Organochlorine Pesticides and Polychlorinated Biphenyls in Human Adipose Tissue*

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ABSTRACT: For many years, residues of halogenated organic compounds have been detected in human adipose tissue of individuals in a number of countries, including those in Europe, Asia, and Africa, as well as in the United States. Levels detected have been used as an index of the level of general population exposure to these compounds over time. Over the past two decades, some countries have observed a decline in levels of exposure, reflecting a reduction in the use of these compounds, and a corresponding decrease in their environmental levels. Levels of concentrations vary from chemical to chemical as well as from isomer to isomer and country to country.

INTRODUCTION: The release of a chemical into the environment suggests a need for knowledge of its geographical transport, its chemical transformation, its possible impact on target organisms, and its fate as well as the identity and fate of its metabolites. Exposure of humans to chemicals and their ultimate effects can be represented by the following:

Source →	Environmental Pathway →	Environmental Conditions →	Exposure/ Dose →	Dose Delivered →	Effects

After the principal pathways of exposure have been identified, monitoring data are used to estimate releases and environmental concentrations. These releases and environmental concentrations are used to estimate the amount of chemical to which individuals may be exposed. Once a chemical is within the body, it may undergo extensive biotransformation Some chemicals are rapidly metabolized and excreted from the body in the urine and/or feces; others are slowly metabolized and undergo extensive storage in tissues, finally passing through the body virtually intact. Along with exposure studies, therefore, studies of tissue storage of xenobiotics are relevant to human health. For instance, most highly lipophilic chemicals such as the halogenated organic compounds are slowly biotransformed and tend to concentrate in the body fat tissue (e.g., adipose tissue).

The halogenated organic compounds reviewed in this article include aldrin, dieldrin, endrin, chlordane, oxychlordane, heptachlor, heptachlor epoxide, trans-nonachlor, hexachlorocyclohexane, DDT and related compounds, toxaphene, and mirex, in addition to hexachlorobenzene and polychlorinated biphenyls (PCBs). Monitoring studies have shown that these organic compounds are stored in the adipose tissue of humans and animals.

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As a group, complex halogenated organic compounds such as these are highly persistent in the environment because of their stable chlorinated ring structure. This persistence leads to potential incorporation into the food chain and subsequent uptake by humans. Because these compounds are extremely lipophilic and are metabolized very slowly, chronic exposure, mainly through the food chain, has led to accumulation of both the parent compounds and their metabolites in human adipose tissue.

RESULTS AND DISCUSSION: For many years, residues of halogenated organic compounds have been detected in adipose tissue of individuals in a number of countries, including those living in Europe, Asia, and Africa, as well as in the United States. The levels detected have been used as an index of the level of exposure of the general population to these compounds over time. Over the past two decades, most countries have observed a steady decline of chlorinated hydrocarbon storage and exposure, reflecting a reduction in the use of these compounds, restrictions on or banning of their use, and a corresponding decrease in their environmental levels. Studies have also been conducted on the levels of organochlorine compounds found in adipose tissues as they relate to such demographic factors as age, sex, race, particular physiological states, and living and working conditions.

To determine the trends of concentration levels in the adipose tissue of the general population, monitoring studies have been conducted in the United States and some foreign countries.[1] Several of these efforts are described briefly below, and an overview of their results are shown in Table 1.

Table 1. Organochlorine Pesticide and Polychlorinated Biphenyl Residues in Human Adipose Tissue[a]

Compound	Range of average concentrations (ppm)	Compound	Range of average concentrations (ppm)
Aldrin	ND[b] - 0.193	DDD	0.01 - 1.1
Dieldrin	0.02 - 0.40	Heptachlor	ND - 0.02
BHC (total)	0.02 - 11.9	Heptachlorepoxide	0 02 - 0.38
alpha - BHC	0.02 - 9.83	Chlordane	0.01 - 0.02
beta - BHC	0.03 - 6.43	Oxychlordane	0.01 - 0.19
delta - BHC	0.02 - 7.46	trans-Nonachlor	0.01 - 0.35
DDT (total)	0.33 - 62.45	Hexachlorobenzene	0.05 - 8.41
P,P'-DDT	0.30 - 12.08	Mirex	0.01 - 2.50
O,P'-DDT	0.03 - 0.70	PCBs	0.40 - 8.60
DDE	0.40 - 45.85	Toxaphene[c]	ND

[a]Ranges based on reported average concentrations from studies in various countries of the world. For a more detailed compilation of reported concentrations for each chemical, the reader is referred to Reference 1.
[b]Not detected.
[c]Toxaphene identified qualitatively but not quantitatively.
SOURCE: (1)

The National Human Monitoring Program (NHMP) was established in the United States in 1967 to monitor the levels and prevalence of chemicals in humans and the environment. The program was initiated by the Public Health Service, but was transferred to the U.S. Environmental Protection Agency (EPA) in 1970.

The National Human Adipose Tissue Survey (NHATS) is a major component of NHMP. Its purpose is to detect and quantify the prevalence of selected toxic compounds in the general population. The NHATS is designed to select a representative national sample of adipose tissue specimens each year. By selecting and chemically analyzing the tissues of a representative sample of individuals, information is then available for determining existing residue levels in the U.S. population as a whole. The adipose tissue specimens are collected annually and are chemically analyzed for 20 chlorinated hydrocarbon compounds.

including PCBs. The specific objectives of the adipose tissue survey are to (1) assess the prevalence of these substances in the adipose tissue of the general U.S. population, (2) measure time trends of these concentrations, (3) assess the effects of regulatory actions on the levels of concentration, and (4) establish baseline levels for the selected compounds in adipose tissue.[2]

The Federal Republic of Germany established an Environmental Specimen Bank for Human Tissue at the University of Meunster in 1977. One task of this pilot Specimen Bank is to maintain a continuous surveillance for possible changes in the concentration patterns and trends of xenobiotics in human samples (real-time monitoring).[3] In Germany, organochlorine pesticides have been analyzed in the adipose tissue and blood of living people, using real-time monitoring, as well as in autopsy material (Bertram et al. 1986).

Czechoslovakia has a long tradition of monitoring environmental organochlorine pesticide contamination. Monitoring for residues of organochlorine chemicals in adipose tissues from the general population began as a result of the country's widespread use of DDT.[4] Monitoring was originally conducted in 1960-1962, was initiated a second time in 1971-1974, and was performed again in 1980-1981.

Romania has also performed several surveys to determine the concentration of organochlorine pesticides in the adipose tissue of the general population. The surveys, conducted in 1965-1966, 1967-1968, and 1971-1972, were performed specifically to determine the concentration of total DDT and total BHC in the general population. In the last of these surveys (1971-1972), an increase (from 4.34 ppm in 1965-1966 to 5.12 ppm) in the level of BHC concentrations and a decrease (17.34 ppm in 1965-1966 to 3.33 ppm) in the level of DDT concentrations were noted. These trends were believed to result from a decrease DDT use, an increase in use of BHC, and a greater emphasis on proper labeling and use of agricultural products.[5]

In Canada, Ontario banned the use of aldrin, dieldrin, and heptachlor in 1969 and curtailed the general use of DDT in early 1970. The use of DDT was subsequently canceled in late 1970. Canada then conducted a monitoring program to determine the level of organochlorines in adipose tissue and to ascertain whether use restrictions affected organochlorine contents of these tissues. PCBs and HCB were also measured.[6]

SUMMARY: Monitoring data are critical factors in assessing exposure and evaluating risks.[7] Studies of laboratory animals determine the actual or potentially adverse biological activity (toxicity) of a chemical, while monitoring data are used to assess the exposure of selected human and environmental components to the chemical. Monitoring studies also contribute substantial information about the intermediate and final environmental fate of pesticides and other toxic chemicals.

Because the development of information related to the adverse health effects of pesticides and other toxic chemicals on human beings is a primary objective of monitoring programs, the media and chemicals selected must be those that contribute efficiently to understanding these effects. Thus, monitoring programs are designed to develop scientific information that describes: (1) the direct and indirect pathways of human exposure; (2) the health, economic, and ecological impacts of the exposure; and (3) the processes of mobility, metabolism, bioaccumulation, and degradation that affect pesticide transport in the environment.

Since the use of aldrin and dieldrin has now been banned or restricted in the U.S. and a number of other countries, residue levels have slowly decreased. Mean values in human adipose tissue in the U.S. and some foreign countries ranged from 0.04 to 0.40 ppm for dieldrin. Aldrin was detected in only two countries in the 1970's and endrin was not detected anywhere anytime.

By 1978, all products containing BHC registered in the United States either had been discontinued or were reformulated to incorporate lindane rather than BHC. The potential for exposure to BHC is virtually nonexistent in the United States; however, exposure to lindane is possible since products containing this chemical are still marketed and used particularly as a medicinal in human medicine

DDT was banned for agricultural purposes in the United States in 1972, although it is still used elsewhere for public health purposes (vector control). Since the decline in use of DDT, however, the average levels of concentration have also declined.

Heptachlor, chlordane, and trans-Nonachlor (a component of both heptachlor and chlordane) are chlorinated cyclodiene chemicals. Since heptachlor/chlordane chemicals remain biologically active for more than 30 years after application, monitoring data have shown that their residues have been detected throughout the food chain and in most human tissues examined, both in the United States and abroad. In the United States all uses of these compounds were canceled, and their use has also been restricted or prohibited in a number of foreign countries.

The use of HCB has been banned domestically and has not been produced as a commercial product in the United States since 1975. Several foreign countries have used it as an agricultural fungicide, but have since banned its use.

Production of mirex ceased in the United States in 1967 and its use was banned in the mid 1970s. Environmental residues of mirex are widespread. However, a special survey of general population adipose tissue from residents of the southeastern United States, where it was used extensively for fire ant control revealed that less than 1% of the samples contained detectable mirex.

PCBs were widely used as pesticide extenders as well as coolants and lubricants in transformers, capacitors, and other chemical equipment prior to 1972. Industrial manufacture of PCBs ceased in the U.S. in 1977 when it was decided that their persistence and accumulation in the environment might cause toxic effects. However, because of their presence in electrical equipment still in use, general population, exposure to PCBs is still possible.

Toxaphene was formerly the most heavily used insecticide in the United States primarily to treat cotton pests. Toxaphene was also widely used in foreign countries. Although this insecticide is less persistent and bioaccumulative than many others, its former widespread use has resulted in significant environmental distribution. However, animal studies have shown that its elimination from mammalian tissues is rapid. Toxaphene is either entirely absent from general population adipose tissues, or its concentration is below detection limits or the concentration of storage product(s) in adipose tissue is below analytical detection limits

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