

TABLE 13.

POSSIBLE FUTURE STUDIES INVOLVING PCB'S, THEIR INDIVIDUAL ISOMERS AND CONTAMINANTS.

1. Definitive studies on the mammalian distribution of the Aroclors, a number of key common individual isomers and their metabolites and/or degradation products in different tissues, the metabolic rate, retention times or turnover and excretion rates.
2. Elaboration of the relative toxicity of a number of the various purified isomers of PCB.
3. Elaboration of the effects of Aroclors and isomeric PCB's in mammalian reproduction studies are required because of the apparent anomalous relationship found in the pattern of chronic studies.
4. Elaboration of the teratogenicity of Aroclors and isomeric PCB's in several mammalian species at a range of dose levels.
5. Mutagenic studies involving the Aroclors and isomeric PCB's in test systems other than the Dominant Lethal (e.g., host mediated assay).
6. Elaboration of short-term toxicity effects on liver microsomal enzymes, study the influence of dilantin and hexobarbital and possible synergism and/or potentiation.
7. Study of the interaction of PCB's with other chemicals and drugs.
8. Study of the toxicity of the Aroclors and their individual isomers for different cell systems.
9. Elaboration of mammalian tissue distribution, metabolic rate and retention times of chlorinated dibenzofurans.
10. Liver function studies as well as cytogenic studies on workers in a) PCB production, b) application, e.g., packing of transformers, capacitors, c) waste disposal, and d) fishmeal processing plants.
11. Elaboration of aspects of hyperlipemia. Does it occur with low exposures and could it aggravate arteriosclerosis? Does it affect the pancreas, etc.?
12. Study of induced porphyria and clinical consequences.



Spalding NIEHS, (64) is elaborating the effect of Aroclors 1221, 1242, 1254, 1260 and 1268 as well as a number of isomeric polychlorinated biphenyls on mouse lymphoma and DDT-resistant mouse lymphoma cells.

V. SUMMARY AND CONCLUSIONS

Despite the nearly four decades of PCB use in a broad spectrum of applications, the increasing awareness of its environmental aspects as well as an increasing number of recent mammalian toxicological investigations, aspects of definitive acute, sub-acute and chronic toxicity still remain poorly known as regards man. The chemical and physical properties, e.g., the stability, complexity and heterogeneity of the material per se, the difficulty of separation and analysis as well as the non- or ill-defined nature of the material actually used or reported in many studies, have all certainly contributed in making the evaluation of toxicity and biological data difficult. Table 12 summarizes some biological and toxicological effects of the PCBs.

The above review of the current status of the toxicologic and biologic aspects of the PCBs suggests a number of future studies that hopefully should yield additional information to enable a more definitive evaluation of the risks involved in exposure to chlorinated biphenyls. A number of possible future studies are outlined in Table 13.

TABLE 11.

EXPERIMENTS TO DATE NOT INCLUDED IN THE MANUSCRIPT, "POLYCHLORINATED BIPHENYLS: DISTRIBUTION AND STORAGE IN BODY FLUIDS AND TISSUES OF SHERMAN RATS" - A. CURLEY, V. W. BURSE, M. E. GRIM, R. W. JENNINGS AND R. E. LINDER. (37)

Experiment No.	No. of Rats	Sex	Age at Onset of Experiment (days)	Wt. (Gms)	Dosage/Route
Ar 7-70-B12	4 (analyzed)	F	30	224*	100 ppm in Diet for 247 days *8.1 mg/kg/day
Ar-7-70-B12	3 (analyzed)	F	30	224*	100 ppm in Diet for 300 days *8.1 mg/kg/day
Ar-7-70-B12	3 (analyzed)	F	30	224*	100 ppm in Diet for 366 days *8.1 mg/kg/day
Ar-7-70-B10	4 (analyzed)	F	30	240*	20 ppm in Diet for 280 days *1.6 mg/kg/day
Ar-8-71-B	A study to determine placental transfer, excretion in milk and consequent tissue storage in weanling rats of Aroclor 1254 when the compound is given to the mother rat during organogenesis.				
Ar 7-70-G4	The effect of Aroclor 1260 upon reproduction in female rats when the compound is given during organogenesis.				

*Average weight of group and average rate of food consumption for group.

The results of a study with Ar 1260 show consequent tissue distribution and storage levels in weanling rats following oral dosage to the mother daily on the 7th through 15th day of gestation at 50 mg/Kg by stomach tube and is summarized as follows:

Note: One female and one male taken from each of 3 litters for analysis.

<u>Tissue</u>	<u>Sex</u>	<u>Mean (3 animals)</u>	<u>±S.E.</u>
Kidney	M	7.38	2.56
	F	5.44	1.41
Brain	M	7.53	1.04
	F	7.76	2.54
Liver	M	12.80	1.72
	F	16.13	6.75

Weights of Mothers 284, 264, and 288 gm.

Mean weight of Mothers 278 gm.

Additional residue studies completed include the following:

<u>Experiment No.</u>	<u>Tissue</u>	<u>Mean ppm (4 animals)</u>	<u>±S.E.</u>
Ar-7-70-B12	Fat	778	72.4
	Liver	9.9	1.16
	Kidney	5.1	.95
	Muscle	1.22	.104
	Brain	6.96	.68
	Plasma	1.6	.311

When compared to males at the same dosage level for an equal amount of time, Student's t-test shows significant difference in brain and liver storage. When these data are compared to data from male rats on the same dosage for an equal amount of time, the Student's t-test shows significant differences for brain and liver storage.

Dr. G. J. Love (61) of EPA has reported that 72 sets of specimens (blood, urine, and hair) collected from 36 workers occupationally exposed to burning automobiles or refuse dumps and from an equal number of controls are to be collected and analyzed for PCB levels.

It is of interest to note the analysis of PCB in human adipose tissue. Birks and co-workers (48) examined two human adipose tissue samples by combined GLC-mass spectrometry and found substantial quantities of PCBs ranging from pentachlorobiphenyl to decachlorobiphenyl and including at least 14 isomers and chlorine homologs. The samples were estimated to contain 200 parts per million and 600 parts per million total PCB, respectively, as determined by electron-capture gas chromatography.

IV. STUDIES IN PROGRESS

Curley and co-workers (37) have described results in a study with Aroclor 1254 to determine placental transfer, rates of excretion in milk and consequent tissue distribution and storage levels in fetuses and weanling rats following oral dosage to the mother daily on the 7th through the 15th day of gestation at 10 mg/Kg, respectively, by stomach tube. Table 11 lists the experimental protocol for the above studies. This is summarized as follows:

Fetus Analysis: Samples were taken by Caesarian section on the 20th day of pregnancy. The mean concentrations of Aroclor are given for the respective dosages as parts per million.

	<u>Controls</u>	<u>10 mg/Kg</u>	<u>50 mg/Kg</u>
Mother 1	0	1.42	2.42
Mother 2	0	1.24	2.90
Mother 3	0	1.14	2.93

10 mg/Kg

	<u>Wt. at onset (gms)</u>	<u>Age (days)</u>
Mother 1	254	90
Mother 2	265	90
Mother 3	258	90

50 mg/Kg

Mother 1	242	90
Mother 2	244	90
Mother 3	261	90

TABLE 4 -

OBJECTIVE SAMPLES - CY 1971
for PCB'sSUMMARY
PPM - fat Basis

ANIMAL AND POULTRY TISSUE CY 1971

Class	N.D.	.01-.1	.11-.50	.51-1.5	1.51-3.0	3.01-5.0	5.01-7.01	7.01-15	Over 15
Animals	2379	1	9	11	4				
Poultry	1664	4	25	53	23	4	5	15	11

PCB RESIDUES IN ANIMAL AND POULTRY
TISSUES COLLECTED IN OBJECTIVE PHASE
DURING CY 1971

Animal or Poultry	Number of Samples Analyzed	Number of Samples with A Residue	Percent of Samples with A Residue	Number of Samples Exceeding Guidelines	Percent of Samples Exceeding Guidelines
Cattle	722	9	1.2	0	0.0
Calves	66	4	6.1	0	0.0
Swine	1436	7	0.5	0	0.0
Sheep	180	5	2.8	0	0.0
Young Chickens	1637	127	7.8	2	0.1
Mature Chickens	69	5	7.2	0	0.0
Turkeys	88	8	9.0	0	0.0
Ducks	10	0	0.0	0	0.0
	4208	165	3.9	2	0.04

packaging material was identified as the source of PCB in the food. The manufacturer of the packaging material used about 95 percent recycled paper to manufacture paperboard containers. FDA analysis of different types of the firm's paperboard showed PCB levels ranging from about 2 to 433 parts per million. Various types of packaged food products, some of which used this firm's paperboard, were also analyzed as part of FDA's investigation. Nine samples of the 28 packaged foods examined contained PCBs in the food portion.

As a result of this limited investigation, FDA initiated a nationwide survey in September 1971, to determine the extent of the PCB food packaging problem. The survey included analysis for PCBs in all paper packaging components and the packaged food portions of 15 different representative food categories. This survey was completed in late December 1971. A detailed statistical analysis of the results of the survey is currently being compiled. Sixty-seven percent of the packaging portion of the samples contained PCB residues as high as 338 parts per million; 19 percent of the food portions of the samples contained PCB residues, with an average PCB concentration of 0.1 parts per million. The maximum PCB level found in food was 5 parts per million.

The FDA survey, as well as other studies by the paper and food industries, show a significant correlation between the presence of PCB residues in the food component and the packaging component. The mechanism of PCB migration from the packaging to the food probably occurs through both the vapor phase and abrasion or physical contact. The level of PCB contamination is dependent upon many factors -- levels of PCBs in the packaging materials, type of food, length and conditions of storage, and others. The extent of migration of PCB from paperboard packaging to the food contents is being investigated (Trout, 5). There is also significant correlation between the presence of PCB residues in packaging and the presence of recycled paper components in the packaging. The occurrence of PCBs in recycled paper materials is attributed primarily to the recycling of the so-called "carbonless" carbon paper (contains 3-5 percent PCB -- use of PCBs for this purpose has been discontinued) and to a lesser degree, the use of certain printing inks. PCB residues also were found in some packaging components that appeared to be composed entirely of virgin paper material. This source of PCBs probably occurs in the packaging manufacturing processes.

Industry has taken steps to reduce the levels of PCBs in food packaging materials by avoiding the recycling of carbonless carbon paper. Although it is not known if this practice has been instituted industry wide, data provided by the Grocery Manufacturers of America, Inc., does reflect a change. For example: recycled board manufactured during the period June 1970 - January 1972 shows that only 18 percent of the samples contained less than 5 parts per million PCB; the same type of recycled board manufactured from November 1971 through January 1972 shows that 95 percent of the samples to be below 5 parts per million PCB.

IX. SPECIAL SURVEYS

FDA is currently conducting a national survey to determine the extent and levels to which complete animal feeds are contaminated with PCBs.

million. Approximately 1 million turkeys approaching market weight were withheld from market until residue levels were reduced to less than 5 parts per million.

5. Oklahoma Incident. On August 20, 1971, USDA informed FDA of excessive PCB findings in chickens in Mississippi during routine sampling. Investigation revealed that the birds came from a grower in Oklahoma and the feed from a mill also in Oklahoma. FDA analysis of eggs and feeds from these firms showed no PCBs.

6. California Incident. USDA examined turkeys after slaughter in warehouse storage in California. PCBs were found in the amount of 1.41 to 28.0 parts per million in the fat tissue. There were 100,000 pounds of turkeys detained until testing was completed. The turkeys had originated from flocks raised in four counties in California. The source of the PCBs could not be determined.

B. MEAT BY-PRODUCTS

National By-Products, Inc., Mason City, Illinois Incident - On July 28, 1971, FDA inspection of this firm revealed that PCBs were used in heat treatment equipment. Sampling showed the pasteurized meat meal to contain PCBs. The firm initiated recall of the contaminated product.

C. MILK

1. West Virginia Incident. In July 1969, FDA's Baltimore District found PCBs in milk samples collected in the routine food surveillance program. Baltimore District investigated possible routes of contamination, and by February 1970, the investigation pointed to spent transformer fluid used as a vehicle for herbicide sprayed along power right-of-ways in the Martinsburg, West Virginia area. Through this route, PCBs contaminated dairy cattle grazing areas. The dairy farms involved were taken off production by State officials.

2. Ohio Incident. In April 1970, the State of Ohio notified FDA's Cincinnati District of unidentifiable residues in milk. FDA identified the residues as PCBs and advised the State of a guideline of 0.2 parts per million (whole milk). The State of Ohio and FDA investigated the problem and determined that the dairy farms were using a PCB-containing sealant in silos that migrated to the silage. The State of Ohio banned milk from some producers and destroyed an undetermined amount of milk.

3. Florida-Georgia Incidents. The States of Florida and Georgia reported findings of PCBs in milk to FDA's Atlanta District in August 1970. A PCB-containing sealant in silos was found to be the source of contamination in this incident. FDA found approximately 11 percent PCB in the silo coating.

VIII. PAPER FOOD PACKAGING

FDA first learned of the PCB food packaging problem in July 1971. The total diet market basket samples showed low level PCB residue in a grain and cereal composite (Table 3). The PCB was traced to the Shredded Wheat

distribution of poultry containing less than 5 parts per million. This level was applicable to the edible tissue on a whole tissue basis or to the separate fat removed during slaughter or processing and intended for use as a food or feed ingredient.

The regulatory control action extended from December 1970 until August 1971, when all samples submitted for testing prior to slaughter were found to be below the 5 parts per million guideline. To support this control activity and determine disposition of the fowl scheduled for slaughter the following samples were analyzed for PCBs: 1,566 dozen eggs, 198 feed, and 5,790 chicken samples. Most of the analytical work was done in the New York State chemical laboratory. On the results of these samples, 140,450 chickens were killed on the farm and buried, 75,740 chickens were passed for restricted slaughter, and 409,000 chickens were released for normal slaughter.

The alleged source of the PCBs in this incident is believed by State officials to be plastic bakery wrappers. Bakery goods were used as a feed ingredient for the poultry and the plastic wrappers which may have contained high PCB levels were ground with the bakery goods.

2. East Coast Terminal Incident (FDA Actions). The Monsanto Chemical Company informed FDA in July 1971 that large amounts of fish meal might have been contaminated with Aroclor 1242 leaking from a heating system during pasteurization of fish meal at East Coast Terminal, Wilmington, North Carolina. Aroclor 1242 was used as the heat exchange fluid. FDA inspection revealed PCB contamination of processed fish meal on hand at the firm. Investigation indicated the leak began in April 1971 and continued through July.

The fish meal on the premises was embargoed and the firm initiated a voluntary recall of fish meal processed since April 1971. An estimated 12,000 tons were distributed. Over 2,000 tons were recalled. Individual fish meal samples examined contained from 14 to 30 parts per million PCB.

FDA also initiated follow-up sampling of fish feeds, catfish from fish farms, and eggs when the contaminated fish meal was implicated. USDA was informed when investigation indicated eggs were being distributed to commercial egg breakers. As of September 1971, 224 samples of eggs had been analyzed with 71 containing residues in excess of 0.5 parts per million.

FDA seized 3 lots of eggs. The samples representing these lots contained from 0.7 to 1.9 parts per million PCB.

FDA seized 5 shipments of fish feeds that were manufactured from contaminated fish meal. These seizures were in the States of Louisiana, Georgia, and Mississippi, and were on feeds that contained from 0.6 to 4.5 parts per million PCB. In addition, a shipment of the contaminated fish meal from East Coast Terminal that had not been recalled was seized. The analysis of this seized product showed levels in excess of 350 parts per million PCB. Catfish sampled from commercial fish farms contained less than 3.0 parts per million PCB.

Arcolex 1362 Light yellow solidy 1.46 resin	Arcolex 1363 White to off-white powder	Arcolex 1365 Light-yellow, clear, brittle resin	Arcolex 1367 Yellow Trans- parent sticky resin	Arcolex 1368 Clear, yellow- to-amber, brittle resin	Arcolex 1369 Black, coarse brittle resin
20 Max. (APHA)	1.5 Max. SPA (molten)	2 Max. SPA (molten)	1 Max. SPA (molten)	2 Max. SPA (molten)	1 Max. SPA (molten)
0.024	0.05	0.05	0.05	0.05	0.05
200000 (25°-45°)	200000 (20°-100°)	200000 (25°-45°)	200000 (25°-45°)	200000 (25°-125°)	200000 (25°-125°)
1.872-1.883 (40°/25.5°) 13.72	1.804-1.811 (25°/25°) 15.36	1.807 (25°/25°) 13.91	1.807 (25°/25°) 13.91	1.807 (25°/25°) 13.91	1.807 (25°/25°) 13.91
100°-125°	100°-125°	100°-125° at 1 mm. Hg.	100°-125° at 1 mm. Hg.	100°-125° at 1 mm. Hg.	100°-125° at 1 mm. Hg.
0.5 to 1.5 0.5 to 1.5	0.5 to 1.5 0.5 to 1.5	0.5 to 1.5 0.5 to 1.5	0.5 to 1.5 0.5 to 1.5	0.5 to 1.5 0.5 to 1.5 (at 25°-45° Hg.)	0.5 to 1.5 0.5 to 1.5
None	None	None	None	None	None
None	None	None	None	None	None
10°-15° 40°	10°-15° 40°	10°-15° 40°	10°-15° 40°	10°-15° 40°	10°-15° 40°
-	100° to 125° (solid st.) 100° to 125° (solid st.)	100° to 125° 100° to 125°	100° to 125° 100° to 125°	100° to 125° 100° to 125°	100° to 125° 100° to 125°
1.460-1.467	1.460-1.467	1.460-1.467	1.460-1.467	1.460-1.467	1.460-1.467
40-100	40-100	40-100 (25°-45° or 125°)	40-100	40-100	40-100
100-150 100-150 or 125°	100-150 100-150 or 125°	100-150 100-150 or 125°	100-150 100-150 or 125°	100-150 100-150 or 125°	100-150 100-150 or 125°
11.3100	11.3100	11.3100	11.3100	11.3100	11.3100
W1100	W1100	W1100	W1100	W1100	W1100
W1100	W1100	W1100	W1100	W1100	W1100

Based on available monitoring data and reports, one route of human exposure to PCBs currently in the environment is through food. The PCB contribution made by other routes of exposure has not been sufficiently measured.

The FDA has issued a proposal which will prohibit the use of PCBs in and around food processing plants and will establish limitations on the use of salvaged paper containing industrial chemicals for food packaging. These proposed actions should prevent occurrences such as the Wilmington incident and the problem of PCBs in food packaging materials. However, there will still be problems, as evidenced by the Coho Salmon contamination, the mysterious Minnesota turkeys, and the discovery of high levels of PCBs in cardboard food containers. The solution to these problems seems to lie in a better understanding of the path which PCBs follow through the environment and on full use of existing regulatory authorities. Even with better understanding we can probably expect future isolated incidents of PCB contamination.

Existing regulatory authority is generally inadequate to prevent more PCBs from entering the environment. The Monsanto Company has reported voluntarily limiting the distribution of PCBs to "closed systems" but this limit has no force of law behind it. The government has no power to restrict imports of PCBs by foreign manufacturers, and if it disagreed with Monsanto's judgment on allowable uses it could not impose more stringent limitations on Monsanto or on any other potential manufacturer.

This regulatory gap would be filled by the Administration's proposed Toxic Substances Control Act. The proposed Act, sent to the Congress in February 1971, would authorize the Administrator of EPA to restrict or prohibit the use or distribution of a chemical substance if such restriction were necessary to protect health and the environment, and it would also authorize him to issue standards for tests to be performed and for results to be achieved from such tests for various classes and uses of new substances. Thus, in addition to providing the regulatory authority needed to deal with the PCB problem, it would also establish a system for preventing new chemicals from becoming similar problems. Action by the Congress to approve the Toxic Substances Control Act is the most important step which can be taken to deal with PCBs and similar problems.

materials be established permitting unavoidable PCB residues in such materials for a period of one year. This will provide an opportunity for the orderly elimination of PCB-containing raw materials used in the manufacture of food packaging materials.

EPA recently has proposed regulations which would prohibit all intentional discharges of PCB into the water, and would limit PCB levels in the water to .01 parts per billion. These regulations probably would be enforced through use of the Refuse Act.

III. APPLICATION OF REGULATORY AUTHORITIES

Within the past two years there have been several incidents involving PCB contamination. These include the following:

In September 1969 FDA detected PCBs in West Virginia milk. The source of PCBs was suspected to be the use of spent transformer fluid as a solvent for herbicide spray. Grade A milk shippers involved were taken off production by the State.

In April 1970 FDA identified the presence of PCB residues in milk sampled by the Ohio State Department of Agriculture. The Department removed a large quantity of milk from the market. The chemical was traced to a material used as a sealant in the silos where dairy feed was stored. Similar occurrences of PCB contamination of dairy herds have been reported in several Southeastern States.

Since June 1971, the Meat and Poultry Inspection Program (MPIP) and the Poultry Division, Consumer and Marketing Service, USDA, have been surveying specifically for PCBs. Prior to that time, the MPIP's ongoing survey of chlorinated hydrocarbons should have detected any PCBs present in animal or poultry fat at a level of 1 parts per million or above. None was detected in the fat of poultry, swine, cattle, or sheep prior to December 1970. Since that time, there have been five separate incidents of contamination of poultry with PCBs. Each appears to be a single-source, one-time occurrence. The Poultry Division's egg sampling program in the Southeastern U.S. and in Minnesota has not detected levels of PCBs which are significant--most values falling below the sensitivity of the method.

Contamination of hens slaughtered on December 2, 1970, led to placing all laying hens in Orange, Sullivan, and Ulster Counties, New York, under quarantine through August 30, 1971, requiring pretesting for PCBs prior to slaughter. Levels up to 26.8 parts per million PCBs were found in the fat. Approximately 137,100 hens were condemned and buried on the farms. Flocks containing less than 5 parts per million PCBs were sold in commercial channels, frequently at drastically reduced prices. Eggs from contaminated flocks were destroyed. The source of contamination was feed containing returned bakery product wrappings.

Frozen turkeys produced on farms from Modesto, Fresno, Stockton, and Santa Rosa, California, were found to contain up to 28 parts per million of PCBs in the fat. The source of contamination is unknown. All turkeys

II. STANDARDS, TOLERANCES, OR GUIDELINES ESTABLISHED

The most important limits which have been established for PCBs have been those established by FDA to deal with particular instances of food or feed contamination.

Standards or, more accurately, tolerances for products such as for PCBs may be established under Section 406 or Section 409 of the Food, Drug, and Cosmetic Act, which require a finding that the substance is required in the production of the food or cannot be avoided by good manufacturing practices or a showing of safety and a need for use. No permanent tolerances for PCBs have been established, since all the safety data necessary and the need for use to support such tolerances are not available at this time. In the absence of tolerances, the Food and Drug Administration, in order to respond to accidental contamination, has set interim guidelines for levels of PCB in some foods at which it will take action under the Food, Drug, and Cosmetic Act. It is now proposing to establish temporary tolerances for permitting unavoidable PCBs in several categories of food.

FDA has taken action to remove from the market shell eggs containing more than 0.05 parts per million PCBs and feeds containing more than 0.5 parts per million PCB where the PCBs present appears to be from accidental contamination of feed. The U.S. Department of Agriculture has also taken action to remove poultry from the market containing 5.0 parts per million PCBs where such contamination was the result of accidental contamination of feed fed to poultry. The action level of 5 parts per million (whole tissue basis) was established in 1971 by FDA. This level was reduced to 5 parts per million on a fat basis in 1972.

The Food and Drug Administration has taken no action against any other products for PCB contamination but has informed the States and others that it would consider action on milk if PCBs exceed 0.2 parts per million (whole basis) and on fish if PCBs exceeds 5 parts per million. Some States have taken action to remove milk from the market that contained more than 0.2 parts per million PCBs.

The temporary tolerances recently proposed by FDA are listed in Table 1.

The guidelines and the temporary tolerances taken into account available toxicological data, the estimated amount and type of intake of PCB from food, and also the sensitivity of the methods used for detecting PCB. Thus more PCB is allowed in poultry than in eggs because children are fed egg yolk, and children are not considered to have as efficient detoxication mechanism for handling PCBs as adults. It should be noted that these limits were established to deal with particular incidents, and thus may be changed as new knowledge develops or as circumstances change.

Some food has been discovered to be contaminated because of migration from food packaging materials containing PCBs. Thus FDA also has proposed that a temporary tolerance of 5 parts per million in paper packaging

shipped in interstate commerce must be registered with the EPA. EPA can refuse to register a product if it will cause injury to man or the environment if used according to the label. The registration of a product can be suspended or cancelled if it is found to no longer meet the criteria for registration.

On October 29, 1970, the Pesticides Regulation Division (then in the Department of Agriculture; now in EPA) issued a notice (PR Notice 70-25) to all pesticide manufacturers, formulators, and distributors. The notice stated that, "Formulators and manufacturers of economic poisons containing polychlorinated biphenyls and polychlorinated terphenyls should change their formulations to eliminate such chemicals either as active or inactive ingredients. It is believed that a period of six months is a reasonable period of time within which to affect such formula changes." Assuming that the notice has been complied with, there should be no pesticides which currently contain PCBs.

B. FEDERAL WATER POLLUTION CONTROL ACT (33 U.S.C. 466 et seq.)

The Federal Water Pollution Control Act (FWPC Act) authorizes the Administrator of EPA to enforce State water quality standards established by the States and approved by the Federal Government if the State is not adequately enforcing the standards. No States have established water quality standards relating specifically to PCBs. Thus the water quality standards part of the FWPC Act is not a useful tool for dealing with the PCB problem.

Section 12 of the FWPC Act applies primarily to accidental discharges of hazardous polluting substances. It requires the immediate reporting to EPA or the Coast Guard of any discharge of a hazardous substance from a vessel or an onshore or off-shore facility. The discharger is responsible for making the report and for clean-up, but EPA is authorized to remove or arrange for the removal of the hazardous substance if the discharger is unable or unwilling to do so. PCBs are being designated as hazardous substances under section 12, and the authority contained in the section could be used if an accidental spill of PCBs into water should occur.

C. THE REFUSE ACT OF 1899 (33 U.S.C. 407)

Another legal authority for controlling water pollution is section 13 of the 1899 Refuse Act which forbids discharge of any wastes (other than municipal wastes) into navigable waters without a permit, issued by the Army Corps of Engineers, which can limit the discharge of substances into water. EPA and the Justice Department are prepared to use the Refuse Act to prevent PCB discharges.

D. THE CLEAN AIR ACT (42 U.S.C. 1857 et. seq.)

The general authorities contained in the Clean Air Act are not, for the most part, applicable to PCBs because PCBs are not generally emitted into the air in the normal operations of a municipal or industrial facility. PCBs may become air contaminants through the burning of refuse, but such emissions usually could be controlled only by preventing the substance from initially getting into the refuse.

II. Problems in Analytical Chemistry - Comparison of Methods

II. 1 Separation

One of the primary and early problems in the identification of the polychlorinated biphenyls (PCBs) was that of possible interference in the GLC determination of organochlorine pesticides, where the PCB occurred along with the pesticide residue. During 1969 and 1970, various investigators worked on methods for separating PCB from pesticides (7-14). An excellent treatment of the subject of PCB as a contaminant in the environment, as related to its detection in the presence of other compounds, is covered by Jensen (15).

Jensen (15), in his review, has shown that some of the earlier studies of DDT and DDE in human fat by GLC must have been inordinately high. He first identified some GLC peaks in wildlife in 1964-66 that were not reconcilable but later identified chromatograph peaks from human fat that were not attributable to DDT or metabolites of DDT, which were more nearly comparable to peaks ascribed to PCB. The possibility that these peaks could be attributed to naturally occurring constituents in fish eaten by man was discarded when it was suggested that these same peaks could come from environmental pollutants.

To further establish the then uncertain composition of the chemicals causing the false DDT peaks, Jensen (15) separated out one of the chemicals by GLC and subjected this fraction to mass spectrometry. The mass spectrometry data showed compounds with molecular weights of 324, 358, 392, and 426. The molecular weight differences or differences of 34 mass units suggested one less chlorine atom per position on a carbon atom. In essence, through calculation, he deduced that these unknown chemicals could only be polychlorinated hydrocarbons, in this case having 5, 6, 7, and 8 chlorine atoms in the molecule. He verified his conclusion by introducing a synthetic or known PCB into the mass spectrometer. He also found that PCB standard chromatogram matched those with the same retention times as observed in various samples he analyzed, i. e., eagles, fish, or other wildlife.

It is interesting to point out that failure to recognize such interferences led to spurious results and data and obviously led to the overestimation of DDT in our environment, in man, in wildlife, and aquatic organisms. Jensen (15) referred to PCB as a new pollutant, but, as stated earlier, PCB was with us in the environment since 1930 and thus it would be an old pollutant only recently correctly identified by appropriate analytical chemistry.

In earlier work in the identification of some organochlorine pesticides such as p,p'-DDT; o,p-TDE (DDD), lindane, dieldrin, aldrin, heptachlor, and lindane, some unidentified spots and peaks in TLC and GLC interfered with the detection of these pesticidal chemicals. Jensen (15) in his work extracted the compounds from biological samples and, by appropriate cleanup of some contaminants, identified the pesticides and PCBs by thin layer and gas liquid chromatography followed by mass spectrometry. In 1964, Jensen used TLC to separate the fat soluble chlorinated hydrocarbons from the rest of the sample.

Some biological samples require more extensive pretreatment than for water or effluents from industrial plants. The measurement of PCB concentration of effluents is a simple procedure involving chromatogram of sample and then chromatograms of standard samples developed from known PCBs. For more accurate analysis, calibration graphs can be developed from known specific peaks in the standard samples (15).

In the following charts (Figures 1-6) some chromatograms of the various representative chlorobiphenyl Aroclors are presented according to Armour (18).

Some additional points might be made relevant to separation and quantitation of PCBs. First of all, in separation, the methods used prior to quantitation of residues in samples containing PCBs and chlorinated hydrocarbons fall essentially into two categories: (a) those which necessitate destruction or alteration of one or more of the compounds and (b) those which do not. Peakall and Lincer (19) have described in detail the procedures used for separation.

o Briefly, the first group requires nitration ($\text{HNO}_3 + \text{H}_2\text{SO}_4$) treatment at 0 C for 5 minutes, which destroys or alters many of the organochlorine pesticides; thus PCB is left unaffected along with lindane and EHC. Some workers such as Armour and Burke (1) reported that complex chromatograms resulted after nitration, which could not be related to the unreacted DDT-PCB mixture. Thus, nitration was not pursued as a practical means of separating DDT and PCB for further analyses.

Saponification with alcoholic NaOH or KOH will dehydrochlorinate some pesticides such as Perthane, Toxaphene, DDD and DDT to their respective olefinic compounds (20).

Perhaps the more desirable technique allows for special separation of many chlorinated hydrocarbon pesticides from PCB. This involves using various columns and solvents. Another procedure is to use a series of differing polarity columns in the gas chromatograph at the time of determination (21).

II.2 Quantitation

Koeman, et al (2) measured residues in Japanese quail by using one of the peaks in a phenachlor DP6 mixture as standard. Risebrough (22) quantitated relative levels of PCBs by assuming that each PCB compound produced the same peak height with the electron capture detector as the same amount of weight by p,p'-DDE. After adding the heights of the individual peaks, the total was multiplied by a factor derived from measurements of standard solutions with EC and MC detectors. Jensen and co-workers (23) reported concentrations of PCB as the sum of all PCB components and based the estimation on several detection systems such as mass spectrometry and EC and MC detectors. In spite of all these techniques, these investigators consider the method approximate and correct only within a factor of 2.

There are other modifications of techniques, but with all the quantitation methodology available, relative estimates of concentrations of PCB are