# Diesel Engine Emissions and The Link to Human Dioxin Exposure

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## 1. Introduction

The role of mobile sources in human dioxin exposure has not been given adequate attention. The U.S. EPA has instead totally focused on waste combustion sources as being the primary source of food chain uptake of dioxins. Although the data base on direct emissions measurements is quite limited there is a growing body of evidence which associates the various environmental media observations with diesel engine emissions. The fingerprint of diesel engine exhaust is unique and distinct in comparison to waste combustion sources. Most environmental media data mirror this source. Observed concentrations of dioxins can also be predicted from the emissions factors developed by this author.

## 2. Background

During the course of the conduct of a risk assessment for a proposed hazardous waste incinerator this author evaluated the potential dioxin emissions from other sources in the vicinity of the proposed site. This investigation led to the development of emissions factors for gasoline and diesel powered cars and trucks, a nationwide estimated emissions inventory, and the modeling of atmospheric concentrations of dioxins along roadways.[1] The total national emissions estimate for cars, buses, and trucks was about 1100 gm TEQ/yr. Although EPA's best estimate of the total recognized inventory was 9200 gm TEQ/ yr.[2] an extensive peer review found major qualitative and quantitative flaws in this EPA inventory.

It is this author's opinion that mobile diesel dioxin emissions including off highway sources, e.g., railroads, ships, farm equipment, construction equipment etc., account for the largest dioxin source category in the United States. The U.S. EPA has estimated that hospital incinerators accounted for 5,100 gm TEQ/ yr. However, EPA has informally admitted that this estimate was high by more than an order of magnitude. The American Hospital Association's (AHA) detailed inventory estimate[3] is 140 gm TEQ/ yr., while this author's previous estimate was 527 gm TEQ/ yr.[1] EPA's estimate of emissions from municipal waste combustion is also high by at least two fold. Further, some 24 old control technology RDF and refractory walled incinerators are responsible for over 90% of the current nationwide inventory from the 170 facilities in this source category. In addition to the equivalent magnitude of the mobile source inventory to other possible stationary source categories, the link between mobile source emissions and multipathway exposures is overwhelmingly favored based on source receptor considerations.

3. Approach

In this study available fingerprint data associated with the various environmental media was compared to the diesel exhaust 2378 congener profile. Additionally, some specific source receptor impacts were evaluated numerically and qualitatively.

4. Results

Figure I shows the adipose and serum 2378 congener profiles from three separate sample populations in the U.S.[4) 5)]They are almost identical in pattern with the 2378 HxCDD HpCDD and OCDD as the dominant congeners. There is no clear explanation as to whether or not this pattern is biased by preferential bioconcentration or excretion factors. EPA's recent draft dioxin reassessment states that our current body burden of dioxins/ furans is primarily from the consumption of contaminated foodstuffs , in particular beef and dairy products,[2)] i.e., 66% of our total daily intake. Figure 2 shows the 2378 congener profiles for U.S. beef and cows milk and cattle in Germany. [6) 7)] The similarity in the human tissue/ serum and foodstuff 2378 congener profiles is evident. This makes sense in that the pharmokinetics in the two species are more than likely similar.

Figure 3 shows the emissions profiles for several known emissions[8)9)10)11)] and exposure sources. Only diesel emissions and pentachlorophenol have similar fingerprints , while stationary waste incineration sources show little relationship to the animal and human profiles. It is difficult to broadly associate the likelihood of pentachlorophenol residues to the dairy/ beef contamination pathway. Alternatively, there are several pathways suggesting diesel engines as the direct or indirect source. These are:

1. farm machinery fumigation of fodder crops
2. open truck crop transportation
3. rural highway/ railroad emissions related deposition on crops
4. feed lot soil contamination by adjacent highways/ railroads
5. contaminated manure recycling

If the ambient air 2378 air congener profile and the associated concentrations necessary to achieve the observed U.S. beef levels are back calculated, it is found that the profile mirrors that of diesel exhaust. (See Figure 4.) The total concentration of the 2378 congeners near the fodder crop would theoretically have to be about 4 pg/ $m^3$, which is higher than most urban levels in the U.S. (See Table 1.) This result supports the farm machinery fumigation pathway possibility. Soil data from a recent study [12)] in Norfolk, Virginia shows high concentrations (8-21 ppt TEQ) and diesel like profiles in the soil samples taken near a major freeway and a RDF incinerator. (See Fig. 5.) It is apparent that diesel exhaust is the principal contributor, not the RDF incinerator emissions.

The U.S. EPA has suggested that urban sources, in particular stationary waste combustion sources are the most likely causes of fodder and hence beef/ dairy contamination. This hypothesis is driven primarily by EPA's reliance on an EPA report authored by Hites.[13)] Hites hypothesized that urban air ( his data from

Bloomington and Indianapolis) undergoes atmospheric transformation between the urban sources and his identified ultimate sink, i.e., the sediments in Siskwit Lake on Isle Royale in the remote upper region of Lake Superior.

There are two compelling pieces of evidence which support an alternative explanation. Most urban ambient data which are not influenced by known point sources mirror diesel exhaust and not necessarily the Bloomington and Indianapolis ambient data analyzed by Hites. (See Fig. 6.) Note also that Hites' sediment profile looks very much like diesel exhaust. Secondly, Siskiwit Lake is not remote with respect to sources that were not discussed by Hites. There is a very large industrial/ shipping complex located in Thunder Bay some 40 km. away. But more importantly, all of the shipping to U.S. ports out of Thunder Bay passes within a few kilometers of Isle Royale. The sediment data of Czuczwa et al[14] show an increasing deposition flux until the early 70's and declining since then. These authors believe that this trend could be associated with air pollution controls placed on incinerators in the U.S. An alternative explanation relates to the changes to the shipping technology in the Great Lakes and their likely dioxin emissions. In the early 70's the Great Lakes shipping industry made a dramatic shift from less efficient steam powered ships to much larger fuel efficient diesel powered ships. Although dioxin emissions factors do not exist for either of these power systems, the estimated fuel economy factors[15][16] match the sediment flux trends quite closely as shown in Figure 7. These same relationships, based on preliminary dioxin emissions trends estimates, appear to explain the Green Lake sediment observations made by Smith et. al.[17] There are three major potential diesel engine emissions sources near Green Lake, namely the Erie Canal, the N.Y. Throughway and Conrail.

A strong correlation exists between the diesel truck emissions estimate made by this author and the 2378 congener profile and ambient concentrations measured at a major freeway interchange in L.A.[18] The sampler was located approximately 50 meters from the interchange. The observed ambient average concentration was .08 pg TEQ/$m^3$ (n=3). *The predicted concentration was* .14 pgTEQ/$m^3$. *The* 2378 congener profiles were also similar.

## 5. Conclusions

There is an increasing body of evidence to suggest that mobile sources, in particular diesel powered vehicles may be the predominant direct and indirect source of human dioxin exposure. Mass emission rates, source receptor considerations and congener fingerprints strongly support this view. A much more thorough evaluation is needed in the U.S. before rational conclusions can be drawn about the sources of our current exposure as well as whether or not a deminimus emission policy relative to stationary sources has any scientific rationale.

## 6. References

1) Jones, Kay H.: Diesel Truck Emissions, an Unrecognized Source of PCDD/PCDF Exposure in the United States. Risk Analysis (1993), Vol. 13, No. 3, 245-252.
2) Review Draft, EPA/600/6-88/005Cb U.S. EPA (June 1994): Estimating Exposure to Dioxin-Like Compounds, Vol. II: Properties, Sources, Occurrence and Background Exposures.
3) AHA, Office of Health Facilities Management, Chicago (Jan. 1995): Comments from the American Hospital Association on U.S. EPA Dioxin Exposure and Health Effects Documents.

4) Patterson, D.G. Jr., Todd, G.D., Turner, W.E., Maggio,V., Alexander, L.R., Needham, L.L.: Levels of Non-Ortho Substituted (Coplaner), Mono-and Di-Ortho Substituted Polychlorinated Biphenyls, Dibenzo-p-Dioxins, and Dibenzofurans in Human Serum and Adipose Tissue, Env. Health Perspective Supplements, (1994) Vol. 102, Suppl. 1: 195-204.
5) Schecter, A, Devito, M.J., Boggess, K.: Dioxins, Dibenzofurans and Dioxin-Like PCBS in Blood of Americans, Dioxin 93, Ecoinforma Press,Bayreuth Ger.,V.13,51-54.
6) Winters, D., Lorber, M., Cleverly, D., Schaum, J., Harless, R., Dupuy, A., McDaniel, D., Ferrario, J., Byme, C., Ellis, R., Deyrup, C., Meier, K, Leese, W., Walcott, J. : Statistical Survey of Dioxin - Like Compounds in the U.S. Beef Supply, presented at Dioxin 94, Kiota, Japan.
7) Jimenez B., Gonzalez, M.J., Hernandez, L.M. : Presence of PCDDs and PCDFs in Food for Human Consumption: A Review, Food Chemistry 39 (1991), 257-271.
8) Personal communication with T. Tiernan, Wright State Univ. (1994): PCP Profile Data.
9) Hagenmaier, H., Dawidowsky, N., Weberrus, U., Hutzinger, O., Swind, K.H., Thoma, H., Buhler, U., Greiner, R.,: Emission of Polyhalogenated Dibenzodioxins and Dibenzofurans from Combustion-Engines, (Diesel and Pb Car Profile Data), Short Papers, Dioxin 90, EcoInforma Press , Bayreuth, Germany (1990).
10) State of California Air Resources Board: Determination of PCDD and PCDF Emissions from Motor Vehicles, Oct. 1987 draft. (Diesel Profile Data.)
11) Crane, G.K., Brasowske, L., Nagy, C.G., Aldina, G.J.: The Dioxin Fingerprint, presented at Intl. Conf. on Solid Waste Management Thermal Treatment and Waste To Energy Technologies, (April 1995,) Wash. D.C.
12) Soil Sampling Study Report, submitted to U.S. EPA Region III by Southeastern Public Service Authority of Virginia (SPSA), Sept. 1994.

13) Hites, R.A.: Atmospheric Transport and Deposition of Polychlorinated Dibenzo-P-Dioxins and Dibenzofurans, (Jan., 1991), NTIS PB91-144667.
14) Czuczwa J.M., Hites, R.: Airborne Dioxins and Dibenzofurans: Sources and Fates, Env. Sci. and Tech. (1986), Vol. 20, No. 2.
15) Personal communication with Port of Thunder Bay, Dec. 1994.
16) Personal communication with Great Lakes Commission, Dec. 1994.
17) Smith, R.M., O'Keefe, Hilker, D.R., Bush, B. Conner, S., Donnelly, R., Storm, R., Liddle, M. : The Historical Record of PCDDs, PCDFs, PAHs, PCBs, and Lead in Green Lake, New York - 1860-1990, Dioxin 93, Vol. 12, Ecoinforma Press, Bayreuth, Germany, 215-218.
18) Hunt, G., Maisel,B., Hoyt, M.,: Ambient Concentrations of PCDDs/PCDFs in the South Coast Basin: Report to California Air Resources Board (Jan. 1990), ENSR Consulting and Engineering, Acton, MA.

**TABLE 1**
**Background Urban/ Suburban Ambient**
**2378 PCDD/ PCDF Congener Concentrations**

| Urban Region | Number of Observations | Average 2378 PCDD/ PCDF Concentration (pg/m3) |
|---|---|---|
| Niagra, N.Y. | 16 | 1.92 |
| Bridgeport, CT | 7 | 3.62 |
| Wallingford, CT | 16 | 6.58 |
| Albany, N.Y. | 3 | 3.21 |
| Los Angeles, CA | 27 | 30.12 |

Figure 1: 2378 Congener Profiles in the Adipose Tissue and Serum of U S Populations

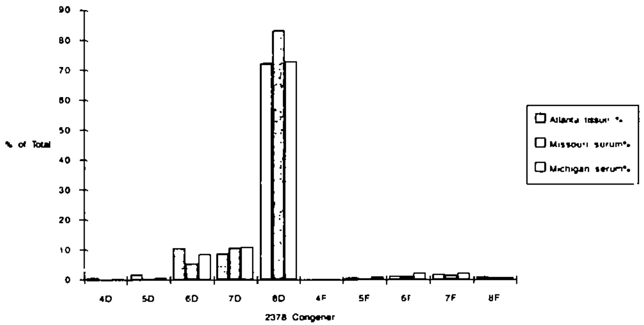


Figure 2. 2378 Congener Profiles for U S Beef, and Milk and Cattle in Germany

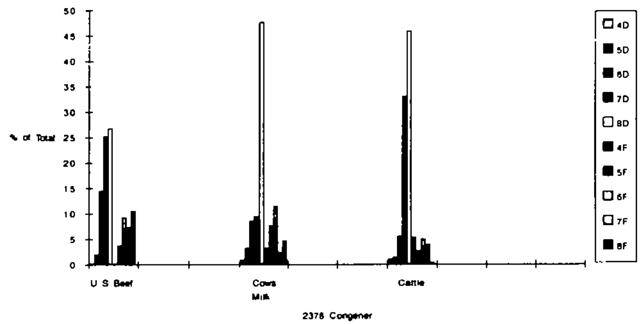


Figure 3 2378 Congener Profiles for Recognized Sources of Dioxins Emissions

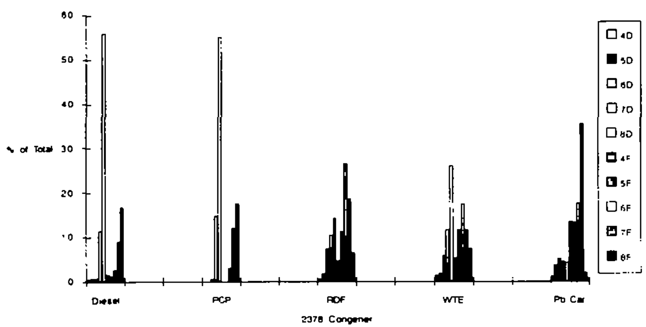


Figure 4 Comparison of 2378 Congener Profile for Perfect Fit Air to Beef Model Fit and Diesel Exhaust

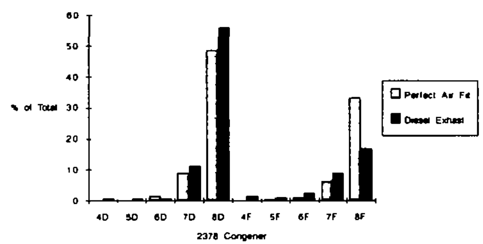

Figure 5 Comparison of SPSA/Navy and ABEX Soil 2378 Congener Profiles to Navy RDF Plant and Diesel Emissions

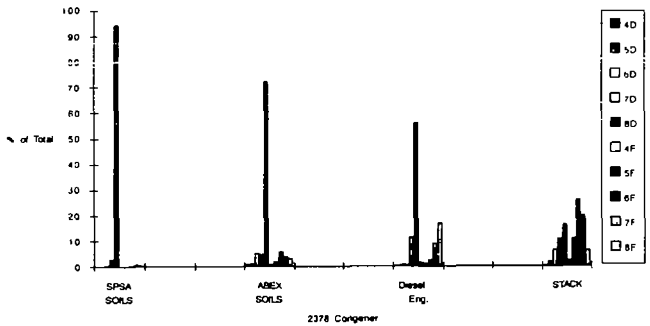


Figure 6 Comparison of Urban Air Homologue Profiles to Siskiwit Lake Sediment Profile

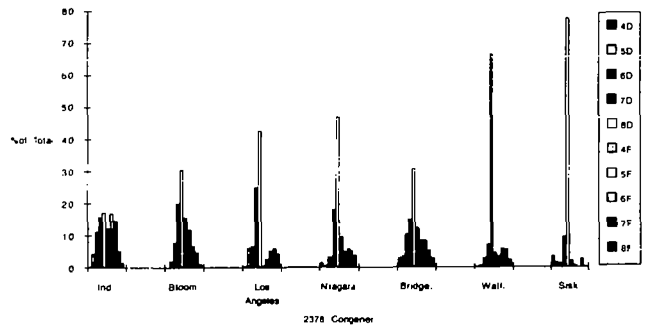


Figure 7. Trends in Thunder Bay Shipping and Fuel Use Estimates Relative to Lake Siskiwit Sediment Deposition Rates