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Review

Persistent pollutants: A brief history of the discovery of the widespread toxicity of chlorinated hydrocarbons

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ABSTRACT

Rachel Carson's Silent Spring is often depicted as the beginning of a broad societal concern about the dangers of DDT and other pesticides. Attention to the other chlorinated hydrocarbons, specifically PCBs, is seen as an outgrowth of the late 1960s environmental movement. Carson's work was clearly critical in broadening the history to include the environmental impact and set the stage for the path breaking work decades later by Theo Colburn and others on endocrine disruptions associated with other synthetic chemicals. This article reviews the development of the understanding the dangers of the chlorinated hydrocarbons in the decades preceding Carson's book. Although little noticed, Rachel Carson makes this observation herself.

1. Introduction

The modern understanding of the dangers of chemicals on the environment, animal life and human beings is often traced to the publication of Rachel Carson's Silent Spring in 1962, a half century ago. This was certainly a seminal moment in environmental history for it brought to public attention the impact of the new chemical environment on wildlife and reproduction. Carson's work built on information that had accumulated in the professional and public sphere during the 1940s and 1950s. Much of this earlier discussion centered on chlorinated hydrocarbons, a family of compounds of which PCBs, along with DDT, are perhaps the most well-known . Carson herself acknowledged this historical relationship in Silent Spring, noting that in the 1930s hepatitis outbreaks among workers in the electrical industry was caused by "a special group of hydrocarbons, the chlorinated naphthalenes." (Carson, 1962). Although others have documented the historical understanding of pesticides, including DDT, Aldrin, dedrin, organophosphates, lead arsenate and other chemicals for agricultural uses there is no study of the evolving understanding of the dangers of chlorinated hydrocarbons as a class (Carson, 1962; Dunlop, 1981; Perkins, 1981; Russell, 2001; Rudd, 1964; Daniel, 2005). More recently researchers and journalists have called our attention to the actual and potential dangers that chlorinated hydrocarbons pose to the ecology and human health (Whorton, 1975; Thornton, 2000; Colburn et al., 1996). And certainly the more recent work by Theo Colburn, Dianne Dumanoski, Pete Myers, Frederick Vom Saal and others has opened up a host of new concerns about endocrine disruptions and other disorders linked to synthetic chemicals in the environment (Colburn, 1996; Vogel, 2013; Colburn et al., 1993).

In light of this work and industry's recent resistance to acknowledge the threats from newer chemicals introduced into a host of consumer products, it is important for environmental scientists to recall this long history of knowledge. Here we will review the research literature beginning in the Depression and World War II era that led to the growing recognition of chlorinated hydrocarbons as a serious threat to the environment and to human health. The attention to the environmental dangers of pesticides, specifically DDT, endrin, and aldrin, in the mid-1940s, climaxed in the recognition of polychlorinated hydrocarbons as a major threat by the late 1960s, completing the circle that began in the 1930s.

It is also important to look at the dynamics of science and scientific inquiry in the era before the modern environmental movement to understand the transformation of the relationship between science and industry before and after the publication of Carson's seminal book. Prior to the publication of Silent Spring a wealth of information accumulated in the scientific, medical and public health literature about the potential and actual harms of DDT, PCBs and other chlorinated hydrocarbons. In the 1950s there was "an inviolate notion of progress pervaded by science and technology," as historian Pete Daniel puts it. Hence, the chemical

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industry did not seek to discredit this literature and, in fact, sometimes sponsored the very research that raised questions about their products (Daniel, 2005: 4). Such forewarnings of danger had little impact on public policy in part because of the close and intertwined relationship between the industry and the governmental agencies that were meant to regulate pesticides (Daniel, 2005).

But, Carson's book made what had been an internal discussion between industry and scientists both within and outside of industry, into a public issue that threatened industry interests. As a result, the chemical industry responded with public relations campaigns that forever would change the relationship between corporate managers and scientists themselves. As is well documented by Carson's biographer, Linda Lear, the Agricultural Chemical Manufacturers Association and major chemical companies sought to discredit her, and with her, other scientists as well (Lear, 1997).

Indeed, this attack on Carson was in spite of what had been espoused as the best practices by the chemical industry itself. Henry F. Smyth of Union Carbide and the Mellon Institute clearly stated the responsibilities of manufacturers in a 1946 statement. "It is clearly the duty of a manufacturer to delay production of a chemical until the health hazards are well enough defined so that protection of his workmen is possible," Smyth pointed out. "It is also his duty not to sell a chemical for an application in which it would endanger the health of the public and to inform customers, by proper labeling and otherwise of the hazards of the compounds they buy" (Smyth, 1946). The Manufacturing Chemists Association acknowledged these principles in its guide for labeling dangerous chemicals (Manufacturing Chemists Association, 1946).

2. Early warnings of the dangers

The Depression of the 1930s was a signal moment in American social and economic history for the extreme hardship it produced for millions of Americans. But the Depression and World War II also marked the emergence of the country as the world's preeminent industrial society. The federal government through various New Deal programs such as the Works Progress Administration and the Public Works Administration hired the workforce needed to rebuild and modernize America's infrastructure, including the electrification of the country through the building of the giant Hoover and Grand Cooley dams and the power stations that provided electricity to huge swaths of rural America. One of the largest public works projects, the Tennessee Valley Authority, created in 1933, electrified major portions American south, including Tennessee, Alabama, Mississippi and Kentucky, building hydroelectric plants and laying thousands of miles of electrical cable (Freeman, 2012).

Following the end of World War II the rapid expansion of suburban America and the mechanization of American agriculture led to the dramatic increase in the use of synthetic pesticides. At the same moment the effectiveness of certain chlorinated hydrocarbons as effective insulating materials and pesticides led to a dramatic increase in their production and distribution throughout American society. Huge corporations such as General Electric, Westinghouse, Monsanto, Ciba, NCR and others developed a host of uses for the chlorinated hydrocarbons, including "carbonless" copy paper, paint additives, adhesives, de-dusting agents, cutting oils, water-proofing, plasticizers, wood-floor finishes, fire retardants, coolant and lubricating oils, to name a few. By the late 1970s when PCBs were finally banned from use in virtually all products, chlorinated hydrocarbons had emerged as a universal pollutant, present in the bodies of virtually all living organisms.

While chlorinated hydrocarbons were first synthesized in the early nineteenth century and PCBs in German labs in 1881, American commercial production began in the early 1930s when the first load of polychlorinated biphenyls, used initially primarily as an electrical insulating material capable of resisting high temperatures, was shipped from the Swann Chemical Company plant in Anniston, Alabama to the General Electric Company (PCB Presentation, 1970) (Shortly after, Monsanto took control of this small company and expanded production of PCBs which they marketed under the trade name "Aroclor"). It was identified as a cause of chloracne by Herxheimer in 1899, (Herxheimer, 1899) and, shortly after production began in the United States workmen at Swann developed dermatitis and yellow atrophy of the liver. In 1933, the company contracted with Dr. Frederick Flinn of Columbia University to investigate "whether or not the various chlorinated diphenyl compounds submitted or some impurities contained therein might be the causative agent producing the dermatitis which had developed among some of the workmen in the plant" At first it was suspected that styrene might be the source for the problem and that "means be provided for the men to take a bath with soap and water if they come in contact with the type of material found to be positive." Flinn told the company that "if a leak or spillage occur[ed] the immediate bathing under these circumstances should be insisted on." (Report of Dr. Frederick B. Flinn, 1934).

Flinn and N.E. Jarvik continued to follow the problem and soon reported on "Three cases of yellow atrophy of the liver [which] have occurred in each of 3 widely separated plants and under different management within a year or two" arguing that the cause of the illnesses was "chlorinated naphthalene heated above the melting point and giving off fumes." (Flinn and Jarvik, 1936: 118). To test their hypothesis Flinn and Jarvik conducted an experiment where they exposed rabbits to naphthalene, concluding that their study of "30 rabbits, all show[ed] the same pathological picture" which confirmed that "chlorinated naphthalenes or impurities contained within them [were] capable of producing yellow atrophy." Hence, these fumes pointed "to [naphthalenes or impurities] being a possible etiological agent in the factory cases" since "no other material used in the factory was found to produce the lesion" (Flinn and Jarvik, 1936: 120).

The worries about the health effects of these chlorinated hydrocarbons continued as Cecil Drinker, professor of public health and medicine and Dean of Public Health at Harvard University, followed up on this work, examining "the problem of possible systemic effects" of other chlorinated hydrocarbons, specifically, chlorinated diphenyls (PCBs). His study, which appeared in The Journal of Industrial Hygiene and Toxicology in September 1937, was first presented at a one-day "Symposium on Certain Chlorinated Hydrocarbons" at the Harvard School of Public Health. At the conference Drinker noted the growing use of PCBs in electrical equipment and the worrisome implications of widespread dispersal of this material. There was a "large literature" on the "troublesome acne" caused by PCBs but he was most concerned "with the possibility of systemic effects following ingestion or inhalation of such products." The previous year, he pointed out, the Halowax corporation, which was a division of the Bakelite Corporation, experienced "three fatal cases of jaundice in workmen using chlorinated naphthalenes and chlorinated diphenyl, and requested that the subject be investigated as rapidly and thoroughly as possible" for, he noted, there was a "meager literature upon systemic effects from these substances." He worried that the "more highly chlorinated" naphthalenes were "capable of causing liver injury when inhaled steadily in quite low concentrations." While he saw no sign of injury to other organs, chlorinated diphenyls were also capable of doing harm "in very low concentrations and [were] probably the most dangerous,"