RISK MANAGEMENT IMPLICATIONS OF EMERGING DIOXIN SCIENCE

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Introduction

Dioxin science has made significant advances over the last decade. Direct epidemiological evidence of the carcinogenic potential of dioxins in humans has reinforced concerns that were initially based only on animal data (1). An ever increasing list of non-cancer effects have been documented (1), and many consider them to be of equal or greater concern than cancer(2). At the same time that advances in dioxin toxicology were made, even more significant advances have been accomplished in dioxin exposure science. The list of dioxin sources, both quantifiable and suspected, has increased significantly and many countries have developed national dioxin environmental release inventories. Levels and pathways of human exposure have been documented as have environmental trends. Collectively, these scientific advances reveal a much more complicated and sometimes counter intuitive view of dioxin risk. This paper identifies a few of these scientific advances and explores their implication for risk management.

Discussion

Emission inventories of industrial nations have successfully estimated dioxin emission for most industrial-scale waste combustion sources. In the U.S. releases from municipal and medical waste incinerators dominated release estimates and have also undergone dramatic reductions as a result of regulations (1). In the U.S., municipal and medical waste air emissions have dropped from 8800 $gTEQ_{dfWHO98}$ in 1987 to 1250 $gTEQ_{dfWHO98}$ in 1995 and are expected to be less than 12 $gTEQ_{dfWHO98}$ when implementation of current standards is complete (2004). Collectively, these will represent a >90 % decrease in overall quantifiable emissions. Similar kinds of reductions are occurring in other countries as well. Unfortunately, however, these dramatic reductions may not be representative of the reduction of overall environmental releases in the U.S. A significant number of sources are not included in the inventory because of a lack of data to support sound quantitative estimates. Among the poorly characterized sources are a number of industrial categories as well as broad groups of uncontrolled combustion sources (landfill fires, agricultural burning, forest fires, structural fires). Recent progress in characterizing “backyard barrel burning” has resulted in an estimate that this form of uncontrolled combustion is likely to be the largest quantifiable source to air by the year 2004 and will be 10 times larger than the next largest air release. If other uncontrolled combustion sources, either collectively or individually, are of the same magnitude as barrel burning, then releases from uncontrolled combustion may have played a much more important role historically than indicated by current inventories based primarily on industrial sources. In non-industrial and developing countries, uncontrolled burning appears to be much more prevalent and is likely to dominate release for these countries and possibly total global releases. What is less clear is whether uncontrolled combustion in non- industrialized countries can result in environmental or exposure levels similar to those found in industrialized nations. Progress in characterizing these sources is of immediate policy relevance for both developed and developing nations.

An additional source category that is poorly understood but has similar policy relevance is reservoir sources. Reservoir sources come from past releases that have been temporarily sequestered in soil, sediment, biota or other media and later reintroduced into the circulating environment. The EPA draft dioxin reassessment suggests that as much as half of current general population exposure to dioxin-like substances can be attributed to reservoir sources. If this estimate is reasonably close, it carries with it significant implications for identifying risk management opportunities. Given the magnitude of past releases to the environment and the persistence of dioxin-like compounds, it seems likely that existing reservoir sources could sustain their current level of exposure contribution for decades. If this is the case, then, even if we could eliminate all contemporary sources, exposure and subsequent risks could be sustained at about 50 % of its current level for decades. Better quantifying the current exposure contribution made by reservoir sources and gaining a better understanding of future strength of these sources would do much to facilitate long-term strategic planning for dioxin risk management.

There is, however, at least some potential of reducing exposure from reservoir sources. For developed countries, most of general population exposure comes from the commercial food supply (>95 % in the U.S.). If opportunities can be identified that prevent or reduce dioxin transmittal in the flow of dioxins from source to dietary intake, then exposure from reservoir sources (and potentially contemporary sources) could be reduced. A few examples of successful pathway interventions have already been demonstrated. Reduction in dioxin levels in animal feeds have been accomplished by eliminating contaminated feed additives such as ball clay; contaminated citrus pulp; contaminated mineral supplements; and through reducing the levels of dioxin contamination in fish oils used in animal feed. A detailed examination of how and where dioxin flows through the human food chain could lead to identification of a number of pathway intervention opportunities. The full potential for pathway interventions to reduce dioxin risk is unknown, and pathway intervention should not be seen as a substitute for source control. Rather, without pursuing both source control and pathway inventions simultaneously, our ability to significantly reduce general population exposure will be limited.

If we examine what has been learned about the size and distribution of sources in the context of the food pathways, it becomes clear that it is not the size of a source alone that determines its contribution to risk but rather the contribution that source makes to the food supply. In the U.S. animal fat production tends to be concentrated in a limited number of geographic areas and, consequently, so is the entry of dioxin into the food supply. Coincidently, large dioxin sources are also concentrated in specific geographic areas, primarily in the eastern U.S., associated with high population densities. As a consequence, a majority of the dioxins released to air in the U.S. are being emitted downwind of most intensive animal fat production areas. This leads to the possibility that small to moderate sources more closely associated with domestic meat and dairy production (e.g., uncontrolled burning) may make an exposure contribution that is disproportionately large compared to historically big sources such as municipal and medical waste incinerators

Two opportunities exist to test this hypothesis. In the U.S., surveys of dioxin in meats were conducted in the mid-90’s just as waste combustion regulations were promulgated. These surveys are currently being repeated and the results should provide some empirical basis for evaluating the impact these regulations have had on dietary exposure levels. An additional approach for evaluating the relative contribution sources make to food production areas is long-range air transport modeling. Both the U.S. EPA and the National Oceanographic and Atmospheric Administration (NOAA) have been working to incorporate dioxin into long-range air transport models. When development and testing of these models is completed, they can be used to estimate the relative contribution different sources make to ambient air in agricultural production areas. This air modeling work is part of a broader effort through the EPA Dioxin Exposure Initiative (DEI) to quantitatively link current intake back through

Inventory of Sources of Dioxin in the United States-	1987 * Emissions (g TEQdf-WHO98/yr)	1995 * Emissions (g TEQdf-WHO98/yr)	2002/4 ** Emissions (g TEQdf-WHO98/yr)
Backyard barrel burning	604.0	628.0	628.0
Sewage Sludge/land applied, land	76.6	76.6	76.6
Residential Wood Burning, air	89.6	62.8	62.8
Coal-fired Utilities, air	50.8	60.1	60.1
Diesel Trucks, air	27.8	35.5	35.5
Secondary Aluminum Smelting, air	16.3	29.1	29.1
2,4-D, land	33.4	28.9	28.9
iron ore sintering	32.7	28.0	28.0
Industrial Wood Burning, air	26.4	27.6	27.6
Cement Kilns (non-haz waste)	13.7	17.8	17.8
Sewage Sludge Incineration, air	6.1	14.8	14.8
Municipal Solid Waste Incineration, air	8877.0	1250.0	12.0
Bleached Pulp and Paper Mills, water	356.0	19.5	12.0
EDC/Vinyl chloride, air	NA	11.2	11.2
Oil-fired Utilities, air	17.8	10.7	10.7
Crematoria	5.5	9.1	9.1
Cement Kilns (haz waste), air	117.8	156.1	7.7
Medical Waste Incineration, air	2590.0	488.0	7.0
Unleaded Gasoline	3.6	5.9	5.9
Secondary Copper Smelting, air	938.0	271.0	5.0
Hazardous Waste Incineration, air	5.0	5.8	3.5
Kraft Black Liquor Boilers	2.0	2.3	2.3
Petrol Refine Catalyst Reg., air	2.2	2.2	2.2
Leaded Gasoline, air	37.5	2.0	2.0
Secondary Lead Smelting, air	1.2	1.7	1.7
Paper Mill Sludge, land	14.1	1.4	1.4
Cigarette Smoke	1.0	0.8	0.8
EDC/Vinyl chloride, land	NA	0.7	0.7
EDC/Vinyl chloride, water	NA	0.4	0.4
Lightweight ag kilns, haz waste,air	2.4	3.3	0.4
Boilers/industrial furnaces	0.8	0.4	0.4
Drum Reclamation	0.1	0.1	0.1
TOTALS	**13,949**	**3,252**	**1,106**
Net Percent Reduction from 1987		77%	92%

* From EPA draft dioxin reassessment

** preliminary estimate not part of reassessment exposure pathways to their sources of origin, including reservoirs. This work, if successful, would provide a basis for evaluating the risk reduction potential of both source controls and pathway interventions. With major sources under strict regulatory control and dozens of small source categories unaddressed by regulation, an exposure- based source attribution analytic capability would provide a powerful tool for risk management priority setting.

The views expressed in this paper are those of the author and do not necessarily reflect the position of the United States Environmental Protection Agency

1. U.S. EPA (2000) Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-P-Dioxin (TCDD) and Related Compounds, Sept 2000.
2. Dioxin Reassessment - An SAB Review of the Office of Research and Development's Reassessment of Dioxin EPA-SAB-EC-01-006 May 2001