

Inventory of Sources and Releases of Dioxin-Like Compounds in the United States

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I. Introduction

In 1996, the U.S. Environmental Protection Agency (USEPA) began a detailed assessment of the sources of CDDs and CDFs in the United States. This purpose of the process was to gain a better understanding of the types of sources that form and emit CDDs and CDFs, and, to develop a national inventory of sources and releases. Within the limitations of the data, estimates of total environmental releases of CDDs, CDFs to air, water, and land were made from each source. The focus of this lecture will be to discuss the rudiments and structure of the U.S. Inventory of Sources.

II. Methods

The USEPA generally classified sources of CDDs/CDFs as: combustion sources; metals smelting, refining and processing; chemical manufacturing; biological and photochemical processes; and reservoir sources. These classifications are summarized in Table 1. The sources were evaluated for environmental releases from the perspective of time-dependency. Two reference years were selected: 1987 and 1995. 1987 was selected to represent sources that were largely uncontrolled with respect to dioxin. 1995 represents a time when many identified sources had controlled or reduced dioxin releases. The use of reference years allows for time-trend analysis. Annual environmental releases from a single source or a class of sources were generally estimated by multiplying the emission factor by the annual activity level, as in equations 1 and 2 below.

$$E_{total} = \sum E_{tested,i} + \sum E_{non-tested,I} \quad (\text{Equ. 1})$$

$$E_{total} = \sum E_{tested,i} + \sum (EF_I * A_i)_{non-tested} \quad (\text{Equ. 2})$$

Where:

- E_{total} = annual environmental releases from all sources; g TEQ yr⁻¹
- E_{tested} = annual environmental releases from all tested facilities in source class i; g TEQ yr⁻¹
- $E_{non-tested}$ = annual environmental releases from all untested in source class I;
g TEQ yr⁻¹
- Ef_i = mean emission factor for tested facilities in class I; g TEQ yr⁻¹
- A = activity measure for untested facilities class I; kg yr⁻¹

Some source categories are made up of facilities that vary widely in terms of design and operating conditions. For these sources, subcategories were created that grouped facilities with

common features, and then separate emission factors were developed for each subcategory. Implicit in this procedure is the assumption that facilities with similar design and operating conditions should have similar CDD/CDF release potential. Each subcategorization was based on the differences in design and operating conditions, combined with what is known about how these features contribute to CDD/CDF formation and release. A confidence-rating scheme was developed to reflect differences in the quality of data used, and as a qualitative indicator of the uncertainties associated with their development.

Table 2 outlines the confidence ratings.

III. Technical Issues

In addition to the complexities of developing an accurate and reliable national inventory of sources of dioxin-like compounds, there are a number of technical issues to be addressed and presented.

Among these issues topics are:

1. Municipal Solid Waste Combustion: Differences in emission factors corresponding to differences in system design, and design of the air pollution control technology.
2. Medical waste incineration: Differences in emission factors corresponding to whether the facility is controlled or uncontrolled with respect to particulate matter and acid gases.
3. Cement kilns: Differences in emissions between facilities that burn and don't burn hazardous waste as supplemental fuel, and the importance of temperature inlet to the control device.
4. Forest fires: Are forest fires sources of dioxin-like compounds, or are they re-emitting dioxin-like compounds stored in the biomass?
5. Back yard trash burning: How big a potential source is this?
6. Sources that can not be quantified because of limitations in existing data.
7. Dioxin-like PCBs. Are PCBs formed in combustion sources? What are potential sources?
8. The importance of the reservoir sources.

IV. Results

Table 3 summarizes the annual dioxin TEQ emissions from sources in the United States for both reference years. The following conclusions can be made from the national source inventory:

1. The environmental releases of CDD/CDFs in the U.S. occur from a wide variety of sources, but are dominated by releases to the air from combustion-related activity.
2. Central estimates of releases of CDDs/CDFs to all environmental media were approximately 12 kg TEQ and 3 kg TEQ in reference years 1987 and 1995, respectively.
3. Comparison of the central estimates suggests that there was approximately a 75% decrease in releases of CDDs/CDFs to the U.S. environment between 1987 and 1995.
4. The development of a national inventory of sources of CDDs/CDFs and other POPs permits the identification of annual environmental releases; identification of the principal sources contributing to these releases; and an analysis of time-trends with respect to the magnitude of environmental release.

V. References

1. *The Inventory of sources of Dioxin in the United States*. The Office of Research and Development, National Center for Environmental Assessment, Washington, DC 20460. External Review Draft. EPA/900/P-98/002Aa, April 1998.
2. *Database of Sources of Environmental Releases of Dioxin-Like Compounds in the United States*. The Office of Research and Development, National Center for Environmental Assessment, Washington, DC 20460. External Review Draft. EPA/900/P-98/002Ab April 1998.

VI. Tables

Table 1 Classification of Principle Confirmed Sources of CDD/CDFs in the United States

Sources	Description
I. Combustion Sources	CDD/CDFs are formed in most combustion systems. These can include waste incineration, burning of various fuels (e.g., wood, petroleum products), other high temperature sources (such as cement kilns), and poorly controlled combustion sources (such as building fires).
II. Metals Smelting, Refining	CDD/CDFs can be formed during various types of primary and secondary metals operations including iron ore sintering, steel production, and scrap metal recovery.
III. Chemical Manufacturing	CDD/CDFs can be formed as by-products from the manufacture of chlorine bleached wood pulp, chlorinated phenols
IV. Reservoir Sources	Reservoirs are materials or places which contain previously formed CDD/CDFs or dioxin-like PCBs and have the potential for redistribution and circulation of these compounds into the environment. Potential reservoirs include soils, sediments, vegetation, and PCP-treated wood. Recently, CDD/CDFs have been discovered in ball clay deposits. Although the origin of the CDD/CDFs in these clays has not been confirmed, natural occurrence is a possibility

Table 2. Confidence Rating Scheme for U.S. Emission Sources

Category	Rating	Activity Level	Emission Factor
A	High	Comprehensive data	Comprehensive data
B	Medium	Based on limited data	Based on limited data
C	Low	Based on expert judgment	Derived from few tested facilities
D	Preliminary Estimate	Inadequate data	Inadequate for more than an order of magnitude estimate
E	Not quantifiable	Insufficient data	Insufficient data

Table 3 Inventory of Sources Types and Estimates of Environmental Releases of CDD/CDF (expressed as g I-TEQ yr⁻¹) in the United States: 1995 and 1987

Source Category	Release type	Confidence Ratings Reference Year 1995			Confidence Ratings Reference Year 1987		
		A	B	C	A	B	C
WASTE INCINERATION							
Municipal solid waste	Air		1,100			7,915	
Hazardous waste incineration	Air		5.7			5.0	
Boilers/industrial furnaces	Air			0.38			0.77
Medical waste incineration	Air			477			2,470
Crematoria	Air			9.1			5.5
Sewage sludge incineration	Air		6.0			6.0	
Tire combustion	Air			0.11			0.11
POWER/ENERGY GENERATION							
Vehicle fuelleaded	Air			1.7			32.4
.....unleaded	Air			6.3			3.8
.....diesel	Air			33.5			26.3
Wood Combustion	Air						
residential	Air			62.8			89.6
industrial	Air		29.1			27.5	
Coal combustion.....utilities	Air		72.8			62.6	
Oil combustion..... utilities	Air			9.3			15.6
HIGH TEMPERATURE SOURCES							
Cement kilns (with haz waste)	Air			**			**
Cement kilns (no haz waste)	Air			**			**
Cigarette combustion	Air			0.81			1.0
Carbon reactivation furnace	Air			0.15			0.11
Kraft recovery boilers	Air		2.3			2.0	
Forest, brush, straw fires	Air			208			170
METALLURGICAL PROCESS							
Ferrous metal smelting/refining							
Sintering plants	Air		25.8			30.1	
Nonferrous metal smelt/refining	Air						
Primary copper	Air		0.5			0.5	
Secondary aluminum	Air			27.4			15.3
Secondary copper	Air			541			308
Secondary lead	Air		1.63			1.22	
Drum and barrel reclamation	Air			0.23			0.23
CHEM MANUFACTURING							

Source Category	Confidence Ratings Reference Year 1995				Confidence Ratings Reference Year 1987		
	Release type	A	B	C	A	B	C
EDC/vinyl chloride	Air		11.2			NA	
EDC/vinyl chloride	Water		0.43			NA	
Bleached chemical wood pulp and paper mills	Water	19.5			356		
Bleached chemical wood pulp and paper mills	Land	1.4			14.4		
Municipal wastewater sludge	Land	207			207		
Total Releases in 1995	~ 3 Kg						
Total Releases in 1987	~12 Kg						

Note: ** in the boxes for cement kilns indicates that emissions are currently under review.

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