Perspective on Accidental Exposure to Dioxin-like Compounds

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Introduction and Methods

Accidental exposure of humans to dioxins, furans, and those PCBs which bind to the Ah receptor (collectively called dioxin-like compounds) has occurred in many situations since the earliest study of the effects of these anthropogenic compounds. Indeed some degree of human exposure to these compounds is necessary scientifically in order to define their adverse effects. An accident is commonly defined as any incident that occurs unexpectedly, often without a known cause, and usually involves some adverse effect or injury. Exposures to dioxins, furans and PCBs mostly occur as mixtures of chemicals rather than discrete compounds. They are never voluntary and those in accidental settings often result in high dosage and elevated risk. Other less obvious and usually more benign incidents lead to lower exposures designated as background, or general population exposure; this type of exposure will not be addressed here. This perspective will categorize and describe the various accidents attributed to dioxin-like compounds, both historically and recently, give insight into their occurrence with some well-known examples, tend to focus on human exposure rather than environmental risk, and speculate on future happenings.

Results

Generally, accidental exposure to dioxin-like compounds can be classified as either occupational or environmental. Some of the characteristics of these two types of mishaps are listed in more detail in Table 1.

Table 1. Comparison of types of accidental exposures to dioxin-like compounds

	Occupational	Environmental
Source	Combustion and heat	Variable
Exposure	Acute	Mostly chronic
Route of exposure	Dermal and respiratory	Mainly oral by food
Degree of exposure	Usually high	Variable
Target group	Workers	General population
Frequency	More common historically	More important now

Occupational exposure typically involves workers who produce or use chemicals that contain dioxin-like compounds. These incidents frequently occur as a result of some combustion such as a fire or overheating although long term constant exposure will also produce elevated exposure. The

contact with the offending chemicals is initially unavoidable and exposure routes are mostly dermal and respiratory. The incident itself is often dramatic so that exposure tends to be recognized. Since measures are taken to reduce or eliminate the danger, exposure is usually acute. Occupational exposure to dioxin-like compounds is often elevated in its degree and was more of a problem formerly since today most sources of these compounds are now understood. Some of the better known and important occupational exposures to these compounds are listed chronologically in Table 2.

Table 2. Occupational accidents involving dioxin-like compounds

Year	Location	Manufacturer or Incident	Type	Number of workers	Degree of exposure
1949	Nitro, West Virginia, USA	Monsanto	Explosion	>200	High
1952-54	Hamburg, Germany	Boehringer-Ingelheim	Occupational	>100	High
1953	Ludwigshafen, Germany	BASF	Explosion	75	High
1965-67	Ufa, Russia	Khimprom	Occupational	>100	High
1965-70	Vietnam	Agent Orange handlers and sprayers	Occupational	>1000	Moderate-low
1968	Bolsover, England	Coalite	Explosion	~100	High
1981	Binghamton, U S A	PCB transformer fire and cleanup	Explosion	<50	Moderate-low
1996	Swan Hills, Canada	Incinerator fire	Explosion	<20	Moderate-low

In the above list, the degree of exposure has been categorized either from an observed health effect (usually chloracne) or from measured blood levels. It is noteworthy that the highest exposure has resulted from the manufacture of chlorinated compounds (e.g. the early American and German production cohorts) and not from their use such as spraying or handling (e.g. the Ranch Hand study of Agent Orange). Most of the above incidents took place many decades ago prior to the realization of the danger from chlorinated aromatic compounds many of which are now candidates for global regulation under the umbrella of persistent organic pollutants (POPs). Some additional industries have recently been found to generate significant amounts of dioxin-like compounds. However, contemporary examination of workers in such occupations as waste incineration, pulp and paper production, chloralkali manufacturing, and metal processing (nickel, steel, copper, aluminum etc) has shown only moderate to low level worker exposure. In addition, those

individuals involved in control and cleanup of fires originating from material with significant amounts of dioxins, furans, or PCBs do not appear to uptake important amounts of these compounds in the short time span usually involved.

A similar listing as above is given below for environmental exposure in Table 3. Exposure from environmental accidents is more variable in degree, is less likely to be recognized initially as hazardous, and is more inclined to be chronic in duration. One of the reasons for the somewhat insidious nature of this type of exposure is that many of the environmental accidents occur from the consumption of contaminated foods. Usually such behavior involves the ingestion of relatively low concentrations of contaminants over an extended period of time, often months, which does not lend itself readily to detection of the adulteration. A notable exception to this has been the Seveso accident in 1976 where a toxic plume containing extensive amounts of TCDD exposed a civilian population both dermally and through respiration, and even through the consumption of tainted food. Mention should also be made of the recent adulteration in Belgium of chicken feed with PCBs and the related PCDFs. At this writing, the question of source and full impact of this food poisoning have yet to be clarified.

Table 3. Environmental accidents involving dioxin-like compounds

Year	Location	Name	Incident	Number of individuals	Degree of exposure
1957	U S A	Chick edema	Contaminated poultry products	Large but unknown	Uncertain; analysis not available
1968	Southern Japan	Yusho	PCB and PCDF contaminated rice oil	~ 2000	Elevated; health effects
1971	Missouri, U S A	Times Beach	TCDD containing waste oil	Not certain but high	Probably moderate to low
1976	Seveso, Italy	Seveso	Explosion of trichlorophenol production	Thousands	High to moderate
1979	Middle part of Taiwan	Yucheng	PCB and PCDF contaminated rice oil	>2000	Elevated; health effects
1999	Belgium	Chickengate	PCB and PCDF contaminated chicken feed	Uncertain but possibly high	Most likely low

Comments

It is to be anticipated that accidental exposure of people from the occupational manufacture of chlorinated compounds including the dioxin-like compounds will decrease to a very low level given that most chlorinated pesticides and other POPs are no longer produced in industrialized countries. However, it is to be expected that significant exposure may still occur from environmental contamination given the widespread global occurrence of these materials. In the latter context the PCBs are noteworthy. Although no longer produced in industrialized countries, large amounts of PCBs continue to be used and some of these can find their way into the food supply as evidenced recently in the Belgian chicken feed incident.

References

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