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The Invisible Environment Fact Sheet Series

PCBs

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Polychlorinated biphenyls (PCBs) are a family of 209 chemical compounds for which there are no known natural sources. Even though PCBs are no longer commercially produced in the United States, high levels of the chemicals remain in various parts of the country, in poultry, and in fish.

What are PCBs?

A phenyl is a univalent radical with a chemical equation of C_6H_5 (six carbon, five hydrogen atoms) with the symbol Ph. Valent refers to the measure of capacity to combine the number of atoms of hydrogen with one atom of a chemical element in a reaction: a univalent is capable of replacing or combining with one atom of hydrogen or its equivalent. Radicals are a group of atoms that enter into and go out of chemical combinations without change. A radical forms one of the fundamental constituents of a molecule.

A biphenyl molecule is comprised of two benzene rings of hydrogen and carbon atoms. Benzene rings serve as the building blocks of petroleum, gasoline, and other fuels. These molecules are extremely flammable. By substituting chlorine for hydrogen atoms, the molecule becomes flame-resistant. Chlorinated biphenyls are any of a group of substances in which chlorine replaces hydrogen. Molecules with more than one chlorine atom are known as polychlorinated biphenyls. Polychlorinated biphenyls are toxic and accumulate in animal tissues.

The flame resistance of the polychlorinated biphenyls made them ideal for use in electrical products because they did not burn, break down, or react with other chemicals. Originally produced for use as flame retardants and as electrical insulators in transformers, capacitors, and other electrical equipment, PCBs were used in heating coils, carbonless carbon paper, lubricating oils for industrial drills,

caulking compounds for skyscraper windows, electrical motors in refrigerators, in air conditioners, typewriters, power saws, and the like. At one time or another, a wide variety of products including cereal boxes, degreasers, varnishes, lacquers, waterproofing materials, and bread wrappers used PCBs. The unique properties of PCBs allowed them to be used in the manufacturing of many common products such as plastics, adhesives, paints, and varnishes. Between 1930 and 1970, 1.4 billion pounds of PCBs were manufactured in the United States.

In consistency, PCBs range from light, oily fluids to greasy or waxy substances and are clear to yellow in color. During their manufacture and use, PCBs were released into the atmosphere through sewers, smokestacks, weathering of asphalt and other substances containing PCBs, and burning products containing PCBs. PCBs continue to be released from leakage of old equipment, leaching from landfills, and from previously contaminated sediments.

What happens to PCBs in the environment?

The very characteristic of the PCBs that made them good for use in manufacturing makes them problematic in the environment. PCBs are very persistent: they are generally unalterable by microorganisms or by chemical reaction (they do not readily degrade). The stable nature of PCBs also lends to accumulation in the fatty tissues of animals once the PCBs are released into the environment. These accumulations increase as the tissue from contaminated animals moves through the food web. Because of bioaccumulation, the concentration of PCBs found in fish tissues is expected to be considerably higher than the average concentration of PCBs in the water from which the fish were taken.

Acute toxic effects in the environment include death of animals, birds, or fish, and death or low growth rate in plants.

Chronic effects from PCBs may include shortened lifespan, reproductive problems, lower fertility, and changes in appearance or behavior. The primary concern of PCBs in surface water is the chronic effect of bioaccumulation.

During the mid-1960s, some environmental scientists began seeing an increase of PCBs in animal tissues. In 1978, the U.S. Environmental Protection Agency banned the use of PCBs in all but closed systems of manufacturing. In 1979, the use of PCBs was banned in all applications, but the persistence of them in the environment ensures concern remains.

What are the health impacts of exposure to PCBs?

PCBs are extremely toxic. Low levels of PCBs have been shown to cause health problems in humans. Two parts per million (ppm) of PCBs is the highest acceptable concentration level in fish. The airborne limit of permissible exposure is 1 mg/m³ (42% chlorine) and 0.5 mg/m³ (54% chlorine) over eight hours of exposure. PCBs can affect humans through inhalation (respiration), digestion, or through the skin (dermal absorption).

In acute exposure, vapor can irritate the eyes, nose, and throat and cause an acne-like rash called chloracne. High exposure can damage the liver and may damage the nervous system causing numbness, weakness, and tingling in arms and legs. Chronic exposure may result in reproductive system problems; PCBs are animal teratogens. PCBs can be passed to a child through its mother's milk. PCBs can sometimes affect the immune system.

Individuals can be exposed to PCBs through a variety of means. Old appliances such as TVs and refrigerators may leak small amounts of PCBs when hot, as can old fluorescent lighting fixtures. Eating food containing PCBs is a means of exposure. Breathing air near contaminated sites and drinking PCB-contaminated well water are two additional means of exposure. People who work with equipment containing PCBs are potentially exposed, and OSHA and NIOSH have set limits and procedures for those working in these situations.

What can be done about PCBs?

All people in industrial countries have some PCBs in their bodies. There are tests to find out if the individual was exposed to higher than normal levels of PCBs. These tests can

look for PCBs in blood, body fat, and breast milk. There is no predictive test to indicate if an individual will experience harmful health effects from exposure. Like many chemicals, the impacts of PCBs on individuals are widely varied and relate to many factors such as genetic predispositions, diet, general health, age, type and frequency of exposure, etc.

There are ways of destroying PCBs in both water and soil, effectively removing them from the environment. For soil, there are two tests for PCBs:

1. Rapid analysis of soil for presence of PCBs, which employs an atmosphere pressure ionization mass spectrophotometer. The rapid analysis uses soil samples heated in a flowing stream of pure nitrogen in which vaporized materials are trapped. A detection limit of 1 microgram can be achieved.
2. The immunoassay uses standards with known concentrations of PCBs to compare (assay) alongside samples of suspected soil.

PCBs can be destroyed by burning at 2400 degrees Fahrenheit. Therefore, many items containing PCBs can be destroyed appropriately and safely in hazardous waste incinerators that use burners at appropriate levels of heat. Two different technologies are being used for on-site destruction of PCBs. The first is the use of plasma arc torches, which burn up to 10,000 degrees F. This is used for many soils that are contaminated with large amounts of PCBs. The second process is a bacterial process or bioremediation that is used for rivers where large sediment concentrations of PCBs are found. Presently there are more than 20 strains of bacteria capable of using biphenyl as their sole source of carbon.

PCBs were a valuable family of chemicals for manufacturing throughout much of this century. Looking back, it is possible to identify problems caused by PCBs and consider what might have been done differently. The reality is that society benefited from the use of these chemicals, and we now must deal with the negative legacy of these chemicals in the environment.

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