

Occurrence and Methods of Control of Chemical Contaminants in Foods

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Contamination of food by chemicals can result from their use on agricultural commodities; accidents or misuse during food handling and processing; nuclear weapon testing and operation of nuclear power plants; and disposal of industrial chemicals or by-products with subsequent dispersal into the environment. The Food and Drug Administration (FDA), as the Federal agency mainly responsible for evaluating the hazards of chemical contaminants and enforcing any established tolerance levels for them in foods, has been monitoring pesticides, industrial chemicals, metals, and radionuclides in foods in its nationwide programs for many years. In addition, FDA searches for potential contaminants among the approximately 50,000 industrial chemicals manufactured in the United States and coordinates its efforts with those of other Federal and state agencies in these investigations. The overall results of the FDA surveillance and compliance programs for chemical contaminants in foods, as well as specific examples illustrating the wide range of incidents and types of occurrences, are presented.

Introduction

Incidents that release chemicals into the environment often occur as a result of human activities. Such chemicals, which include pesticides, other industrial chemical contaminants, metals, and radionuclides, can also enter food by accident or misuse during food handling or processing. The Food and Drug Administration (FDA) programs for monitoring and controlling levels of contaminants in foods, the results the agency has obtained, and the steps being taken to improve these monitoring programs are presented.

The overall planning, coordinating, and evaluating required to make these programs productive is carried out at the Bureau of Foods. The samples are collected and analyzed in most cases, however, by 16 of the 21 FDA Districts in various Regions throughout the United States. These Districts have laboratories equipped for carrying out chemical analyses; this arrangement provides considerable flexibility in dealing with local problems when they arise.

The purpose of the monitoring activities can vary, depending on the nature of the contaminant involved and FDA's knowledge of the extent of its occurrence in the food supply. Consequently, some continuing field programs such as the Total Diet Studies, the Heavy Metals Program, and the Radionuclides Program are primarily surveillance-oriented, whereas FDA field programs for pesticides and polychlorinated biphenyls (PCBs) in agricultural products and for pesticides, PCBs, and metals in fish are compliance-oriented. These latter programs are carried out primarily to determine whether the contaminants in question are present in excessive levels in foods and to remove the foods from the market if they contain violative levels. The programs dealing with special contaminants, however, are exploratory in nature and, depending on the particular situation, may involve either surveillance or compliance.

Pesticides

Residues of pesticides occur in foods or animal feed as a result of their use (either permitted or unauthorized) on the commodities concerned and through their entry into the general environment.

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occurrence in foods, the Environmental Protection Agency (EPA) permits the commercial use of a pesticide only after the petitioner has submitted sufficient information to demonstrate that the pesticide can be used safely and efficaciously on the crops concerned. EPA issues regulations concerning labeling, use on specified crops, and levels or tolerances that will be allowed.

Surveillance for pesticides on various commodities is carried out by the states on products moving in intrastate commerce and by FDA and the United States Department of Agriculture (USDA) on those moving in interstate commerce. Finally, EPA can and does change the registration of a pesticide to reduce or prohibit its use if new information indicates this is necessary.

There are about 280 pesticides registered by EPA for current use on food or animal feed commodities. Although monitoring for these pesticides is complicated by the number of different crops on which each may be used, the acreage involved in food and feed production, and the sophistication of many of the residue analytical methods required, FDA has, nonetheless, carried out nationwide programs for many years.

At present, FDA collects and analyzes about 8500 samples of various domestic and imported agricultural commodities for pesticides and PCBs; determines pesticides, PCBs, mercury, and other contaminants in about 1200 samples of domestic and imported fish; and also examines about 750 samples of animal feeds. Other government agencies (Federal and state) also monitor various foods for chemical residues.

As might be expected, the occurrence of the organochlorine pesticides has decreased significantly, as a result of the complete or partial bans on their use on crops. This downtrend, however, is not so noticeable in fish, milk, and eggs because of the stability of these pesticides in the environment and their propensity to bioaccumulate in fatty tissues. The overall level and rate of occurrence of the organophosphorus pesticides has increased to some extent, but not so much as might be expected from their greatly increased usage. This difference reflects their relative instability in the environment. The rate of overtolerance findings for domestic commodities in these programs is about 3%; that for imports is slightly higher.

Since it is much more efficient to determine a group of chemicals in one analysis, rather than one at a time, FDA relies mainly on the use of multiresidue methods and can determine about 230 pesticides and their alteration products by these means.

several changes to make these field programs even more effective. Each pesticide is presently being evaluated to determine the relative hazard it may present as a food contaminant. Such factors as production volume, crop usage, environmental stability, and toxicity are used in this assessment. For those pesticides having higher hazard classifications, monitoring will be carried out on crops on which they are used. This evaluation will also be valuable in guiding analytical methods research for pesticides, including those not amenable to analysis by multiresidue methods.

Until recently, FDA's Pesticide Program was planned and directed in detail from headquarters in Washington. In order to provide more flexibility, each District now plans its own monitoring program for chemical contaminants in agricultural products and fish, with general guidance from headquarters, and also develops information on pesticide usage and on disposal of industrial chemicals in its own area. More resources have been made available to each District to carry out these activities. General crop and usage information will still be developed and be made available to the field, and results from the field will be followed on a continuing basis by headquarters so that significant information can be exchanged between Districts.

Industrial Chemicals

In the late 1960s, it became evident that industrial chemicals can contaminate foods, even though they are not intentionally used on agricultural products or in processed foods. Contamination by industrial chemicals may be due to various causes, the chief of which are: their use as components in food processing equipment, cross-contamination of food and nonfood formulations, use as components in chemical processes or equipment, disposal of unwanted by-products, and ultimate dispersal into the environment.

Contamination by Components of Food Processing Equipment

A prime example of widespread food contamination by a component of food processing equipment was the leakage of a PCB-containing heat exchange fluid in 1972 into fish meal which was being pasteurized in a North Carolina plant. This meal was incorporated into poultry feed and resulted in the contamination of poultry and eggs. As a consequence of this and similar instances, FDA established regulations in 1973 which prohibit the use of

food, feeds, and food packaging materials (1). Since then, some leaks of PCB fluids have occurred from "sealed" electrical equipment such as transformers and capacitors. A leaking transformer in a Montana packing plant in 1979 led to the widespread PCB contamination of animal feed, poultry, hogs, eggs, and foods containing the latter (2). As a result FDA, EPA, and USDA have proposed regulations which would ban PCB-containing transformers and capacitors in food, feed, food packaging material, and agricultural chemical plants (2). In the meantime, all three agencies have sent a technical brochure (3) to all establishments under their jurisdictions describing what can be done on a voluntary basis to prevent such incidents.

Cross-Contamination of Food and Nonfood Formulations

Sometimes industrial chemicals enter the food supply by a mistaken use of a product in a formulation. The accidental substitution of a polybrominated biphenyl (PBB), a flame retardant, for magnesium oxide in an animal feed product in 1974 (4) is a good example. Foods such as milk and meat were extensively contaminated. After an incident of this type, FDA uses as much of its resources as possible to aid the state affected and to prevent contaminated foods from entering widespread interstate commerce. In the PBB incident, FDA's Detroit District maintained constant contact with the State of Michigan and provided extensive assistance, especially laboratory support. In addition, FDA carried out a special nationwide survey for PBBs in products such as milk and eggs (5, 6). The results showed that the contamination of food did not extend to other states to any significant degree.

Component of Chemical Processing Equipment

An example of the contamination of food by a component of chemical processing equipment was the extensive contamination of fish by the mercury used in the electrolytic cell for production of chlorine and sodium hydroxide (7). After it was discovered in 1969 that mercury entering the waterways could be converted to methylmercury by bacteria in sediments and could accumulate in fish (8), strict effluent guidelines for mercury were established. As a result, the amount of mercury introduced into water from those plants was reduced from about 1,200,000 lb to less than 20,000 lb per year by 1973. This in turn has led to a decrease in mercury levels

FDA has enforced its action level for mercury in fish.

Disposal of Unwanted By-Products

Contamination of the food supply by an unwanted by-product occurred several years ago when the still-bottoms from a perchloroethylene plant were routinely disposed of while hot (5). This material contained various by-products including hexachlorobenzene (HCB), which subsequently escaped into the atmosphere and settled on crops and forage. Thousands of cattle feeding nearby became contaminated with HCB. Subsequently, the company effected better control of its effluents, and there have been no more known instances of HCB contamination of food animals near this plant. Another producer has installed well-designed incinerators to burn the tar; this method is probably the best way to dispose of such by-product materials.

The common presence of the DDT family and of PCBs in fish is a graphic illustration of the escape of these products into the aqueous environment at various steps of their processing, use, and disposal.

PCBs

For years FDA has been monitoring agricultural products and fish for PCBs in its field programs. The multiresidue analytical method employed for organochlorine pesticides also determines PCBs. Generally, PCBs have been found only in animal-derived products—fish, milk, eggs, cheese—and also in animal feed components such as fish meal or other animal-derived products.

PCBs still continue to be found in animal feeds and their components, but to a lesser degree than in fish. The occurrence in feeds is generally not reflected in milk, eggs, cheese, or meat, where findings each year vary from zero to several percent of the samples examined. Minor increases in findings in certain years usually reflect isolated incidents of PCB contamination. Such incidents can be expected to continue, and FDA undoubtedly will need to monitor for PCBs on a nationwide basis for many years.

The PCB findings in individual foods are confirmed by the results obtained in FDA's Total Diet Studies (9). The Composition of the Total Diet is based on the USDA survey of 1966, and is typical of the intake of the teenage male, the heartiest eater in the United States. (A new Total Diet, reflecting more recent surveys, is now being developed.) The foods in the market baskets are made table-ready and combined into composites of 12 food categories for subsequent analysis.

Food class composites

Fiscal year	Dairy products	Meat, fish, poultry	Grains, cereals	Potatoes	Legume vevs	Root vevs	Garden fruits	Oils, fats, shortening	Sugar and adjuncts
1972	6	46	6	—	6	3	3	17	6
1973	10	33	17	3	—	—	—	3	—
1974	—	43	—	—	—	—	—	—	3
1975	—	40	—	—	—	—	—	—	—
1976	5	5	—	—	—	—	—	—	—
1977	—	35	5	—	—	—	—	20	—
1978	—	30	—	—	10	—	—	5	—
1979	5	10	—	—	—	—	—	5	—

In FDA's Total Diet Studies, PCBs have been found consistently in only the meat, fish, and poultry composite (Table 1). In most cases, the source is the fish in this composite. Significantly, PCBs have been much less prevalent in the diet since 1973, when FDA promulgated tolerances for PCBs in various foods, prohibited their use in most industrial fluids in food and feed plants, and established an action level in paper food packaging materials (1). Some of these tolerance levels were subsequently lowered in 1979, when new information indicated PCBs are more toxic and that they are more persistent in the environment than had previously been thought (10).

Metals

FDA has accorded highest priority to mercury, lead, cadmium, arsenic, selenium, and zinc in its investigations of contamination of foods by toxic elements (11). All of these elements occur in the earth's crust and, therefore, are present naturally in all foods to some extent. In addition, they have a variety of uses. It is important that their disposal does not lead to a substantial increase in their levels in the aquatic environment or in the soil.

Because of their toxic behaviors and their levels in foods, FDA has concentrated most of its attention on mercury, lead, and cadmium and, since 1972, has devoted more of its resources to lead and cadmium than to the other metals.

Infants are particularly susceptible to the hazards of lead contamination (12) for a variety of reasons: (1) toxic effects occur at lower threshold levels in children; (2) they absorb a higher proportion of the lead ingested than do adults; (3) they ingest more food per pound of body weight; (4) their central nervous systems are more sensitive to lead than those of adults; and (5) infants and children frequently ingest high levels of lead from nonfood

sources such old paint, dirt, or house dust. For cadmium, damage to the kidneys in middle age after cumulative ingestion of low concentrations of this metal is the first effect to be noted from the low level intake of this metal (13).

In the early 1970s, FDA carried out extensive surveys on individual foods and on composites in the Total Diet Studies to relate levels of lead and cadmium found in food to daily intakes. The average daily intakes can be calculated from the Total Diet Studies because both the level of lead and cadmium in each composite and the average amount of each composite consumed per day are known. The daily intakes can also be estimated if the levels of the metals in enough foods of dietary importance have been measured because the average amount consumed per day of each food item will be known. The intake estimated by the latter approach is always higher (and probably more accurate) than that calculated from the Total Diet Studies because food items which do not contain measurable amounts of a contaminant may have a diluting effect and prevent its detection in the same Total Diet Study composite.

For a teenage male, we have estimated the average lead intake derived from the individual foods to be about 220 µg/day, compared with the tolerable daily intake of about 430 µg/day (13), proposed by the Food and Agriculture Organization/World Health Organization (FAO/WHO). For cadmium, however, the estimated dietary intake of 57 µg/day (14) approximates the suggested FAO/WHO tolerable intake of 57-71 µg/day (13).

One controllable source of lead in the food supply is the lead-containing solder in tin cans. In 1972, FDA encouraged the can-making and the canned food industries to reduce the lead levels in their products. Since then, FDA has followed their programs to decrease lead in foods, especially for infants (15). From FDA and industry data, it was estimated that the daily dietary intake for lead in

1-year age group (16). In comparison, it has been recommended that for infants under 6 months of age and for children in the 6-month to 2-year age group, total lead intake from all sources should not exceed 100 and 150 $\mu\text{g}/\text{day}$, respectively (17).

The average lead levels in various infant foods are now only 10-20% of those originally found several years ago (Table 2). Industry has achieved this significant improvement by a variety of means, including better control of raw products, technical improvements in can-making and canning, and changing from lead-soldered cans to other containers. Another factor contributing to this accomplishment was the fact that FDA informed industry of its concern, convinced them of the need to improve, and stayed in close touch with them while their programs were implemented.

In July, 1979, FDA published a Notice of Intent (15) in which the achievement of a 50% reduction in the amount of lead contributed to food by lead-soldered cans was stated as a goal to be attained within 5 years, and certain information and data were requested to guide subsequent Agency actions. The Notice of Intent stated that, after the receipt and evaluation of this information, action levels for lead in infant juices, glass-packed infant foods, infant formula, and evaporated milk would be set by FDA, followed by action levels for lead in "adult foods" eaten by the young.

With respect to cadmium, the data developed by FDA do not indicate that the handling, processing, and shipping of food cause a noticeable increase in cadmium content in foods (14). FDA estimates for cadmium intake do suggest, however, that no new practice leading to a significant increase in cadmium in the diet should be instituted. The increased application of municipal sewage sludge to crop land several years ago with little or no control is an example of such an action (18). The appropriate utilization of municipal sludge on lands (19) with

ports of F. A., EPA, and A. EPA's latest criteria for the application of solid waste to land will unquestionably reinforce other efforts being made to reach this goal.

Radionuclides

The presence of radionuclides in foods may result from natural occurrence (such as potassium-40), atmospheric testing of nuclear weapons, operations of nuclear power plants, and accidents.

FDA's monitoring program for radionuclides consists of three main segments: radionuclides in imported foods, the Total Diet, and foods collected near nuclear plants (20).

FDA has monitored imports of various foods for strontium-90, iodine-131, ruthenium-106, cesium-137, and potassium-40. The first four are representative of fallout products, and potassium-40 is a naturally occurring radionuclide. Strontium-90 is the only man-made nuclide found regularly in all imported food types, but at levels too low to present a hazard to the consumer. Cesium-137 is found less regularly, and iodine-131 and ruthenium-106 have almost never been found in any samples analyzed by FDA.

Only strontium-90 (and, of course, potassium-40) are detected with any consistency in the Total Diet samples. The average daily intake calculated from these findings is around 11 picocuries/day of strontium-90, well below any level of concern. No particular trend has been noted in the levels of strontium-90 intake in the Total Diet samples since this program was instituted in 1973.

In the FDA studies of foods grown near nuclear plants, samples of milk, fish, vegetables, fruits, and grains harvested near eight nuclear plants are regularly examined. Four different plants per year are now substituted for a like number on the list. Originally, tritium was the only radionuclide measured, and an increase in tritium levels is an indication of reactor leakage. More recently, scanning for beta- and gamma-emitters was added to detect radioactive corrosion products and fallout products that would result from an incident or from faulty operations.

The levels of tritium found in the food samples have been extremely low—almost down to the limit of detection. No upward trends have been noted since this part of the program was instituted in 1975. Generally, no findings have resulted from the beta- and gamma scans of these food products.

Surveillance of foods collected near nuclear plants was of special significance during the Three Mile Island accident, which occurred in 1979. FDA was

Table 2. Decrease in lead levels in foods for infants.

Type of food	Average lead levels, ppm	
	Start of program	Current
Glass-packed	0.15	0.25
Infant juices	0.30 ^a	0.15 ^b
Infant formula ^c	0.10 ^a	0.015 ^d
Evaporated milk	0.52 ^a	0.09 ^a

^aLead-soldered cans.

^bGlass-packed.

^cReady-to-feed basis.

^dSome changes from lead-soldered cans.

contamination of food by radionuclides because broad monitoring programs were already in operation. The FDA regular program called for the monitoring of foods produced near the Peach Bottom, Pennsylvania plant, 40 miles below Three Mile Island, and, as part of the Total Diet Studies for fiscal year 1979 (21), a market basket was due to be collected at Harrisburg shortly before the incident happened. Elevated radionuclide levels were not found in either group of food samples.

Additionally, FDA collected and analyzed many samples of food, primarily milk and water, from the Three Mile Island area during and after this incident. Generally, the radionuclide levels were no higher than those observed previously in the regularly screened samples.

The background information collected in the FDA surveillance program is similarly used to assess radionuclide contamination of food caused by atmospheric testing of nuclear weapons, such as the Chinese bomb blast which produced fallout over the Northeast several years ago.

FDA has also analyzed food samples from a phosphate mine tailings area of Florida for radium-226 (21). Levels in certain locally grown foods such as citrus fruits are slightly higher there than those found in fruit grown elsewhere; however, there appears to be no potential danger to the consumer. FDA is still conducting some surveillance on food grown in the area to identify any uptrends in radionuclide levels.

Although the FDA surveillance program for radionuclides has never found levels believed to be truly hazardous in any of the monitored food samples, FDA plans to conduct these broad monitoring programs on a continuing basis so as to detect and evaluate both gradual uptrends and sharp increases in radionuclide levels.

Suspected Industrial Chemical Contaminants

It was discovered in 1969 and the years immediately following, as described earlier in this report, that industrial chemicals, such as PCBs, can contaminate food.

In 1971 FDA launched a formal, continuing program to search for as-yet-unrecognized industrial chemical contaminants in foods. The chief objectives of this program were: to anticipate and search for these potential contaminants; to evaluate their hazards if found in foods; and to take actions to eliminate or minimize the problem (22).

According to information developed by EPA's

ensuring industrial chemicals, each containing impurities and by-products, are manufactured in the United States. It is possible, therefore, to investigate only a very small fraction of these chemicals or chemical families.

The criteria used by FDA since 1972 for selection of potential industrial chemical food contaminants are: production volume (the greater the amount of a product produced and used, the more likely it is to contaminate foods); toxic by-products; toxicity; environmental stability; solubility behavior or partition coefficient (a fat-soluble, water-insoluble material is more likely to concentrate in the fatty portion of fish, meat, milk, and eggs); end-use pattern (the less confined the uses of a product, the more likely it is to cause environmental and contamination problems); and means of disposal. These criteria are not listed in any order of priority and are similar to the factors now used by other workers in the environmental field including FDA's appraisal of pesticides as potential food contaminants. FDA assesses information from all sources—industry, government agencies, universities, and the literature—in making these selections. Among the chief agencies with which FDA exchanges industrial chemical information are EPA and USDA.

Classes of materials that have been evaluated for investigation include flame retardants, plasticizers, electrical fluids, halogenated solvents, various chemical intermediates, functional fluids, lubricating oil additives, replacements for PCBs, and chemicals present in sludges or wastewater.

Investigation of an industrial chemical involves several steps (23). First, a satisfactory analytical approach to detect and measure low levels of the compound in the presence of many other chemicals in food such as fish has to be developed. FDA has established a collection of over 600 different industrial chemicals for use as reference materials by FDA district laboratories, other Federal and state agencies, and selected researchers.

Next, information about location of manufacture and quantity of production is needed to obtain food samples from specified locations, often with the active assistance of individual states. If the suspected contaminants are found, the appropriate state or Federal agencies are notified. FDA's monitoring activities may be expanded, up to and including nationwide surveys of various foods by the field laboratories. On the basis of these results, FDA toxicologists may then judge whether the levels of contaminant in foods constitute a hazard to the consuming public.

Many of the less commonly encountered industrial chemical contaminants have been detected in

Table 3. The freshwater fish has been a prime indicator food, because most contaminants eventually enter the waterways. Since almost all of the contaminated food samples were fish from inland waters near manufacturer or user sites, the results do not necessarily reflect general public exposure but may indicate that some chemicals are in the effluents from nearby plants or are leaching from treatment operations or disposal sites.

Some of the main chemical families found as contaminants in these investigations are: chlorinated aromatics, chlorinated aliphatics and cyclic aliphatics, brominated aromatics, phosphate esters, and aromatic amines.

Chlorinated Benzenes

Residues of these compounds have been found in fish from many different geographic locations and are apparently ubiquitous. Levels up to about 7 ppm have been found in the edible portion.

Table 3. Industrial chemicals found in foods: FDA exploratory program.

Type	Principal areas
Chlorinated benzenes	Many lakes and rivers
Chlorinated toluenes	Niagara River, N. Y. Bald Eagle Creek, Pennsylvania Raritan River, N. J. Newark Bay, N. J.
Chlorinated benzotrifluorides	Niagara River, N. Y. Raritan River, N. J. Newark Bay, N. J.
Other chlorinated aromatics	
Nitrobenzenes	Mississippi River; Delaware River
Anilines, phenylmethyl sulfides	Mississippi River
Styrenes	Lake Ontario, N. Y. White Lake, Michigan
Phenols and anisoles	Many lakes and rivers
Chlorinated cyclics	
Norbornenes	Mississippi River; Wolf Lake, Illinois
Cyclopentenes	White Lake, Michigan
Chlorinated aliphatics	
Butadienes	Mississippi River; Ohio River; White Lake, Michigan
Haloforns, ethylenes, and ethanes	Many lakes and rivers
Brominated aromatics	Pine River, Michigan; Ohio River, Ohio Ohio River, West Virginia Mississippi River, Iowa Buffalo River, N. Y. Delaware River, Delaware
Aromatic amines	
Aryl phosphates	Many lakes and rivers

Benzotrifluorides

These chemical intermediates have been found mainly in fish from the lower Niagara River, New York, in levels up to about 1 ppm in the edible portion (24).

Other Chlorinated Aromatics

Pentachloroaniline and pentachlorophenyl methyl sulfide are associated with the pesticide, pentachloronitrobenzene (PCNB). Pentachloroanisole is derived from the pesticide, pentachlorophenol, and is frequently found as a residue in fish in many areas.

Chlorinated Cycloaliphatics

The chlorinated norbornene derivatives are precursors of the pesticide endrin and have been found in Mississippi River fish below a manufacturing plant in Memphis, Tennessee, in levels up to about 16 ppm in the edible portion (25). The chlorocyclopentenes were found in fish near a plant manufacturing hexachlorocyclopentadiene (HCP) near White Lake, Michigan, and are probably by-products.

Chlorinated Aliphatics

The chlorinated butadienes are by-products of chlorinated hydrocarbon manufacture. FDA has found hexachlorobutadiene (HCB) frequently as a contaminant of fish, but not to any extent in other foods (26). The findings have varied from about 0.03 ppm to 4.6 ppm in the edible portion.

Brominated Aromatics

In addition to the PBBs, low levels of several bromobenzenes have been detected in fish collected near a bromocarbon producer in Michigan and in other waterways.

Phosphate Esters

FDA interest in these orthophosphate esters results from the fact that they have replaced PCBs in some flame retardant, plasticizer, and functional fluid applications. Aryl phosphate residues have been found in fish obtained near various user sites (27) and are believed to be ubiquitous contami-

the edible portion).

Aromatic Amines

These chemical intermediates have been found in fish near dyestuff producers (28). Although the concentrations found were low, FDA has maintained interest in this class of compounds because of their carcinogenic potential.

FDA regards assistance furnished to states and municipalities as part of a policy of mutual cooperation. Investigations of potential chemical contaminants are typically combined FDA-state efforts. The following instances illustrate the wide range of incidents and chemical types that have been involved in these investigations:

FDA found isopropylphenyl diphenyl phosphate in fish furnished by the State of Pennsylvania. The samples were obtained in a creek near a steel plant known to discharge aryl phosphates (27).

At the request of the State of Maine, FDA analyzed samples of sediment and fish obtained in rivers containing floating drums of tris(2,3-dibromopropyl) phosphate (TRIS). No residues of TRIS were found.

FDA analyzed for residues of methylene bis(*o*-chloroaniline) (MOCA) in various samples from Adrian, Michigan, furnished by the State of Michigan. MOCA was present in the water and sludge samples from an industrial lagoon, but none was detected in fish from the nearby Raisin River (29).

Benzidine and dichlorobenzidine were found in water but not in fish in samples furnished by the State of Michigan. Samples were obtained near a plant discharge point in Muskegon County.

Bis(β -chloroethyl) ether was found in water and fish from a lake near Pitman, New Jersey, near a dump site. Samples were furnished by the State of New Jersey.

In Louisville, Kentucky, still-bottoms from HCP production were dumped into the sewer system. FDA provided assistance to Louisville and other municipalities and supplied analytical reference samples. High concentrations of HCP and octachlorocyclopentene, as well as many other organochlorine compounds, were found in the sewage sludge.

Methylchloroform was found in samples of ice cream and process water furnished to FDA by the State of Massachusetts.

Conclusion

When significant levels of a recognized chemical contaminant such as PCBs are reported, the prob-

control. The search for new chemical contaminants, however, poses a greater challenge because the number of potential contaminants is always much larger than the actual total detected. Neither FDA nor any other single agency will ever have sufficient personnel and resources to investigate all the possibilities.

With the passage of the Toxic Substances Control Act, the Resources Recovery and Conservation Act, and the Clean Water Amendments in recent years, more and better information about the chemicals produced, the composition of effluents and wastewaters, the levels of chemicals in drinking water, and the number and character of dump sites is now available. In spite of this progress, increased and unexpected demands on present resources will make cooperation among Federal and state agencies even more necessary than ever before.

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