970).

Anderson (1970) found the Great Lakes Herring Gulls contained the highest chlorinated hydrocarbon levels in eggs ever reported for that species. He also found that the Lake Michigan gull, which declined dramatically in the early 1960's but recovered in the late 1960's, had egg shell thinning which varied from nine percent in 1953-1956 to 18 percent in 1965. However, since 1965, the degree of thinning

has decreased to eight percent in 1969. In comparison, gulls on Lake Huron and Lake Superior have exhibited thinning of seven and eight percent, respectively, and those from the east coast have remained essentially unchanged from earlier eggs.

Anderson (1970) also showed that double-crested cormorants from Wisconsin had 20 percent thinner eggs and produced eggs with the highest DDE concentrations of this species from interior North America. Golden eagles which primarily feed on mammals do not show as dramatic egg shell thinning as do the Bald Eagles which feed on fish. Despite the lack of detailed data in the literature, it is not unreasonable to suggest that the disappearance of Bald Eagles from the shores of Lake Michigan may also be linked by correlation to the chlorinated hydrocarbons in the food resources of the lake.

The Lake Michigan system is also unique in that the use of the major persistent chemicals have been curtailed in the watershed by a variety of actions. Although it is likely the use of the chlorinated pesticides in agriculture was diminishing in the late 1960's, the Lake Michigan Enforcement Conference recommended regulatory actions on many uses in 1968. This recommendation led to restrictions on DDT in Illinois, Michigan and Wisconsin, including the sale of this compound. A more detailed summary is presented by Lueschow (1972).

The realization that the widespread use of PCB's has resulted in the widespread occurrence of these potentially hazardous chemicals in the environment moved Monsanto Company, the sole producer of PCB's in the United States, to restrict the sales of PCB's in 1970 and by April, 1971, only "close system" uses were able to purchase PCB's from Monsanto. However, there is no data to confirm the fact that PCB useages are significantly reduced.

As previously discussed, the FDA has placed a 5 ug/gm action level on PCB's in food for human consumption. Moreover, on March 18, 1972, this restriction was extended to food packaging materials. On May 2, 1972, the Environmental Protection Agency announced that all discharges to the aquatic environment involving PCB's will be restricted to the lowest possible level and that the desired limit will be 0.01 ug/l PCB's. These restrictions were re-enforced by the recommendation of the joint task force headed by the Council on Environmental Quality and the Office of Science and Technology (Task Force, 1972) which called for all current uses of PCB's, except capacitors and transformers, to be discontinued.

In summary, the use of chlorinated hydrocarbons in the agriculture and industry in the Lake Michigan watershed over the last few decades has resulted in the contamination of this valuable, mesotrophic body of water. Indirect evidence exists that these chemicals are having subtle detrimental effects on the species near the top of the food chain, and some of the food resources have been deemed unfit for human consumption. However, the Lake Michigan watershed has also realized unparalleled legislative action regarding the use of these hazardous, persistent chemicals in the last two years. The following sections

of this report summarize the activities of the States in the Lake Michigan watershed concerning PCB's and the results of its activities.

Table 1. The Comparative Toxicity of Eight Aroclors[a] (in µg/liter) to Daphnia magna in Lake Superior Water as Determined in Static Test Conditions

| Aroclor | Three Week LC50 | Confidence Limits[b] | Reproductive Impairment 50% | Confidence Limits | 16% | Confidence Limits |
|---|---|---|---|---|---|---|
| 1221 | 180 | 158-205 | 125 | 116-135 | 89 | 85.6-92.6 |
| 1232 | 72 | 62.6-82.8 | 66 | 60-72.6 | 53 | 50.5-55.7 |
| 1242 | 67 | 55.4-81 | 63 | 56.3-70.5 | 48 | 45.2-50.9 |
| 1248 | 25 | 21.4-29.2 | 24 | 21.2-27.1 | 16 | 13.9-18.4 |
| 1254 | 31 | 25.8-37.2 | 28 | 23.1-33.9 | 18 | 14.5-22.3 |
| 1260 | 36 | 27.7-46.8 | 33 | 27.5-39.6 | 22 | 17.7-27.3 |
| 1262 | 43 | 37-49.9 | 41 | 33-53.3 | 24 | 17.6-32.6 |
| 1268 | 253 | 222-288 | 206 | 185-228 | 162 | 146-179 |

[a]Polychlorinated Biphenyls: Aroclor 1221-1268., Monsanto Chemical Company, St. Louis, Mo.

[b]Ninety-five percent confidence limits.

Programs Underway

Illinois

Water samples were collected routinely at four locations in 1971 and 1972. Two sewage treatment plants and two tributary sources were sampled during this period. The locations sampled were the Waukegan River, Pettibone Creek, North Shore Sanitary District plants at Waukegan and North Chicago. During 1971, thirty-seven sediment samples were collected at tributary streams, ravines, and offshore (within two miles) lake bed stations. Composite samples from fish were also analyzed during 1971 and 1972.

Indiana

In 1957, the State of Indiana initiated a water quality monitoring program. The original sampling network included two stations on Lake Michigan. At the present time, there are 16 sampling stations located on tributaries to Lake Michigan. In addition, five water treatment plant intakes on Lake Michigan are sampled as part of the program. This program provides data that are used to measure general characteristics of Indiana waters in the Lake Michigan Basin at important locations and to record trends in water quality.

The following table indicates the location and frequency of the routine sampling for PCB's:

| Station | Type of Sample | Frequency |
|---|---|---|
| Lake Michigan-Hammond W.W. | grab | monthly |
| Lake Michigan-Whiting W.W. | grab | monthly |
| Lake Michigan-East Chicago W.W. | grab | monthly |
| Lake Michigan-Gary W.W. | grab | monthly |
| Lake Michigan-Mich. City W.W. | grab | monthly |
| Ind. Harbor Canal-Dickey Rd. | grab | monthly |
| Grant Calumet River-Indpls. Blvd. | grab | quarterly |
| Grant Calumet River-Kennedy Ave. | grab | quarterly |
| Burns Ditch-BD-1 | grab | monthly |
| Burns Ditch-Portage Boat Yard | grab | quarterly |
| Burns Ditch-Chrisman Rd. | grab | quarterly |
| Trail Creek-Franklin St. | grab | monthly |
| St. Joseph River-Auten Rd. | grab | monthly |
| Elkhart River-at mouth | grab | quarterly |

In addition to the regular water quality monitoring program, samples of the effluent from all municipal sewage treatment plants in the basin will be collected two times during 1973. When possible these samples will be composited over a 24-hour period.

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This program will be expanded to include the collection of samples from various industrial outfalls and runoffs from landfalls. For the most part, these samples will be collected during comprehensive 24-hour surveys of point discharges which are routinely conducted in the Lake Michigan Basin.

Michigan

Michigan instituted a monitoring program for polychlorinated biphenyls (PCB's) early in 1971. The initial program consisted of a state-wide water sampling survey for determination of concentration in inland waters and tributaries to the Great Lakes. Supplementary sampling has since been conducted on stream sediments, municipal raw water intakes, groundwater drinking supplies, sanitary landfill runoffs, municipal wastewater treatment plants, industrial discharges, and fish from both inland and Great Lakes waters. Sampling is being continued on a periodic basis for establishment of trends.

Wisconsin

The Wisconsin Department of Natural Resources is surveying the waste effluents of some 55 communities in the Lake Michigan Basin. Those municipalities showing significant levels of toxic materials will be investigated to determine the source.

U.S. Bureau Sport Fisheries & Wildlife

Great Lakes Fishery Laboratory program of analysis for PCB's in Lake Michigan fish will continue with selected species of fish from two areas of Lake Michigan in 1973-74 according to the following schedule:

| Time of Collection | Species | Collection Site | Number of Fish | Size Range | Years of Continuous Analysis |
|---|---|---|---|---|---|
| Spring | Chubs | Saugatuck | 200 | 240-280 mm | 2 |
| Fall | Lake Trout | Saugatuck | 30 | 500-800 mm | 3 |
| Fall | Chubs | Saugatuck | 200 | 240-280 mm | 5 |
| Fall | Coho | Ludington | 30 | 500-800 mm | 6 |

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| | Program Description | Agency | Completed | Current | Pertinent Information |
|---|---|---|---|---|---|
| 1. | Great Lakes Monitoring Program | US EPA - Region V Surveillance and Analysis Division | | X | To give administrative guidance and coordination to the various US EPA activities. |
| 2. | Water Quality Assessment Programs on the Great Lakes - Northern Lake Michigan | Canada Center for Inland Waters | X | | In 1972 completed 9 Great Lake cruises employing M/V Martin Karlsen to assess water quality. |
| 3. | Program of analysis for polychlorinated biphenyls, DDT and dieldrin in Lake Michigan fish. | U.S. Bureau of Sport Fisheries and Wildlife, Great Lakes Fishery Laboratory | | X | |
| 4. | Toxic Substances Contamination Program:<br>a. Metal<br>b. PCBs<br>c. Phthalates<br>d. DDT and dieldrin | 4 states:<br>1. Illinois<br>2. Indiana<br>3. Michigan<br>4. Wisconsin | | 1. X<br>2. X<br>3. X<br>4. X | Findings will be given in this Toxic Substances Report. |
| 5. | Has a program for pollution detection, boat sewage, and HU-16 aircraft with infrared and ultraviolet scanner to detect pollution and physical processes. | U.S. Coast Guard | | X | Pollution survey will include a 100 mile district from Duluth, Mn. to St. Regis, N. Y. |
| 6. | Programs include: Water Motion, Water Characteristics, Limnology, Lake Hydrology, and Limnology Systems. | Lake Survey Center - NOAA | | X | Program consists of data collection investigations and studies. |
| 7. | Under the Anadromous Fish Program research is directed toward the cause of die-off. | National Marine Fishery Service (NMFS) | | X | Studies include parasitological, pathological, and pesticide residues |
| 8. | Research program to include mathematical models to describe pollutants in the Great Lakes. | U.S. Geological Survey | | X | Will use $S^{34}/_{S}32$ ratio to describe pollution and circulation patterns |
| 9. | Promotion of all aspects of Great Lakes research and dissemination of information. | International Association for Great Lakes Research | | X | Has conferences annually. |
| 10. | The Sea Grant Program in the Great Lakes area (Lake Michigan) | University of Wisconsin | | | |
| | Pesticide-Sediment Interaction on Green Bay | David Armstrong, Water Chemistry, UWMSN | | X | |
| | Aqueous Environmental Chemistry of Zinc in Lake Michigan | C. Fred Lee, Water Chemistry, UWMSN | | X | |
| | Pesticide Levels of Birds Wintering on Lake Michigan | Robert Ellarson, Wildlife Biology, UWMSN | | X | |
| | Uptake and Accumulation of Pollutants by Lake Michigan Fish | Mark Melancon, Biochemistry, UWMSN | | X | |
| | Factors Affecting Energy Fixation in Lake Michigan | Alfred Beeton, Center for Great Lakes Studies, UWMSN | | X | |
| | A Comprehensive Study of the Water Quality of Milwaukee Harbor and Adjacent Lake Michigan | Alfred Beeton, Center for Great Lakes Studies, UWMSN | | X | |
| | Survey and Analysis of Milwaukee Harbor - Lake Michigan Exchange Rates | David Cutchin, Center for Great Lakes Studies, UWMSN | | | |
| | Sediments as a Source or Sink of Nitrogen in Green Bay | D. R. Keeney, Soil Science, UWMSN | | | |
| | Influence of Heated Effluent on the Distribution and Abundance of Fishes Near the Two Rivers and Kewaunee Nuclear Power Plants on Lake Michigan | John J. Magnuson, Zoology, UWMSN | | | |
| 11. | Lake Michigan Studies | University of Michigan | | X | Employs a vessel to chemical biological and physical parameters. Also monitor air. |
| 12. | Lake Michigan Studies | International Joint Commission (U.S. Section) | | X | To supplement the Upper and Lower Great Lakes Studies to include PCBs, pesticides, phthalates and toxic metals. |
| 13. | PCBs in 1971 Lake Michigan Fish | National Water Quality Laboratory D. Veith | X | | Final report. |

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Data Summary - Lake Michigan, Open Waters and Sediments

Illinois

| | Aroclor (ppb) 1242 Mean | 1242 Range | 1254 Mean | 1254 Range |
|---|---|---|---|---|
| Sediments (<1-3 miles offshore) 24 samples, 1971 | 23.7 | (ND-105.1) | 14.7 | (2.5-46.9) |

Indiana

| | PCB (ppb) Mean | Range |
|---|---|---|
| Water Intakes 15 samples, 1973 | 0.02 | (<.01 - 0.09) |

Michigan

PCB concentrations in drinking water supplies from 45 intakes on the Great Lakes and connecting waters and an additional 20 on inland lakes and streams have generally been less than 0.01 ppb. Limited sampling of groundwater drinking supplies in southern Michigan has indicated that groundwater has not been significantly contaminated with PCB's.

| Water Intakes | Date | Aroclor 1254 ppb |
|---|---|---|
| South Haven | 3/9/71 | <0.010 |
| Holland | 4/14/71 | <0.010 |
| Grand Rapids | 4/14/71 | <0.010 |
| Muskegon | 3/9/71 | <0.010 |
| Ludington | 3/9/71 | <0.010 |
| Traverse City | 3/2/71 | <0.010 |
| Escanaba | 2/25/71 | 0.177 |
| Gladstone | 2/25/71 | <0.010 |
| Menominee | 3/23/71 | <0.010 |
| Bridgeman | 4/14/71 | <0.010 |
| Bridgeman | 5/23/72 | <0.010 |
| St. Joseph | 5/18/72 | <0.010 |
| Benton Harbor | 5/18/72 | <0.010 |
| South Haven | 5/18/72 | <0.010 |
| Holland | 5/18/72 | <0.010 |
| Grand Rapids | 5/18/72 | <0.010 |
| Muskegon | 5/18/72 | <0.010 |
| Ludington | 5/19/72 | <0.010 |
| Northport Point | 6/21/72 | <0.010 |
| Traverse City | 6/21/72 | <0.010 |
| Escanaba | 8/28/72 | <0.010 |
| Gladstone | 8/28/72 | <0.010 |
| Menominee | 8/28/72 | <0.010 |

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Data Summary - Lake Michigan Fish

Illinois

Twenty-nine composite samples from five species of lake fish (yellow perch, chubs, carp, coho salmon, and alewives)were analyzed for PCB's in 1971. Concentrations in the composite samples ranged from 0.1 to 4.0 ppm with an average concentration of 2.1 ppm. The highest average concentrations of PCB's by sex and species were 0.4 ppm for yellow perch males, 3.4 ppm for chub males, 2.3 ppm both carp males and females, 2.2 ppm for coho salmon males and 3.1 ppm for alewife males. The concentrations were below the U.S. Food and Drug Administration's interim action level of 5 ppm.

In 1972, fourteen composite samples (69 individual fish) from two species of lake fish (yellow perch and chubs) were analyzed for PCB's. Concentrations in the composite samples ranged from 0.3 to 3.1 ppm with an average concentration of 1.7 ppm. The highest concentrations of PCB's were found in chub samples. Concentrations of 3.1 ppm were found in samples of female chubs. Samples of male chubs were similar with maximum values reaching 2.8 ppm. These concentrations were also below the FDA's interim action level.

Michigan

In 1972 Michigan developed a cooperative State-Federal study of contaminant levels in Great Lakes fish species including lake trout, salmon, whitefish, chubs, menominee, yellow perch, alewife, carp, and suckers. Fish from Lakes Michigan, Huron, Erie, and Superior are systematically being sampled on an annual basis to obtain information on areas where contaminants approach or exceed FDA guidelines for consumer protection. The project, developed by the State agencies in cooperation with the U.S. Food and Drug Administration and the Bureau of Sport Fisheries and Wildlife Great Lake Laboratory, will establish patterns of residues of mercury, PCB's, DDT and dieldrin in Great Lakes fish. The following table shows the concentrations of PCB's detected in fish from Lake Michigan during the first year of this study. PCB's in Salmonids (lake trout, steelhead, coho salmon, and chinook salmon) and chubs were shown to exceed the FDA guideline of 5.0 ppm while concentrations in other species did not exceed this guideline.

Fish Cont'd

Concentrations of polychlorinated biphenyls (PCB's) found in fish species taken from Michigan waters of Lake Michigan during 1972*.

| Species | PCB's by District** in ppm (sample size in parenthesis) MM3 | MM4 | MM5 | MM6 | MM7 | MM8 | Total # Fish Sampled | Mean Concentration |
|---|---|---|---|---|---|---|---|---|
| Alewife | 1.7 (3) | | | 2.3 (1) | 2.7 (6) | 2.7 (6) | 16 | 2.4 ± 0.6 |
| Carp | | | | | 3.9 (6) | | 6 | 3.9 ± 2.0 |
| Chub | | | | 3.2 (2) | 8.5 (8) | 6.5 (9) | 19 | 7.0 ± 4.2 |
| Menominee | | | | 0.8 (1) | 1.2 (2) | | 3 | 1.1 |
| Perch | | | | 0.5 (1) | 0.4 (5) | 0.5 (11) | 17 | 0.4 ± 0.4 |
| Coho Salmon | | | 11.2 (3) | | | | 3 | 11.2 |
| Chinook Salmon | | | | 12.4 (10) | | | 10 | 12.4 ± 5.0 |
| Suckers | 0.8 (6) | | | 0.7 (2) | 1.5 (3) | 1.1 (6) | 17 | 1.0 ± 0.7 |
| Steelhead | | | 6.0 (2) | | | | 2 | 6.0 |
| Lake Trout | 11.1 (3) | 6.4 (3) | | 3.2 (2) | 5.7 (6) | 9.2 (6) | 20 | 7.4 ± 4.0 |
| Whitefish | | 0.6 (3) | | 0.8 (2) | 1.1 (1) | | 6 | 0.7 ± 0.3 |

* Data from Michigan's Great Lakes Environmental Contaminant Survey, 1972.

** Zones of Lake Michigan within Michigan Boundaries
MM3 - Northern Basin
MM4 - Grand Traverse Bay
MM5 & MM6 - Central Basin
MM7 & MM8 - Southern Basin

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Fish Cont'd

U.S. BF&W

Polychlorinated Biphenyl

Approximately 800 of the fish collected from Lake Michigan were analyzed for PCB mixtures resembling that of Aroclor 1254. A generalized summary of these results is presented in the accompanying table in which the range and average concentrations of PCB's (as Aroclor 1254) is reported for 13 species of fish. The mean concentrations ranged from 2.1 ug/gm in smelt to 15 ug/gm in chinook salmon. The data show that the larger fish such as brown, lake and rainbow trout and chinook and coho salmon contained PCB's at concentrations two to three times the 5 ug/gm action level established by the FDA. The mean PCB concentrations in suckers, smelt and whitefish were considerably less than 5 ug/gm and the mean concentrations in the alewife, carp, chub and perch were approximately 5 ug/gm, ranging from 4.7 to 5.9 ug/gm. As is expected, the larger fish with greater percentage fat contain greater concentrations of PCB's.

Summary of PCB Concentrations in the 1971 Lake Michigan Fish

| Species | Number of Fish Analyzed | Concentration of PCB (µg/gm as Aroclor 1254) Range[a] | Mean[b] |
|---|---|---|---|
| Alewife | 76 | 2.5 - 8.9 | 4.7 |
| Brown Trout | 16 | 6.7 - 12 | 8.8 |
| Carp | 42 | 1.7 - 11 | 5.5 |
| Chub | 229 | 3.4 - 8.1 | 5.3 |
| Chinook Salmon | 21 | 9.9 - 24 | 15 |
| Coho Salmon | 56 | 3.6 - 17 | 12 |
| Lake Trout | 157 | 8.1 - 21 | 14 |
| Perch | 48 | 4.2 - 11 | 5.9 |
| Rainbow Trout | 10 | 8.8 - 12 | 10 |
| Red Sucker | 16 | 2.7 - 3.2 | 2.9 |
| Smelt | 35 | 0.7 - 3.2 | 2.1 |
| White Sucker | 50 | 2.1 - 11 | 4.1 |
| Whitefish | 43 | 1.5 - 6.1 | 3.5 |

[a] indicates range of averaged level of PCB of a given species at a given sampling location--weight wet basis

[b] average of all locations sampled

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Fish Cont'd

Not only does the PCB concentration vary considerably among the 13 species captured, but also the range of concentrations in a single species in the lake was generally greater than 100 percent (the range in red suckers was less; however, all were captured in the same region). Although some variation in concentration is expected because of the normal analytical precision, the table reveals much larger ranges which are undoubtedly due to other factors which limit the usefulness of mean concentrations presented. Previous research has shown (Reinert, 1970) that the lipid content, size of fish, season of capture and concentration in the water may effect the observed concentration of chlorinated hydrocarbons in tissue considerably. Accordingly, the data in the table must be considered in more detail.

The concentration of PCB's in alewives (on a fresh weight basis) were greater in southern Lake Michigan than in the northern regions, although anomolies are apparent. It is apparent that most of the alewives captured south of a line between Saugatuck and Sheboygan contained between 4.4 and 5.5 ug/gm PCB's whereas those caught north of the line contained between 3.5 and 4.4 ug/gm. An interesting exception is the high concentration, 8.9 ug/gm, in the alewives from Rock Island just off the Door County Peninsula in Wisconsin.

The analyses of brown trout suggested similar trends in that those from Michigan City at the southern end of the lake contained 11.9 ug/gm while those from Sheboygan and Gills Rock contained 7.9 and 6.7 ug/gm, respectively.

The carp from Michigan City also had higher levels of PCB's than did those from the northern region. In contrast to the 11.0 ug/gm found in the Michigan City carp, those from Saugatuck and Sheboygan contained 4.6 and 1.7 ug/gm, respectively.

The PCB's in chubs in southern Lake Michigan ranged from 4.9 ug/gm near Milwaukee to 8.1 ug/gm near Saugatuck. In general, the chubs from the northern regions were below 5 ug/gm. The concentration of PCB's in the five groups of chubs collected over three months near Sheboygan varied without trend between 3.7 and 6.1 ug/gm, although the mean was below 5 ug/gm. The variation is somewhat less when the data is expressed on a lipid basis. For example, the PCB's in the 8/27 and 10/15 chubs was 5.0 and 3.7 ug/gm--wet weight, respectively. In contrast, the concentration of PCB's in the lipids was 23 ug/gm and 21 ug/gm, respectively. Thus, much of the observed variability is due to lipid content of the fish analyzed.

One hundred percent of the chinook salmon captured in Wisconsin contained greater than 5 ug/gm PCB's and mean concentrations ranged from 24 ug/gm in Milwaukee to 9.9 ug/gm in Strawberry Creek.

Little trend in the concentration of PCB's in coho salmon was observed with sampling region. With the exception of coho caught early in 1971 near Michigan City, the mean concentration of PCB's ranged from 11 ug/gm in those near Ludington to 14 ug/gm in those near Michigan City.

The PCB's in lake trout were most concentrated in the trout from Michigan City, Saugatuck and Milwaukee where mean concentrations were generally between 15 and 22 ug/gm. The trout from the northern areas such as Sheboygan, Ludington, Grand Traverse Bay and Gill's Rock were considerably lower, and the mean concentrations ranged between 8 and 15 ug/gm.

The concentration of PCB's were unexpectedly high in the perch caught near Milwaukee in that the mean of the 10 fish was 11 ug/gm. In contrast, perch from other regions appear to be less by a factor of two, and those from lower Green Bay contained only 2.7 ug/gm.

Rainbow trout were only caught near Michigan City and Gill's Rock. The Michigan City trout had 12 ug/gm PCB's while those from Gill's Rock averaged only 8.8 ug/gm PCB's.

The concentration of PCB's in suckers and smelt were generally between 2 and 4 ug/gm, although the average concentration in the three white suckers from Saugatuck was 6.0 ug/gm. With the exception of whitefish caught at Grand Haven and Michigan City, the PCB concentration in whitefish was less than 3 ug/gm.

Additional Data from U.S. BSF&W Great Lakes Fishery Laboratory

Mean PCB Levels in Lake Michigan Fish

| Species | Time of Collection | Location of Collection | Number of Analysis | Number of Fish | Mean Length (mm) | Mean Weight (grams) | Mean Lipids (percent) | Total PCB's (ppm) |
|---|---|---|---|---|---|---|---|---|
| Lake Trout | Fall, 1971 | Gd. Traverse Bay | 3 | 15 | 647 | 3,038 | N.M.① | 14.3 |
| Lake Trout | Fall, 1972 | Saugatuck, Mi. | 20 | 20 | 688 | 3,199 | 18.5 | 20.7 |
| Coho | Fall, 1972 | Ludington, Mi. | 10 | 10 | D.A.② | D.A.② | 7.3 | 10.9 |
| Whitefish | Fall, 1971 | Gd. Traverse Bay | 3 | 15 | 505 | 1,399 | N.M.① | 2.2 |
| Bloater Chub | Spring, 1972 | Saugatuck, Mi. | 20 | 200 | 256 | 160 | 16.8 | 8.0 |
| Bloater Chub | Fall, 1972 | Saugatuck, Mi. | 12 | 120 | 255 | 177 | 21.6 | 5.7 |
| Bloater Chub | Fall, 1972 | Saugatuck, Mi. | 8 | 80 | 229 | 120 | 18.8 | 3.6 |

① N.M. = not measured

② D.A. = Data available

Data Summary - Tributaries

Illinois

| | Aroclor (ppb) 1242 Mean | 1242 Range | 1254 Mean | 1254 Range |
|---|---|---|---|---|
| Tributaries | | | | |
| 4 water samples, 1971 | 0.712 | (0.140-1.810) | 0.258 | (0.192-0.388) |
| 13 water samples, 1972 | 0.110 | (ND - 0.653) | 0.158 | (0.033-0.841) |
| Sediments | | | | |
| 13 samples from ravines and minor tributaries, 1971 | 95.8 | (ND - 55.30) | 32.3 | (1.5-232.0) |

Indiana

| | PCB (ppb) Mean | PCB (ppb) Range |
|---|---|---|
| Tributaries | | |
| 6 water samples, 1973 | .025 | (<.01 - .07) |

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Tribs. Cont'd

Michigan

Quarterly water sampling in thirty Michigan tributaries showed that about 60 percent of the samples contained more than 0.01 ppb with one stream, the Saginaw River, having a high concentration of 2.9 ppb. Fish from the Saginaw River had PCB concentrations as high as 165 ppm. Five Michigan streams had mean concentrations in water samples over 0.10 ppb. These were all located in the populous southeastern lower peninsula which drains into lower Lake Huron, Lake St. Clair and Lake Erie. Of the Lake Michigan streams, the Grand and Kalamazoo rivers consistently showed the highest concentrations with means of 0.041 and 0.065 ppb, respectively.

A study of transport of PCB's to Lake Michigan on suspended solids was conducted during March-May, 1973, on the Grand, Kalamazoo and St. Joseph Rivers. Sediment traps were suspended 1-2 meters off the bottom of the rivers and collected at varying time intervals in each river ranging from 3 times weekly to once a month. Concentrations of PCB's were notably higher in the settleable solids from the Kalamazoo River than from the Grand and St. Joseph rivers. The over-all mean for all samples were 3.52, 0.99 and 0.97 ppm (oven-dry basis) for the Kalamazoo, Grand and St. Joseph Rivers, respectively. This data substantiates earlier results indicating elevated levels of PCB's in the Kalamazoo River watershed. Extensive sampling at upstream sections of the watershed has identified past and present wastepaper recycling by paper industries located in the City of Kalamazoo as the major source of contamination to the river. Certain sediment deposits in impoundments on Portage Creek, a tributary to the Kalamazoo River at Kalamazoo, were found to contain PCB's at concentrations exceeding 350 ppm (dry weight basis). Leaching from these PCB enriched sediments appears to be significant. Fish collected immediately downstream from the City of Kalamazoo were found to contain residues of PCB's in their tissue as high as 110 ppm (Hesse and Willson, 1972).

An example of one location in Michigan where monitoring and subsequent control measures have resulted in a marked reduction in PCB contamination is the Saginaw River basin. Even though it is not within the Lake Michigan watershed, the Saginaw River PCB situation is worthy of review. Monitoring of major Great Lakes tributaries during 1971-1972 identified the Saginaw River as having the highest concentrations of PCB's of any tributary within Michigan boundaries. Intensive sampling throughout the river basin in search of point sources successfully isolated ten major points of PCB discharge to the river system. Each of the industrial sources were asked to identify the cause of their losses and to take corrective action. Control measures, in most cases, conversion to non-PCB containing products, have proved very effective toward lowering the PCB concentrations in the Saginaw River. A sharp PCB decline at a monitoring site near the river mouth was observed in October, 1972, and concentrations have remained low since that date. It is hoped that a corresponding decline in PCB concentrations in fish from the river and Saginaw Bay will soon be observed.

Mean PCB Concentrations in Michigan Tributaries to the Great Lakes in 1971-72.

| Lake Basin | River | PCB's (ppb as 1254) | Range (ppb as 1254) |
|---|---|---|---|
| Michigan | St. Joseph | 0.013 | <0.010-0.[illegible] |
| | Kalamazoo | 0.055 | 0.[illegible] |
| | Grand | 0.041 | 0.[illegible] |
| | Muskegon | 0.010 | <0.010-0.[illegible] |
| | Manistee | 0.014 | <0.010-0.[illegible] |
| | Boardman | 0.017 | <0.010-0.[illegible] |
| | Elk | 0.012 | <0.010-0.[illegible] |
| Huron | Saginaw | 1.100 | 0.[illegible] |
| | Cass[1] | 0.014 | <0.010-0.[illegible] |
| | Flint[1] | 0.078 | 0.[illegible] |
| | Shiawassee[1] | 0.029 | <0.010-0.[illegible] |
| | Tittabawassee[1] | 0.140 | <0.[illegible] |
| | Au Sable | <0.010 | <0.010-0.[illegible] |
| | Thunder Bay | 0.023 | <0.010-0.[illegible] |
| | Cheboygan | 0.032 | <0.010-0.[illegible] |
| St. Clair | Clinton | 0.150 | <0.[illegible] |
| | Black | 0.043 | <0.[illegible] |
| | St. Clair | 0.010 | <0.010-0.[illegible] |
| Erie | Raisin | 0.210 | <0.[illegible] |
| | Huron | 0.012 | <0.010-0.[illegible] |
| | Rouge[2] | 0.470 | 0.[illegible] |
| | Detroit | 0.020 | <0.010-0.[illegible] |

[1] Tributary to Saginaw River
[2] Tributary to Detroit River downstream from Detroit River sampling station

Concentrations of PCB's (polychlorinated biphenyls) in the settleable solids collected from the mouths of the Grand, Kalamazoo, and St. Joseph Rivers; Spring 1973, for comparison of variable sampling periods. Concentrations in ppm on an oven-dry basis.

| River | Sample Type[a] | Sample Dates 3/21 | 3/23 | 3/30 | 4/2 | 4/4 | 4/6 | 4/9 | 4/11 | 4/13 | 4/20 | 4/27 | 5/3 | 5/7 | 5/9 | 5/11 | Means |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grand | 3X | 3.24 | | | 1.0* | 0.95 | 1.0 | <0.1 | 0.93 | 1.58 | | | 0.83 | 3.5 | 0.53 | | 1.43 |
| | Weekly | | 1.25 | 0.91 | | | 1.1 | | | 1.00 | 0.55 | 0.74 | | | 0.69 | 0.77 | 0.69 |
| | Biweekly | | | 0.85 | | | | | | 0.73 | | 0.50 | | | | 0.60 | 0.67 |
| | Monthly | | | | | | | | | 1.41 | | | | | | 0.59 | 0.95 |
| | | | | | | | | | | | | | | | Mean | * | 0.93 |
| Kalamazoo | 3X | 6.7 | 27.5 | | 2.03 | <0.1 | 2.52 | 1.33 | 3.20 | <0.1 | | | 3.11 | 3.59 | 3.25 | | 4.22 |
| | Weekly | | *6.83 | 3.0 | | | 3.56 | | | 3.77 | 3.09 | 2.93 | | | 2.03 | 4.87 | 3.87 |
| | Biweekly | | | 3.77 | | | | | | 2.64 | | 2.64 | | | 2.50 | 2.86 | |
| | Monthly | | | | | | | | | 2.11 | | | | | 3.14 | 2.03 | |
| | | | | | | | | | | | | | | | Mean | * | 3.52 |
| St. Joseph | 3X | | | | | | | | 2.13 | 0.68 | | 0.96 | 0.83 | 0.53 | | | 0.73 |
| | Weekly | | | | | | | | | 0.85 | | 0.79 | | 0.83 | 1.21 | | 1.16 |
| | Biweekly | | | | | | | | | | | 0.67 | | | 0.95 | | 1.24 |
| | Monthly | | | | | | | | | | | | | | 0.83 | | 0.75 |
| | | | | | | | | | | | | | | | Mean | * | 0.97 |

[a] 3X = Sample collected Mon, Wed, and Friday
* Concentration based upon a 1:1 ratio of Aroclor 1242 and 1254. All other concentrations calculated as Aroclor 1242.

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Tribs. Cont'd

Polychlorinated biphenyls (PCB's) in composite water samples from the Saginaw River at Bay Harbor Marina, March 1971 - May 1973.

| Collection Date | Concentration in parts per billion |
|---|---|
| 3-9-71 | 0.450 |
| 6-10-71 | 0.550 |
| 8-27-71 | 2.900 |
| 10-26-71 | 1.100 |
| 6-8-72 | 0.640 |
| 10-13-72 | 0.350 |
| 10-29-72 | <0.020 |
| 10-30-72 | <0.020 |
| 11-1-72 | 0.091 |
| 11-2-72 | 0.031 |
| 11-4-72 | <0.020 |
| 11-6-72 | 0.022 |
| 1-26-73 | <0.100 |
| 5-24-73 | 0.210 |

Concentrations of poly-chlorinated biphenyls (PCB's) in fish from Saginaw River, December 7, 1971. ( ppm; wet weight).

| Species | Location | Length | Percent fat | PCB's based upon 1242 standard |
|---|---|---|---|---|
| Perch | Farm-Weadock Discharge Channel | 9.0 | 1.3 | 16.3 |
| Carp | " " " " | 21.0 | 0.9 | 8.8 |
| Catfish | " " " " | 8.0 | 7.0 | 37.1 |
| Catfish | " " " " | 7.5 | 4.9 | 47.9 |
| Carp | U.S. Coast Guard Station | 23.0 | — | 48.0 |
| Carp | " " " " | 24.0 | 10.5 | 70.4 |
| Carp | " " " " | 20.0 | 6.5 | 35.5 |
| Carp | " " " " | 24.0 | 5.9 | 45.8 |
| Carp | " " " " | 21.0 | 4.6 | 33.2 |
| Pike | " " " " | 27.0 | 1.6 | 16.6 |
| Pike | " " " " | 23.0 | 1.1 | 6.9 |
| Gizzard Shad | " " " " | 14.0 | 17.5 | 164.3 |
| Gizzard Shad* | " " " " | 6.0 | 15.3 | 32.5 |
| Gizzard Shad* | " " " " | 4.5 | 15.0 | 161.9 |
| Gizzard Shad* | " " " " | 5.0 | 17.0 | 27.0 |
| Gizzard Shad* | Tittabawassee Bridge | 4.5 | 15.2 | 24.1 |
| Gizzard Shad* | " " | 5.0 | 9.6 | 52.0 |
| Gizzard Shad* | " " | 5.0 | 8.7 | 10.4 |

* Concentration based upon analysis of whole fish. All others based upon edible portion only.

DSW 029676

Data Summary - Discharges

Illinois

| | Aroclor (ppb) 1242 Mean | 1242 Range | 1254 Mean | 1254 Range |
|---|---|---|---|---|
| Sewage Treatment Plants | | | | |
| 6 samples, 1971 | 1.443 | (0.268-4.020) | 0.300 | (0.139-0.568) |
| 16 samples, 1972 | 0.177 | (ND-0.510) | 0.126 | (0.055-0.200) |

Indiana

| Municipality | Date | Flow (MGD) | Aroclor 1254 (ppb) |
|---|---|---|---|
| Michigan City | 11/27 & 28/72 | 11.0 | 2.46 |
| Michigan City | 12/20 & 21/72 | 13.3 | 0.19 |
| Valparaiso | 11/27 & 28/72 | 4.0 | 0.27 |
| Valparaiso | 12/20 & 21/72 | 4.0 | 0.20 |
| Hobart | 11/27 & 28/72 | 2.7 | 0.35 |
| Hobart | 12/20 & 21/72 | 3.1 | 0.11 |
| Hammond | 11/27 & 28/72 | 42.9 | <0.10 |
| Hammond | 12/20 & 21/72 | 42.3 | <0.10 |
| East Chicago | 11/27 & 28/72 | 18.5 | <0.10 |
| East Chicago | 12/20 & 21/72 | 18.7 | 0.10 |
| Chesterton | 11/27 & 28/72 | 1.5 | <0.10 |
| Chesterton | 12/20 & 21/72 | 1.8 | <0.10 |
| Gary | 11/27 & 28/72 | 50.5 | 0.38 |
| South Bend | 3/22 & 23/73 | 35.8 | <0.10 |
| Mishawaka | 3/22 & 23/73 | 10.39 | 0.13 |
| Elkhart | 3/22 & 23/73 | 17.5 | <0.10 |
| Goshen | 3/22 & 23/73 | 4.8 | <0.10 |
| Nappanee | 3/22 & 23/73 | .900 | <0.10 |
| Kendallville | 2/28/73 | 1.2 | <0.10 |
| LaGrange | 3/7/73 | .185 | <0.10 |
| Ligonier | 3/7/73 | .434 | <0.10 |
| Angola | 3/7/73 | .784 | 0.17 |
| Syracuse | 3/7/73 | .305 | 0.13 |

DSW 029677

Michigan

Analyses of surface water runoff from sanitary and industrial landfills in Michigan suggest that these are a minor source of environmental contamination. Five of the 9 samples collected had PCB concentrations ranging from 0.01 to 0.30 ppb while the others contained less than 0.01 ppb.

Sampling of municipal wastewater treatment plant (WWTP) effluents throughout Michigan in 1971 and 1972 indicated that many WWTP's represent major point sources of PCB loss to surface waters of the State. The average PCB concentration of 60 effluents sampled was 2.55 ppb. While only seven of the WWTP effluents exceeded 1 ppb, the Bay City WWTP located on the Saginaw River had an average effluent concentration of 120 ppb (high of 340 ppb), skewing the over-all average for all plants sharply upward. The average concentration excluding the Bay City WWTP was 0.56 ppb. Those WWTP's with PCB concentrations in effluents exceeding 1 ppb were, with one exception, located on rivers already identified as having high levels of PCB contamination. Sampling of 58 WWTP effluents in 1973 continues to show high PCB levels with an average concentration of 0.52 ppb, including the Bay City plant. The PCB discharge from the Bay City WWTP has been greatly reduced as a result of control measures in industries served by the WWTP.

Sampling of sewage sludge from 57 of the 58 WWTP's tested in 1973 showed Bay City to have the highest concentration of PCB's in the sludge being removed by the treatment process. The PCB concentration in the sludge from the Bay City plant was 352 ppm (dry weight basis) compared to a state-wide average of 15.6 ppm.

In an attempt to identify major contributors of PCB's within municipal WWTP systems, sampling at key points in the interceptor systems has been conducted within the municipalities of Bay City, Mt. Clemens, Saginaw, Adrian, Detroit and Kalamazoo. This program has been very successful. The City of Detroit has, in fact, established an on-going sampling program within their interceptor system with analytical assistance from the State. They are applying a new City of Detroit sewer ordinance which limits discharges within the wastewater system to a maximum of 0.1 ppb.

A broad scale sampling of industrial discharges throughout Michigan has shown results indicative of the widespread usage of PCB's. Nearly half of the industrial discharges sampled have contained more than 0.1 ppb with many in excess of 1 ppb. The highest concentration detected in an industrial discharge in Michigan has been 7,200 ppb. Automotive plants, chemical companies, and paper product manufacturers are among the types of industries with highest concentrations. Also industries and building complexes, including some schools and hospitals, with heat transfer systems appear to be another major source. Industries identified as sources of PCB pollution have been encouraged to changeover to replacement compounds or to clean up their operation so that discharges of PCB's do not exceed the present Michigan guideline of 0.1 parts per billion.

Michigan is currently trying to get a handle on losses from electrical transformers in leakage, servicing, and replacement within plants. It

Discharges Cont'd

appears that many of the small transformer maintenance companies are still dumping PCB's down the drain rather than returning them for incineration.

DSW 029679

Dischargers Cont'd

Polychlorinated Biphenyls (PCB's) in Effluents of Municipal Wastewater Treatment Plants throughout Michigan 1971-1972. Unless specified, all samples are 8 hr. composites.

| CITY | DATE | PCB's as Aroclor 1254 (ppb) | Mean Conc. (ppb) |
|---|---|---|---|
| Adrian | 3-30-72 | 1.80 | 4.60 |
| | 6-13-72 | 14.00 | |
| | 6-14-72 | 6.90 | |
| | 9-6-72 | 0.41 | |
| Albion | 3-28-72 | 0.44 | 0.44 |
| Ann Arbor | 10-14-71 | 0.14 | 0.12 |
| | 3-30-72 | <0.10 | |
| Battle Creek | 10-5-71 | 0.39 | 0.39 |
| | 3-28-72 | 0.16 | |
| | 2-21-72 | 0.92 | |
| | 6-6-72 | 0.28 | |
| | 6-7-72 | 0.21 | |
| Bay City | 11-4-71 | 340.00 | 120.00 |
| | 11-22-71 | 210.00 | |
| | 11-23-71 | 60.00 | |
| | 3-2-72[a] | 290.00 | |
| | 4-4-72 | 19.00 | |
| | 6-13-72 | 11.00 | |
| | 6-14-72 | 25.00 | |
| | 9-14-72 | 5.70* | |
| Benton Harbor - St. Joseph | 10-28-71 | 0.99 | 0.65 |
| | 4-4-72 | 0.31 | |
| Brighton | 10-5-71 | 0.38 | 0.38 |
| Charlotte | 7-20-72 | 0.61 | 0.61 |
| Constantine | 4-4-71 | 0.85 | 0.85 |
| Detroit | 10-14-71 | 2.20 | 1.95 |
| | 12-20-72[c] | 3.00 | |
| | 1-20-72 | 0.92 | |
| | 3-9-72 | 2.40 | |
| | 4-17-72[b] | 1.80 | |
| | 6-1-72 | 0.88 | |
| | 10-19-72 | 2.50** | |
| Dexter | 10-14-71 | <0.10 | 0.10 |

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Dischargers Cont'd

| CITY | DATE | PCB's Aroclor 1254 (ppb) | Mean Conc. (ppb) |
|---|---|---|---|
| E. Lansing | 11-15-71 | 0.69 | 0.51 |
| | 4-3-71 | 0.35 | |
| Escanaba | 12-16-71 | 0.29 | 0.29 |
| Essexville | 11-4-71 | 0.21 | 0.24 |
| | 3-31-72 | 0.28 | |
| Flint | 10-5-71 | 1.30 | 0.68 |
| | 3-31-72 | 0.92 | |
| | 6-7-72 | 0.47 | |
| | 6-8-72 | 0.30 | |
| | 10-5-72 | < 0.10 | |
| Flushing | 10-5-72 | 0.52 | 0.52 |
| Gladstone | 7-21-72 | 0.19 | 0.19 |
| Grand Haven | 4-4-72 | < 0.50 | < 0.50 |
| Grand Rapids | 11-15-71 | 0.37 | 0.52 |
| | 3-30-72 | 0.68 | |
| Holland | 10-20-71 | 0.79 | 0.60 |
| | 3-29-72 | 0.42 | |
| Houghton-Hancock | 3-21-72 | <0.10 | 0.10 |
| Iron Mountain-Kingsford | 3-21-72 | 0.55 | 0.87 |
| | 4-4-72 | 1.20 | |
| Ironwood | 3-20-72 | 0.16 | 0.16 |
| Jackson | 11-16-71 | <0.10 | <0.10 |
| | 2-21-72 | <0.10 | |
| | 3-28-72 | <0.10 | |
| Kalamazoo | 10-5-71 | 1.30 | 0.66 |
| | 3-28-72 | 0.83 | |
| | 6-6-72 | 0.48 | |
| | 6-7-72 | 0.53 | |
| | 12-6-72 | 0.19 | |
| L'Anse | 4-21-72 | <0.10 | <0.10 |
| Lansing | 10-7-71 | 0.23 | 0.18 |
| | 4-4-72 | 0.13 | |

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Dischargers Cont'd

| CITY | DATE | PCB/s Aroclor 1254 (ppb) | Mean Conc. (ppb) |
|---|---|---|---|
| Manistique | 12-15-72 | <0.20 | <0.20 |
| Marquette | 12-14-71 | 0.35 | 0.35 |
| Marshall | 3-28-72 | <0.10 | <0.10 |
| Menominee | 12-15-71 | 0.35 | 0.35 |
| Midland | 2-2-72 | 0.29 | 0.23 |
| | 3-31-72 | 0.40 | |
| | 4-14-72 | 0.13 | |
| | 10-2-72[d] | 0.13 | |
| Milford | 10-14-71 | <0.10 | <0.10 |
| Monroe | 11-15-71 | 0.60 | 0.46 |
| | 3-30-72 | 0.33 | |
| Mt. Clemens | 11-15-71 | 1.40 | 5.21 |
| | 3-30-72 | 2.90 | |
| | 6-7-72[c] | 4.50 | |
| | 6-8-72[c] | 3.10 | |
| | 7-26-72 | 9.40 | |
| | 8-2-72 | 10.00 | |
| Mt. Pleasant | 3-31-72 | <0.10 | <0.10 |
| Muskegon | 11-15-71[c] | 0.28 | 0.28 |
| Muskegon Heights | 11-15-71[c] | 0.37 | 0.37 |
| Niles | 4-4-72 | 0.68 | 0.68 |
| Norway | 4-5-72 | 0.40 | 0.40 |
| Ontonagon | 4-21-72 | <0.10 | <0.10 |
| Owosso | 9-14-72 | <0.10 | <0.10 |
| Parchment | 4-20-72 | <0.10 | <0.10 |
| Pontiac (Auburn Rd.) | 11-17-71 | <0.10 | 0.35 |
| | 3-30-72 | 0.61 | |
| Pontiac (E. Blvd.) | 11-17-71 | 0.20 | 0.45 |
| | 3-30-72 | 1.30 | |
| | 6-6-72 | 0.15 | |
| | 6-7-72 | 0.16 | |
| Portage | 11-15-71[d] | 1.90 | 1.90 |

Dischargers Cont'd

| CITY | DATE | PCB's as Aroclor 1254 (ppb) | Mean Conc. (ppb) |
|---|---|---|---|
| Port Huron | 11-15-71 | 0.28 | 0.40 |
| | 3-30-72 | 0.52 | |
| Saginaw | 10-6-71 | 1.10 | 1.80 |
| | 3-31-72 | 3.80 | |
| | 6-7-72 | 2.00 | |
| | 6-8-72 | 1.50 | |
| | 10-4-72[d] | 0.74 | |
| St. Ignace | 12-15-72 | <0.20 | <0.20 |
| South Haven | 4-4-72 | <0.10 | <0.10 |
| Swartz Creek | 10-5-72 | <0.10 | <0.10 |
| Three Rivers | 4-4-72 | <0.30 | <0.30 |
| Trenton | 11-16-71 | 0.14 | 0.53 |
| | 3-30-72 | 1.10 | |
| | 6-6-72 | 0.47 | |
| | 6-7-72 | 0.91[e] | |
| Warren | 11-15-71 | 0.16 | 0.13 |
| | 3-30-72 | 0.10 | |
| Wayne County (Wyandotte) | 11-16-71 | 0.64 | 0.40 |
| | 3-30-72 | 0.17 | |
| White Pine | 4-21-72 | 0.2 | 0.20 |
| Wyoming | 11-30-72[c] | 0.44 | 0.49 |
| | 3-30-72 | 0.55 | |
| Ypsilanti | 11-16-71 | 0.22 | 0.21 |
| | 4-2-72 | 0.21 | |
| Ypsilanti Twp #1 | 11-16-71 | 0.12 | 0.11 |
| | 4-2-72 | <0.10 | |
| Ypsilanti Twp #2 | 11-16-71 | 0.19 | 0.17 |
| | 4-2-72 | 0.16 | |

*Aroclor 1242 Standard
**Aroclor 1242 and 1254 in 1:1 ratio

[a]6 hr [b]10 hr [c]24 hr [d]Grab [e]hexane lost GRAND MEAN 2.55

DSW 029683

Dischargers Cont'd

Concentrations of PCB's in the Final Effluent from Wastewater Treatment Plants throughout Michigan, Spring, 1973. Concentrations in parts per billion dry weight.

| CITY | DATE | PCB's | | |
|---|---|---|---|---|
| | | 1242 | 1254 | 1242:1254 |
| Adrian | 3/7 | | | 0.26 |
| Albion | 2/22 | | 0.34 | |
| Ann Arbor | 3/1 | | 0.25 | |
| Bay City | 3/1 | 3.20 | | |
| Battle Creek | 2/28 | | <0.10 | |
| Benton Harbor-St. Joseph | 2/28 | | 0.20 | |
| Brighton | 3/1 | | | 0.33 |
| Cadillac | 3/28 | | 0.53 | |
| Charlotte | 5/1 | | 0.34 | |
| Constantine | 2/28 | | 0.46 | |
| Detroit | 2/28 | 2.15 | | |
| Dexter | 3/1 | | 0.23 | |
| East Lansing | 5/2 | | 0.18 | |
| Escanaba | 3/28 | | | 0.28 |
| Essexville | 3/1 | | 0.10 | |
| Flint | 2/22 | | <0.10 | |
| Gladstone | 3/28 | | 0.44 | |
| Grand Haven | 2/21 | | <0.10 | |
| Grand Rapids | 2/21 | | 1.05 | |
| Holland | 2/21 | | <0.10 | |
| Houghton-Hancock | 3/27 | | 0.18 | |
| Iron Mountain-Kingsford | 3/28 | | 0.69 | |
| Ironwood | 3/27 | | | 0.29 |
| Jackson | 2/22 | | <0.1 | |
| Kalamazoo | 2/29 | | | 1.12 |
| L'Anse | 3/27 | | | 0.31 |
| Lansing | 4/18 | | 0.22 | |
| Manistique | 3/28 | | 0.63 | |
| Marquette | 3/27 | | 0.29 | |
| Marshall | 2/22 | | 0.15 | |
| Menominee | 2/28 | | 0.57 | |
| Midland | 3/1 | | <0.10 | |
| Milford | 3/8 | | | 2.20 |
| Monroe | 5/4 | | <0.10 | |
| Mt. Clemens | 3/8 | | | 2.90 |
| Mt. Pleasant | 3/28 | | 0.29 | |
| Muskegon | 2/28 | | 0.88 | |
| Muskegon Heights | 2/28 | | 0.13 | |
| Niles | 2/20 | | 0.48 | |
| Norway | 3/28 | | <0.10 | |
| Owosso | 2/21 | | 0.12 | |
| Pontiac (Auburn) | 3/12 | | | 0.60 |
| Pontiac (E. Blvd.) | 3/12 | | | 0.54 |
| Port Huron | 3/8 | | | 1.80 |
| Saginaw | 3/1 | | | 0.77 |
| Sault Ste. Marie | 3/28 | | 0.73 | |

Dischargers Cont'd

| CITY | DATE | PCB's | | |
|---|---|---|---|---|
| | | 1242 | 1254 | 1242:125 |
| St. Ignace | 3/28 | | 0.31 | |
| Three Rivers | 2/21 | | <0.10 | |
| Traverse City | 3/7 | | <0.10 | |
| Trenton | 2/28 | | <0.10 | |
| Warren | 2/27 | | <0.10 | |
| Wayne County | 2/28 | | 0.40 | |
| Wyoming | 2/21 | | 0.22 | |
| Ypsilanti | 2/28 | | | 0.31 |
| Ypsilanti Twp #1 | 3/1 | | <0.10 | |
| Ypsilanti Twp #2 | 3/1 | | <0.10 | |

*Concentrations based on best fit of 3 standards: Aroclor 1242, Aroclor 1254, or a mixture of Aroclor 1242 and 1254 in a 1:1 ratio.

DSW 029685

Dischargers Cont'd

Concentrations of PCB's in the sludge from fifty-seven municipal wastewater treatment plants in Michigan, Spring 1973. Concentrations in parts per million, dry weight.

| City | Date | PCB's* 1242 | 1254 | 1242:1254 |
|---|---|---|---|---|
| Adrian | 3/ 7 | | | 24.0 |
| Albion | 2/22 | | 1.5 | |
| Ann Arbor | 3/1 | | 1.1 | |
| Bay City | 3/1 | 352.0 | | |
| Battle Creek | 2/28 | | 2.8 | |
| Benton Harbor-St. Joseph | 2/28 | | 13.8 | |
| Brighton | 3/1 | | <0.1 | |
| Cadillac | 3/28 | | <0.1 | |
| Charlotte | 5/1 | | 6.8 | |
| Constantine | 2/28 | | 2.1 | |
| Detroit | 2/28 | 32.1 | | |
| Dexter | 3/1 | | 3.2 | |
| E. Lansing | 5/2 | | 4.6 | |
| Escanaba | 3/28 | | 5.9 | |
| Essexville | 3/1 | | 3.9 | |
| Flint | 2/22 | | 6.3 | |
| Gladstone | 3/28 | | 4.1 | |
| Grand Haven | 2/21 | | 4.1 | |
| Grand Rapids | 2/21 | | 11.8 | |
| Holland | 2/21 | | 0.8 | |
| Howell | 4/26 | | 15.0 | |
| Houghton-Hancock | 3/27 | | 5.5 | |

DSW 029686

Dischargers Cont'd

| City | Date | PCB's 1242 | PCB's 1254 | 1242:1254 |
|---|---|---|---|---|
| Iron Mountain - Kingsford | 3/28 | | 9.5 | |
| Ironwood | 3/27 | | 5.2 | |
| Jackson | 2/22 | | 3.0 | |
| Kalamazoo | 2/29 | 23.3 | | |
| L'Anse | 3/27 | | 4.4 | |
| Lansing | 4/18 | | 5.3 | |
| Manistique | 3/28 | | 1.5 | |
| Marquette | 3/27 | | 2.8 | |
| Marshall | 2/22 | | 3.9 | |
| Menominee | 2/28 | | 4.2 | |
| Midland | 3/1 | | 2.3 | |
| Milford | 3/8 | | | 50.5 |
| Monroe | 5/4 | | 3.3 | |
| Mt. Clemens | 3/8 | 1175.0 | | |
| Mt. Pleasant | 3/28 | | 6.5 | |
| Muskegon | 2/28 | | 12.7 | |
| Muskegon Heights | 2/28 | | 11.0 | |
| Niles | 2/20 | | 7.8 | |
| Norway | 3/28 | | <0.1 | |
| Owosso | 2/21 | | 2.0 | |
| Pontiac (Auburn) | 3/12 | | | 12.1 |
| Pontiac (E. Blvd.) | 3/12 | | | 9.2 |
| Port Huron | 3/8 | | | 9.2 |

Dischargers Cont'd

| City | Date | PCB's 1242 | 1254 | 1242:1254 |
|---|---|---|---|---|
| Saginaw | 3/1 | | 5.0 | |
| Sault Ste. Marie | 3/28 | | 2.4 | |
| St. Ignace | 3/28 | | 1.5 | |
| Three Rivers | 2/21 | | 4.1 | |
| Traverse City | 3/7 | | 1.8 | |
| Trenton | 3/28 | | <0.1 | |
| Warren | 2/27 | | <0.1 | |
| Wayne County | 2/28 | 2.0 | | |
| Wyoming | 2/21 | | 0.58 | |
| Ypsilanti | 2/28 | | 2.0 | |
| Ypsilanti Twp. #1 | 3/1 | | <0.1 | |
| Ypsilanti Twp #2 | 3/1 | | <0.1 | |

* Concentration based on best fit of 3 standards: Aroclor 1242, Aroclor 1254, or a mixture of Aroclor 1242 and 1254 in a 1:1 ratio.

Dischargers Cont'd

Wisconsin - 1973 Survey Results

| Municipality | PCB Conc. ppb | PCB Lbs. |
|---|---|---|
| Adell | .33 | .000058 |
| Algoma | <.05 | ------- |
| Amherst | <.05 | ------- |
| Appleton | .26 | .010 |
| Buttes Des Mortes Utility Dist. | .11 | .00019 |
| Bear Creek | <.05 | ------- |
| Berlin | <.05 | ------- |
| Birnamwood | .28 | ------- |
| Boudual | <.05 | ------- |
| Brillion | .5 | .00066 |
| Bristol | <.05 | ------- |
| Brookfield | <.05 | ------- |
| Cedar Grove | <.1 | ------- |
| Chilton | 1.45 | .032 |
| Clintonville | <.05 | ------- |
| Coleman | .1 | .000021 |
| Crivitz | <.05 | ------- |
| Depere | .31 | ------- |
| Elkhart Lake | <.1 | ------- |
| Fond du Lac | .59 | .032 |
| Grafton | <.05 | ------- |
| Green Bay | .44 | .067 |
| Kenosha | <.05 | ------- |
| Marinette | <.05 | ------- |
| Neenah-Menasha | 2.1 | .074 |
| Milwaukee-South Shore | 1.1 | .068 |
| North Fond du Lac | .23 | .00053 |
| Racine | .34 | .021 |
| Shawano | .4 | .0044 |
| Sheboygan | 17 | .34 |
| Suring | .21 | .000059 |
| Waldo | .23 | .000033 |
| West Bend | .19 | .0018 |

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