

Pacific Toxicology Laboratories

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Home

Up

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Search

Pages of Interest

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Polychlorinated Biphenyls (PCBs)

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Up

Human Toxic Chemical Exposure

The Bulletin of Pacific Toxicology Laboratories

Reference Summary

Polychlorinated biphenyls, also known as PCBs, are comprised of two attached benzene rings (biphenyl) with one to ten chlorines (x+y) distributed on the two rings.

TABLE II

MOST COMMON SYMPTOMS IN YUSHO AND YU-CHENG DISEASE:

Disturbance of vision	Chloracne
Easy fatigue	Eye discharge
Malaise	Immune system dysfunction
Numbness of limbs	Reproductive impairment
Pruritus	
Headache, dizziness	

There are 209 theoretically possible chlorinated biphenyl congeners; however not all congeners are formed in the technical chlorination process. Several PCB products called Aroclor have been manufactured, each differing by the degree of chlorination. Their low water solubility, good insulating properties, high boiling points and resistance to chemicals led to many uses in industry. The largest use for PCBs was in capacitors, followed by plasticizers and transformers. Other uses are listed in Table I.

Because of health concerns, in 1971 Monsanto (the major U.S. manufacturer of PCB) voluntarily ceased PCB production for open systems. In 1977, Monsanto stopped all PCB production, but millions of pounds of PCBs are still in place in closed systems. Utility workers experience occupational exposure to PCBs while servicing old transformers and capacitors.

The stability properties that made PCBs so useful commercially have allowed them to persist in our environment. Disposal of the PCBs into soil and water has led to the concentration of these compounds in sewage, vegetation, marine life, and eventually humans (the top of the food chain). As a result, and in spite of the halt in U.S. production, almost all humans in industrialized countries have PCBs in their tissue (1).

PCBs bio-accumulate in human tissue and the levels increase as one ages (1). Virtually all persons in the U.S, have some PCB in their bodies: the average 70 kg male has a total body burden of 20 to 50 mg PCB with approximately 1 ppm in fat.

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TOXICITY OF PCBs:

Workers and others with high level PCB exposure have experienced chloracne, liver dysfunction, elevated triglycerides and/or elevated cholesterol levels (3). An increased rate of hepatic metabolism of drugs and other compounds occurs in PCB exposed workers (4). Pretreatment of rats with a PCB (Aroclor 1254) increased the toxicity of halothane by increasing its rate of metabolism to toxic metabolites (5). Other industrial chemicals such as trichloroethylene and perchloroethylene are also more toxic to rats pretreated with Aroclor 1254 (6).

Yusho Disease

An outbreak of PCB food poisoning occurred in Japan in 1968. The disease was called Yusho which means "the oil disease". Yusho arose from ingestion of rice oil contaminated with PCB-heat transfer oil. A similar outbreak, called Yu-Cheng, occurred in Taiwan in 1979. High concentrations of PCBs and also the more toxic polychlorinated dibenzofurans (PCDFs) (7) were present in the rice oil. The PCDFs were formed by heating the PCB in

rice oil to 200° C, at reduced pressure (8). The average Yusho case had ingested about 2 g of PCBs and a dose-response relationship was evident, i.e., the more PCB oil consumed, the more severe the clinical illness.

Yusho victims exhibited a latent period between ingestion of the oil and outset of symptoms. It averaged 71 days and ranged from 20 to 190 days. By 1978 a total of 22 deaths occurred among 120 of the Yusho victims; 41% of the deaths were due to cancer (9). In the Yu-Cheng outbreak, 39 babies born from PCB-poisoned mothers had hyperpigmentation and 24 of these died from either liver dysfunction, liver cancer or infection. Numerous non-specific symptoms which persisted for years were reported in Yusho and Yu-Cheng patients (2). (See Table II)

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Cutaneous Effects

Skin changes of chloracne, eye discharge and nail changes followed by infection and increased pigmentation are the common cutaneous manifestations in PCB poisoning. A dose-response relationship between skin changes and PCB levels has been reported (9).

Immune System Dysfunction

Immune system dysfunction, both humoral and cellular, was observed in some animal studies (10) as well as in the Yusho and Yu-Cheng victims (11). This dysfunction gradually returned toward normal after a few years (11).

Reproductive Impairment

Infants of PCB-contaminated Yusho mothers exhibited intrauterine growth retardation and a possible alteration of calcium metabolism (12). PCB monkey feeding studies showed higher incidence of early abortion and low birth weight

(13). Rogan reported impaired growth and development in babies whose mothers had PCB levels in cord blood over 10 ppb. Most of the PCB is transferred to the babies by

breast-feeding rather than through the placenta (14).

Cancer

Animal studies suggest that PCBs are carcinogenic (15). Bertazzi reported excess gastrointestinal and hematologic deaths among a group of capacitor workers with blood PCB levels above 200 ppb (16).

Hypertension

Two studies have found a positive correlation between PCBs and high blood pressure (17), and PCBs and arteriosclerotic disease (18); another study found no correlation (19). Further research in this area is needed.

UPTAKE AND METABOLISM

PCBs are lipid soluble and readily absorbed via the skin, gastrointestinal tract, and, in certain cases, inhalation. The more highly chlorinated congeners are metabolized more slowly than the less chlorinated ones and are consequently retained in adipose and other tissues for years (20). Metabolism to phenolic and sulfur-containing products are the major pathways leading to excretion in urine and feces (21).

MEDICAL SURVEILLANCE AND BIOLOGICAL MONITORING

PCB exposure **may** be accurately assessed by analysis of human adipose tissue, blood and/or breast milk. Serum or plasma is often used for screening due to the ease of collection. In a survey of capacitor workers, serum levels were found to be consistently proportional to those in adipose tissue, with an adipose tissue-to-plasma concentration ratio of 190:1 (23).

Since PCBs concentrate in fat, adipose tissue measurements are the most reliable indicators of total body burden. To perform the analysis only 200 to 500 mg of fat is required and may be obtained by a simple needle biopsy technique (24).

Residue analysis of human adipose tissue, blood and breast milk confirms that most individuals have been environmentally exposed to PCBs and contain measurable levels in tissues. Levels in the non-occupationally exposed population generally range from 2 to 14 ppb in serum (26) and 0.5 to 2.5 mg/kg in adipose tissue (27) and milk fat (28). Values above these ranges suggest overexposure to PCBs. Such information should be considered in conjunction with a thorough patient history, physical examination and other appropriate laboratory tests (such as liver function) when making a diagnosis.

Breast milk analysis, (to determine if potentially detrimental levels of PCBs are being transferred to the infant) may be warranted for nursing mothers with a known history of PCB exposure or who are frequent consumers of sport fish. In

West Germany, women with breast milk PCB levels of 2.5 mg/kg milk fat are advised to supplement their infant's milk intake with another source of milk (25).

For workers potentially exposed to PCBs, the California Department of Health Services recommends biological monitoring only to assess the adequacy of work practices and protective gear on a limited group of workers. Elevated values in these workers would trigger medical evaluation of a larger work population (29). The documentation of actual

PCB levels can often prevent lawsuits based on the erroneous presumption of excessive exposure. Presently, the American Conference of Governmental Industrial Hygienists (ACGIH) is studying PCBs to establish Biological Exposure Indices (BEI) for biological monitoring.

PCB ANALYSIS

Pacific Toxicology Laboratories analyzes PCBs in serum, adipose tissue and breast milk using high resolution capillary gas chromatography with congener-specific calibration. Experts agree that this is the best approach to most accurately quantify PCBs in biological matrices. The capillary column separates most of the PCB congeners and also separates them from potential organochlorine pesticide interferences. By calibrating on individual congeners instead of Aroclor mixtures, it is possible to eliminate quantitation problems associated with the highly varied detector response factors and metabolic rates of the different PCB congeners. This quantification of specific PCB congeners is available at an additional charge.

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