
PCBs—The Rise and Fall of an Industrial Miracle

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The story of PCBs and how they have spread throughout the planet and into the body fat of almost every living creature is one of the most fascinating and instructive chapters in the history of the era of synthetic chemicals . . . These long-lived chemicals will be a legacy and a continuing hazard to the unborn for years, decades, or in the case of some PCBs, several centuries.

THEO COLBORN, ET AL., OUR STOLEN FUTURE at 89.

Over the past several decades, polychlorinated biphenyls (PCBs) have been vilified as a pervasive and persistent threat to human health and the environment. However, for many years after their initial production and use, PCBs were accepted, if not embraced, for having seemingly unlimited potential and no obvious faults. Even today, while none would argue PCBs are harmless, some scientists question whether the risk of PCBs to human health and the environment, at least in environmentally relevant doses, is as great as their stringent level of regulation would suggest. Some people have even suggested that PCBs are being used by certain groups as an easy surrogate for the advancement of other agendas. The story of PCBs and their true impact on this and future generations, while perhaps fascinating and instructive, appears far from over.

PCBs are a group of man-made chemicals that contain more than two hundred individual compounds, ranging from light oils to heavy waxes. PCBs and structurally similar compounds (such as polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)) have received substantial attention from scientists, government regulators, the media, and the public since questions surfaced more than forty years ago about their potential effects on human health and the environment. While PCBs are perhaps some of the most extensively scrutinized chemicals ever studied, no scientific consensus currently exists on the human health and environmental impacts of PCBs. Although their manufacture was discontinued more than twenty-five years ago, trace levels of PCBs remain in the environment, and they continue to be used legally and safely today in small amounts and in limited circumstances, primarily in older electrical equipment.

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First discovered in the late nineteenth century, PCBs began to be widely produced and used commercially in 1929. Because of their superior insulating and fire-retardant properties, PCBs were used widely as coolants and lubricants in transformers, capacitors, and other electrical equipment. PCBs were also used extensively in fluorescent light ballasts, inks, adhesives, and carbonless copy paper. It would not be an exaggeration to suggest that PCBs revolutionized industry in the United States—some even dubbed them “the industrial miracle.” So highly valued were the flame-retardant properties of PCBs that some city codes banned the use of electrical equipment in public buildings that did *not* contain PCBs. Many insurance companies also required equipment in some locations to be filled with PCBs.

The Monsanto Corporation was the major producer of PCBs in the United States and marketed its product under the trade name Aroclor. For decades, companies legally discharged PCBs and PCB mixtures into waterways and landfills. It was not uncommon for farmers and municipalities in rural areas to spray dirt roads with PCB oil as a dust suppressant. Due to these common and, at the time, entirely legal practices, PCBs became ubiquitous in the environment. For years, PCBs had been considered relatively nontoxic and practically dismissed from a human health standpoint as being biologically inactive. To this day, the only *known* adverse effects of PCBs on humans are eye irritation and a severe form of acne known as chloracne, which is associated with industrial exposure to unusually large amounts of the chemical.

Widespread concern about PCBs began in the early 1960s, when traces of the chemical began showing up in soil and water samples. At the same time, research began to confirm what some had suspected for years—that many PCB compounds degrade slowly in the environment and can accumulate up the food chain. The same qualities that made PCBs attractive as coolants and lubricants—their stability and persistency—began to suggest potential environmental and health concerns. Because they are relatively insoluble in water and highly soluble in fats, PCBs are stored in body fat. PCBs are resistant to metabolism and they tend to bioaccumulate up the food chain. Most notable for the human consumer (the apex of the food chain) is the accumulation and concentration of PCBs in certain popular species of fish, such as salmon and catfish. Concern over the safety of PCBs grew even

more after two highly publicized poisoning incidents in Japan and Taiwan during the late 1960s, both of which were attributed to rice oil contaminated with PCBs. These incidents became popularly known as Yusho (literally, rice oil disease) and Yu-Cheng, respectively. The once esteemed miracle substance began to come under ever-increasing public scrutiny. In the face of this heightened scrutiny, Monsanto voluntarily ceased most of its production of PCBs in the early 1970s. By the mid-1970s, the time had come for Congress to do something to control what one former congressman called the “mad dog” of the environment.

Regulation of PCBs

In 1976, in response to the growing concern over chemical hazards in general, Congress enacted the Toxic Substances Control Act (TSCA), 15 U.S.C. §§ 2601 *et seq.*, TSCA § 2 *et seq.*, to develop adequate data on and regulate chemicals, including PCBs, to ensure that they would not “present an unreasonable risk of injury to health or the environment.” TSCA § 2(b). Interestingly, PCBs were the only chemical singled out by name for regulation under TSCA. See TSCA § 6(e). The legislative history of TSCA demonstrates that the sponsors of the amendment adding the PCB subsection to the bill were uniquely concerned with the threat PCBs posed to human health and the environment. Specifically, Section 6(e) of TSCA sets forth a detailed scheme for the disposal of PCBs and banned the “manufacture, processing, distribution in commerce or use” of any PCB “other than in a totally enclosed manner.” The statute goes on to define the phrase “totally enclosed manner” as “any manner which will ensure that any exposure to human beings or the environment to a [PCB] will be insignificant as determined by the [EPA] Administrator.” *Id.*

Almost immediately, EPA began proposing rules, through two sets of initial regulations, to implement the PCB provisions of TSCA. First, in the so-called Disposal Regulations, EPA set forth specific rules governing the marking and disposal of PCBs. The disposal regulations applied to pure PCB compounds and other compounds contaminated with at least 500 parts per million (ppm) PCBs. See 43 Fed. Reg. 7151 (Feb. 17, 1978). On May 31, 1979, EPA issued a second set of regulations banning the manufacture, processing, distribution in commerce or use of most PCBs. See 44 Fed. Reg. 31,514. In promulgating this second set of rules, EPA specifically authorized the continued use of PCBs in electrical transformers, capacitors, and certain other electrical equipment, stating that it “considers the use of transformers as use in a totally enclosed manner. Accordingly, the use of PCBs in transformers may continue indefinitely.” *Id.* at 31,530. In addition, EPA’s regulations defined “PCB” for purposes of Section 6(e) as PCBs in concentrations of 50 ppm or greater, thus excluding the manufacture, processing, distribution in commerce, and use of PCBs in concentrations

below 50 ppm from regulation. Subsequently, the Environmental Defense Fund challenged the rule, including the 50 ppm cutoff for applicability of the regulations, and EPA’s finding that the use of PCBs in transformers and other electrical equipment was a “totally enclosed” use.

In 1980, the D.C. Circuit found that the rulemaking record was inadequate to support EPA’s determination that the use of PCBs in transformers and other electrical equipment was “totally enclosed” or to support the 50 ppm regulatory cutoff, and remanded these parts of the regulation for further action. See *Environmental Defense Fund, Inc. v. EPA*, 636 F.2d 1267 (D.C. Cir. 1980). Because the effect of the court’s decision would have been to make the continued use of PCB-containing transformers and other electrical equipment, and the continued manufacture, processing, distribution in commerce, and use of PCBs below 50 ppm a violation of Section 6(e) of TSCA, the court agreed to stay its mandate until the parties could reach agreement on further rulemaking by EPA. In requesting the stay, EPA observed that an immediate ban of these uses would be “completely impractical,” as such an action would not only have disrupted electric service, but would also have caused severe economic hardship for the public and the country’s industries. As a condition of the stay, the Edison Electric Institute (EEI), through the Utility Solid Waste Activities Group (USWAG), agreed to undertake the development of factual material necessary for further rulemaking. The court required EPA to promulgate a final rule for the use of PCBs in electrical equipment within six months of receipt of the EEI/USWAG study.

EPA received the final EEI/USWAG study on February 19, 1982. On April 22, 1982, EPA published a proposed rule for the use of PCBs in electrical equipment. See 47 Fed. Reg. 17,426. In this proposed rule, EPA determined that, based on the EEI/USWAG study, no electrical equipment uses should be categorized as use in a totally enclosed manner. In making this determination, EPA observed that, “the leakage data contained in the study shows that all types of electrical equipment leak during normal operation.” *Id.* at 17,427. However, EPA also observed “the use of electrical equipment could legally continue under an authorization granted by EPA using the provisions of section 6(e)(2)(B) of TSCA.” *Id.* (emphasis added). In order to authorize a use of PCBs under this section, TSCA required EPA to make a finding that such use “will not present an unreasonable risk of injury to health or the environment.”

After analyzing a number of factors, including the risks and benefits of continued use of PCBs in transformers, EPA proposed to authorize the use of PCBs in PCB transformers and the use of PCBs in mineral oil transformers indefinitely. Finally, on August 25, 1982, EPA promulgated a final rule “authoriz[ing] the use of all PCB-containing, mineral oil-filled electrical equipment for its remaining useful life.” 47 Fed. Reg. 37,342, 37,343. In allowing

the use of certain electrical equipment containing PCBs to continue, EPA reiterated its conclusion that such use “would not present an unreasonable risk of injury to human health or the environment.” *Id.* at 37,344. Specifically, EPA concluded that: (1) imposing a total ban would cost the public and United States industry billions of dollars, primarily as a result of the disruption in electrical service; (2) the proposed inspection and maintenance program reasonably reduced the exposure risks associated with the use of PCBs in transformers, and the servicing conditions prevent further PCB contamination; (3) releases of PCBs to the environment and exposure to humans and wildlife from transformers was expected to be very small; and (4) the costs associated with an accelerated phase out or requirements to retrofill or contain in-service transformers were not reasonable when compared to the potential reduction in release of PCBs that such an action would achieve. *Id.* at 37,346–47. Consequently, PCB-containing electrical equipment still in service (or stored for reuse) at the time of the ban was considered safe and removal from service was not required.

Because the life expectancy of electrical transformers and other equipment that contains PCBs can be thirty years or more, some are still in use today. Even so, most of these contain extremely small concentrations (in the low parts per million range) of PCBs. As equipment containing PCBs fails or leaks, strict federal regulations govern cleanup, removal, and disposal of equipment and contaminated media to ensure any additional releases into the environment are avoided. PCB levels in the environment have decreased significantly since production ceased in the 1970s and should continue to do so as these last remaining uses are phased out.

Since the enactment of TSCA in 1976 and the promulgation of the initial regulations implementing the statute, EPA has engaged in numerous other Section 6(e) rulemakings. One of the most significant of these rules is EPA’s PCB Spill Cleanup Policy, published in 1987, which establishes cleanup and decontamination standards for spills of PCBs at concentrations of greater than or equal to 50 ppm. See 40 C.F.R. Part 761.120–761.135.1. The development of the spill policy was one of the rare instances where environmental groups and industry worked together to achieve a workable, uniform solution to what had become an unworkable patchwork of varying local requirements. Prior to the spill policy, requirements for PCB spills were established separately by each EPA regional office. Parties responsible for PCB spills were required to meet those requirements or face potential penalties under TSCA § 16 for improper disposal of PCBs. Under this prior approach, each region set its own cleanup standards in the form of general guidelines on a case-by-case basis for specific spill situations. These guidelines differed widely among regions and upon specific spill situations, resulting in uncertainty and confusion within the regulated industry.

By 1984, EPA recognized the difficulty in applying this approach and concluded that a nationwide PCB

cleanup policy was necessary. Consequently, EPA produced an internal draft TSCA Compliance Monitoring Program Policy covering spill cleanup, which was reviewed by a diverse group of stakeholders including the Environmental Defense Fund, the Natural Resources Defense Council, the Edison Electric Institute, the Chemical Manufacturers Association, and the National Electrical Manufacturers Association. In 1985, the reviewers submitted to EPA an alternative PCB spill cleanup policy for consideration. After reviewing the stakeholders’ proposal, EPA identified two general principles about the appropriate framework for a national PCB spill cleanup policy: (1) it should establish requirements designed to be effective for the vast majority of spill situations, and (2) the risks posed by residual contamination vary depending on the location of the spill and the potential for human exposure. Working from these two general principles, EPA published the current PCB Spill Cleanup Policy on April 2, 1987. The spill policy requires cleanup of PCBs to different levels depending upon the location of the spill, the potential for exposure to residual PCBs remaining after the cleanup, the concentration of the PCBs initially spilled, and the nature and the size of the population potentially exposed. Importantly, the spill policy only applies to the cleanup of spills resulting from the release of PCBs at concentrations greater than 50 ppm. Generally, spills less than 500 ppm PCBs must be cleaned up within forty-eight hours by double washing and rinsing solid surfaces, excavating all soil within the spill area (i.e., visible traces of soil and a buffer of 1 lateral foot around the visible traces), and back-filling with clean soil (i.e., soil containing less than 1 ppm PCBs). More stringent cleanup requirements apply to spills containing PCB concentrations of 500 ppm or greater.

Health and Environmental Effects of PCBs

Due to their persistence in the environment, nearly everyone carries some body burden of PCBs—even today. Most people today are exposed to PCBs by consuming foods containing extremely low levels of PCBs. Although PCBs are one of the most extensively scrutinized families of chemicals ever studied, there is no clear consensus on their impacts to human health and the environment. Much of the data on health effects of PCBs comes from animal studies or studies of humans exposed to large, occupational doses of PCBs. The effects of long-term, low-level exposure have not been as extensively studied, and where they have been, the results have been inconclusive or subject to valid criticism. One important concept to keep in mind when considering the exposure of the general public to PCBs is the difference between “dose” and “exposure.” The term “dose” indicates the amount of something that is actually absorbed into the body. Harmful effects can only result if the body receives some threshold “dose.” The term “exposure,” on the other

hand, means the potential to come in contact with something. The fact that one may have been potentially exposed to a chemical does not necessarily mean that one has received or absorbed a dose of the chemical, much less a harmful dose.

Few people today would disagree that PCBs can cause cancer in animals. In fact, the International Agency for Research on Cancer (IARC), National Toxicology Program (NTP), and EPA all consider PCBs to be animal carcinogens. However, the picture is less clear where humans are concerned. EPA currently classifies PCBs as "probable human carcinogens." IARC classifies PCBs as "probably carcinogenic to humans (Group 2A)." The NTP classifies PCBs as "reasonably anticipated to be human carcinogens." In contrast, some other similarly regulated environmental chemicals, dioxins for example, are universally classified as known human carcinogens.

With respect to noncarcinogenic toxicity of PCBs, animal studies have shown that PCBs can have toxic effects in animals, including effects on the immune system, the reproductive system, the nervous system, and the endocrine system. As with cancer, however, the evidence is not as clear with respect to the noncarcinogenic toxic effects of PCBs on humans. In contrast, PCDDs and PCDFs, which are unintentional by-products of the production of other chlorinated chemicals and breakdown products of PCBs subjected to prolonged periods of intense heat or fires, have been shown to have toxic effects at much lower levels than PCBs.

A primary criticism of the animal studies is the typically large doses administered to initiate a response. As Paracelsus observed in the sixteenth century, "What is there that is not poison? All things are poison and nothing is without poison. Solely the dose determines that a thing is without poison." In other words, the dose makes the poison, and any substance, even water, taken in a large enough dose will be toxic. The typical animal study involves doses greatly exceeding those of most human exposures. The results are then extrapolated to estimate human risk at exposures that are frequently thousands of times lower. Toxic effects observed at these high doses may not, and generally do not, translate to the same effects in humans exposed to much lower doses. For example, some scientists believe that the effects of chemicals at low doses are likely to be much less than a model extrapolating from high doses would predict, and may often be zero. See Jan Ziegler, *Toxicity Tests in Animals: Extrapolating to Human Risks*, 101 ENVTL HEALTH PERSP. 402–406 (Oct. 1993). Moreover, while it is true that most substances that cause cancer in humans will produce cancer in some, but not all, laboratory animals, it is not true that all substances that cause cancer in animals will cause cancer in humans. See Robert L. Brent, *Utilization of Animal Studies to Determine the Effects and Human Risks of Environmental Toxicants*, 113 PEDIATRICS 984–995 (2004). There is no question that animal studies can provide valuable information concerning human and animal vulnerability to chemi-

icals. However, extrapolating animal results to human effects is fraught with confounding uncertainties and must be interpreted objectively and with a measure of caution.

Human studies on the effects of PCBs are inconclusive. Subsequent studies of the Japan and Taiwan incidents have suggested that the adverse health effects experienced in those cases were actually caused by more toxic chemicals like PCDFs and PCDDs rather than PCBs. See Renate D. Kimbrough, *Polychlorinated Biphenyls and Human Health: An Update*, 25 CRITICAL REVIEWS IN TOXICOLOGY, 133–163 (1995). In occupational studies involving workers exposed to PCBs at much higher levels than the general population, exposures to PCBs have definitively been associated only with chloracne. Although the effects of chloracne are reversible, they are not insignificant. Chloracne is painful, disfiguring, and may require a long period before symptoms disappear. In addition to chloracne, some occupational studies of PCB exposure have demonstrated some evidence of liver damage; however the presence of confounding variables in these studies leave the results open to debate. See *id.* at 137–138. In perhaps the most comprehensive occupational study, cancer mortality rates were actually lower in exposed workers than in the general population. See D.P. Brown & M. Jones, *Mortality and Industrial Hygiene Study of Workers Exposed to Polychlorinated Biphenyls*, ARCHIVES OF ENVTL HEALTH, 36, 120 (1981). It is important to note that given the relatively small sample sizes in occupational studies, it is possible that occupational exposure could eventually result in PCB-related disease. However, such effects have not been observed to date.

In addition to the high-level studies, a number of studies have examined the effects of low-level (i.e., nonoccupational) PCB exposure. Several of these have reported that low-level PCB exposure during fetal or neonatal development can affect neurological development and behavior. However, these studies have been criticized by some for several notable limitations, including inadequate controls and possible exposure to other neurotoxic chemicals besides PCBs. Accordingly, these studies, at best, may suggest, but certainly do not conclusively prove, an association between PCBs and neurological and developmental effects.

The debate over the human health effects of PCBs has also become increasingly polarized in the midst and aftermath of several high-profile personal injury lawsuits involving chronic, low-level environmental human exposure to PCBs. Two of the most recent of these lawsuits involved more than twenty thousand plaintiffs in federal and state court over the release of PCBs from a single facility in Alabama. PCBs were first produced in Anniston, Alabama, in 1929 by the Swann Chemical Company. Monsanto acquired the plant in 1935 and produced PCBs at its Anniston plant until 1971. Prior to ceasing production of PCBs, the company legally released thousands of pounds of the chemical into local creeks and buried millions of pounds in a landfill. In 1996, residents of Anniston filed an action in state court against Monsanto alleging personal injury and property damage. In 1997,

Solutia, Inc., was spun off from Monsanto. In 2001, additional residents, who were primarily homeowners and residents of the west Anniston neighborhood closest to the plant, filed an action in federal court against Monsanto alleging claims similar to those brought in the state court case. Attorneys for the plaintiffs in the federal case claim they uncovered internal company documents from the 1930s that indicate Monsanto was aware of health hazards of PCBs but did not share the documents with Anniston residents. Although Solutia/Monsanto denied the allegations, the federal case, *Tolbert v. Monsanto, et al.*, and the state case, *Abernathy v. Monsanto, et al.*, recently settled together for approximately \$700 million.

In addition to the general ongoing disagreement over the magnitude of health and environmental effects raised in litigation, another high-profile debate is currently raging over the relative risks of PCBs in the food chain, particularly in farmed or pen-raised salmon. Concerns over pen-raised salmon began to emerge in the summer of 2003 when a flurry of newspaper stories reported that farmed salmon contained dangerous levels of PCBs. Similar news reports appeared in major newspapers and media outlets across the United States and Canada in the summer of 2003. Also in 2003, the Environmental Working Group (EWG) published a report entitled *PCBs in Farmed Salmon—Factory Methods, Unnatural Results*. The EWG report concluded that, based on tests of farmed salmon purchased at grocery stores in Washington, D.C., San Francisco, and Portland, Oregon, American consumers nationwide are exposed to elevated PCB levels by eating farmed salmon.

In January 2004, an article published in the journal *Science* found seemingly large differences between farmed and wild salmon contaminant concentrations. The study found farmed salmon contained higher levels of PCBs than wild salmon. The authors surmised that the differences were a function of the fishes' diets, pointing out that farmed salmon are fed a concentrated feed high in fish oils and fish meal, which is obtained primarily from small pelagic fishes. The authors advocated labeling salmon as farmed and identifying the country of origin, and recommended further study of contaminant sources, particularly in feeds used for farmed salmon.

Some critics of these studies and reports, however, question the true motives of their authors and supporters, and charge that they are part of a larger, coordinated effort to attack and destroy the salmon farming industry through the use of scare tactics. The recent rise in the number of fish farming operations worldwide (in particular, salmon farming operations) has drawn increased scrutiny from government regulatory agencies and, most notably, environmental groups. These groups have raised a number of potential concerns over the environmental impact associated with fish farms, including concerns regarding chemical and organic water pollution resulting from such operations and "potential biological" pollution; that is, the potential for nonnative species to escape from farms and

potentially alter or otherwise affect native species or the environment. In addition, a frequently unspoken, yet important, factor feeding the opposition to many salmon farming operations is that these operations are commonly located in bays and other coastal areas where they are sometimes viewed as unwelcome pockmarks on coastal vistas. Many in the salmon farming industry believe that environmental groups, unable to achieve their desired result of shutting down salmon farms through increased regulations, are now using the specter of PCBs to scare the public away from eating farmed salmon. The salmon farming industry maintains that the *Science* study actually proves that the levels of PCBs in farmed salmon fall well below the Food and Drug Administration (FDA) safety guidelines. For example, the levels of PCBs found in farmed salmon in British Columbia are roughly 1/100th of the 2,000 parts per billion (ppb) allowable limit set by the FDA and its Canadian counterpart. Yet, because this and other studies demonstrate at least detectable amounts of PCBs, environmental groups and the media are using these studies to suggest that farmed salmon are unsafe to eat.

It is to be determined which side of the farmed salmon debate is correct. However, it is clear that the dispute is far from over. For example, the EWG and the Center for Environmental Health have filed a notice of intent to sue the farmed salmon industry and several major grocery chains under California's Proposition 65, which requires a warning label for any product containing one of several hundred chemicals "known to the State of California" to be carcinogens. The farmed salmon industry continues to vehemently contest the bases of the environmental groups' allegations and to tout the health benefits of their product.

PCBs have been one of the most heavily regulated chemicals in modern history. Production has been banned, and their distribution and use have been severely limited for more than twenty-five years. Nevertheless, PCBs continue to persist in the environment and we all must live with them. As a result of their long-term and, for many years, completely legal use, most people today bear some body burden of PCBs. It would be myopic to suggest that people will not be concerned about the potential harmful effects of PCBs still present in the environment. The weight of results from animal studies supports the conclusion that PCBs can cause cancer and other effects on the liver, blood, immune, reproductive, nervous, and other organ systems in animals. It is without question that acute exposure to unusually large amounts of PCBs can cause chloracne and eye problems. However, more studies are needed on chronic, low-level exposure risks, particularly involving PCBs in the food chain, and to determine if there is reason for continued concern regarding exposure at low levels from various environmental sources. Although PCBs may never entirely disappear from the environment, time and additional research may reduce the real or perceived threat associated with this once celebrated industrial miracle. 