TerranearPMC Safety Share

Week of September 28, 2015 – Polychlorinated Biphenyls

Polychlorinated biphenyls (PCBs) are a group of man-made chemicals. Up until the 1900's PCBs were non-existent in our environment; however as PCBs became an important material in the manufacturer of many types of electrical equipment and hydraulic fluids, these materials, especially prior to the advent of environmental laws, began to appear in our waterways and soils throughout the country (as well as the rest of the industrial world).

PCBs were initially manufacturered in 1929 as a "miracle material" as these compounds proved to be a life-saver for underground construction activities since they are non-flammable and have a high electrical resistance with good insulating properties while being extremely stable (low degree of reactivity). Thus, they were instrumental for preventing fires and explosions and were actually required by fires codes! Because PCBs had so many advantageous properties (resistant to both acids and alkalis, while maintaining thermal stability), PCBs began to be used in hydraulic fluids, casting waxes, carbonless carbon paper, compressors, heat transfer systems, plasticizers, pigments, adhesives, liquid cooled electric motors and fluorescent light ballasts.

Manufacture peaked in the 1960s, by which time the electrical industry had lobbied the U.S. Congress to make them mandatory safety equipment. In 1966, they were determined by Swedish chemist Dr. Soren Jensen to be an environmental contaminant, and it was Dr. Jensen, according to a 1994 article in *Sierra*, who named them PCBs. Previously, they had simply been called "phenols" or the trade name, Aroclor (other countries referred to PCBs as Kennechlor, Pyrenol, Chlorinol). Note: the name Aroclor should not be confused with the insecticide, Alachlor

In 1973, the use of PCBs was banned in "open" or "dissipative" sources, such as plasticisers in paints and cements as well as fire retardant fabric treatments and heat stabilizing additives for PVC electrical insulation. However, they continued to be allowed in "totally enclosed uses" such as transformers and capacitors, which, in certain failure modes or out-of-specification conditions, can leak, catch fire, or explode. It was Ward B. Stone of the New York State Department of Environmental Conservation (NYSDEC) who first published his findings in the early 1970s that PCBs were leaking from transformers and had contaminated the soil at the bottom of utility poles. Concern over the toxicity and persistence (chemical stability) of PCBs in the environment led the United States Congress to ban their domestic production in 1979 (although some use continues in closed systems such as capacitors and transformers).

As its name implies, PCBs consist of many chlorine atoms attached to a double-ringed (or double benzene-type) structure. Because there can be many combinations of chlorine locations about this double-ringed material, there can be many types of PCBs, known as congeners. As a matter of fact, there are 209 individual chlorinated biphenyl structures; however only two or three forms are commonly used; these being Aroclor 1242, 1254 and 1260 (Aroclor is a trade name of Monsanto Company; the only manufacturer of PCBs in the U.S.). The numbering standard for the different aroclors is as follows: The first two digits refer to the number of carbon atoms in the phenyl rings (for PCBs this is 12), the second two numbers indicate the percentage of chlorine by mass in the mixture. So the name Aroclor 1254 means that the mixture contains approximately 54% chlorine by weight and Aroclor 1242 refers to 42% chlorine while Aroclor 60; 60% chlorine.

PCBs are very stable, and while that is a very desirable trait that ensures longevity for a product, it poses a considerable environmental risk (and therefore health risk). Since PCBs do not break down, they remain in the environmental and continue to accumulate as more PCB-waste material are introduced into the environment. When PCBs leak into soils, insects, such as worms may consume them. As the biological food chain progresses (from worms to fish to other, higher forms of animals), bioaccumulation in larger species occur. Because the animals that are lower on the natural food chain have short life spans, they, generally, are not at risk to the potential health effects associated with PCB-poisoning as they do not live long enough to accumulate PCBs. However, when larger animals (such as eagles) with considerably longer lifespans ingest the PCB-contaminated animals, the PCBs accumulate in the fatty tissue, thereby increasing their risk to adverse health effects (Environmental Health Perspectives, 106(8): 513).

Animals that eat PCB-contaminated food even for short periods of time have been reported to suffer liver damage and in some cases, have resulted in death. In 1968 in Japan, 400,000 birds died after eating poultry feed that was contaminated with PCBs (Hatamura Institute for the Advancement of Technology. 2007-12-11). Animals that ingest smaller amounts of PCBs in food over several weeks or months develop various health effects, including anemia and an acne-like skin condition known as chloracne. Other health effects include developing liver, stomach, and thyroid gland injuries. A form of liver cancer, hepatocarcinoma, has also been linked to PCB exposures. Other effects of PCBs in animals include changes in the immune system, behavioral alterations, and impaired reproduction.

In humans, health effects can vary greatly from person to person due to the various amounts and types of PCB mixtures a person may be exposed to. As a result, health organizations have not been able to establish a clear relationship between PCB exposure and any observed effects on human health. Nevertheless, evidence suggests that exposure to PCBs is associated with an increased risk of certain cancers of the digestive tract, liver and skin. PCB exposure is also associated with reproductive deficiencies, such as reduced growth rates, retarded development, and certain neurological effects which may or may not persist beyond infancy. The immune system can also be affected, leading to increased infection rates, and changes in the skin (such as chloracne) and pigmentation disturbances

PCBs accumulate in women and pass on to their infants through breast milk. This accumulation means that nursing infants may ingest PCB levels much higher than the levels in fish and other foods consumed by their mothers. Women exposed to PCBs before or during pregnancy can give birth to children with significant neurological and motor control problems, including lowered IQ and poor short-term memory.

Besides being banned in many worldwide locations, many sites (such as the Hudson River in New York) have been placed on the EPA National Priorities List for cleanup. Typically, soils are removed with the use of bioenzymes while waterways pose a more complex problem, involving pump and treat and filtration methods. At this time, no estimate is available as to when the world's PCB-contamination problem will be completed.

From an occupational health aspect, both OSHA and ACGIH have published exposure limits for Aroclor 1242 and 1254 as 1 mg/m^3 and 0.5 mg/m^3, respectively. Both organizations acknowledge a skin contact concern, causing cloracne while targeting the liver, with Aroclor 1242 causing eye irritation and Aroclor 1254 causing upper respiratory tract irritation.

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The two most powerful warriors are patience and time.
Leo Tolstoy