EVALUATING INCREMENTAL EXPOSURES TO POINT SOURCE RELEASES OF DIOXIN-LIKE COMPOUNDS INTO THE ENVIRONMENT

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The United States Environmental Protection Agency (EPA) is currently reassessing the exposure to and human health/ecological impacts of dioxin and related compounds. This effort began in 1991 and is expected to be completed in late 1993. This paper describes the progress and some key findings of the exposure portion of this effort.

A potential dose is defined as a daily amount of contaminant inhaled, ingested, or otherwise coming in contact with outer surfaces of the body, averaged over an individual's body weight and lifetime. The procedures described in the exposure document are used to estimate dose in the form needed to assess cancer risks.

Before making exposure estimates, the assessor needs to gain a more complete understanding of the exposure setting and the contamination source. The approach used for this assessment is termed the exposure scenario approach. Brief descriptions of 7 steps in this approach are:

1) **Identify Source:** Three principal sources are addressed in this document: "soil sources" where the starting point of the assessment is soil contamination, "stack emissions", which refer to industrial discharges from tall stacks such as from municipal solid waste incinerators, and "effluent discharges", which are point source inputs to surface water bodies.
2) **Estimate Release Rates:** Releases from soil contamination include volatilization, and wind and soil erosion. Stack emissions and effluent discharges are point source releases into the environment.
3) **Estimate Exposure Point Concentrations:** Released contaminants move through the environment to points where human exposure may occur, and/or to impact environmental media to which humans are exposed. Complex atmospheric transport models are recommended for estimation of fate of dioxin-like compounds emitted from stacks. Otherwise, multi-media exposure modeling approaches are

used as described below.

4) Characterize Exposed Individuals and Exposure Patterns: Exposed individuals in the scenarios described in this assessment are individuals who are exposed in their home environments. They are residents who breathe air at their residence, recreationally fish, have a home garden, farm, and are children who incidentally ingest soil.

5) Put It Together in Terms of Exposure Scenarios: A scenario description includes the physical aspects of an exposure area and the behavior characteristics of the exposed individuals in an impacted population.

6) Estimate Exposure: The end result of having followed the above 5 steps are estimates of individual exposures to a characterized source of contamination.

7) Assess Uncertainty: Uncertainties should be considered when applying estimation procedures to a particular site. Pertinent issues explored in this assessment include: model estimations of exposure media concentrations compared to analogous concentrations found in the literature; similarities and differences for alternate models for estimating exposure media concentrations; sensitivity of model results to a range of values for methodology parameters; mass balance considerations for a bounded site of soil contamination to evaluate the assumption of non-degradation of initially assumed concentrations; qualitative and quantitative discussions on the uncertainties with the exposure parameters and exposure estimates generated for the demonstration scenarios; and judgements on use of the parameters selected for the demonstration scenarios for other applications.

Atmospheric transport models are complex models involving detailed site-specific parameterization and environmental inputs. Otherwise, relatively simple, screening level models are used to model fate, transport, and biotransfer of dioxin-like compounds from the source to the exposure media. A critical assumption made is that the source strength remains constant throughout the period of exposure: the initial soil concentration of dioxin-like compound specified for the soil contamination source categories remains the same for the exposure period, and stack emissions and effluent discharges remain steady throughout this period. The multimedia model used for the stack emission source is shown in Figure 1.

Scenarios were developed to demonstrate the procedures of this assessment. EPA[1] recommends developing a central and high end scenario to provide some idea of the possible range of exposure levels. Central and high end exposures were distinguished in this assessment based on proximity to the source and exposure patterns of behavior. The basic setting for which the methodologies are demonstrated is a rural setting which contains both farms and non-farm residences. "Central" scenarios were based on typical behavior at a residence and "high end" scenarios are comprised of a farm family that raises a portion of its own food. The example scenarios were carefully crafted to be plausible and meaningful, considering key factors such as source strength, fate and transport parameterization, exposure parameters, and selection of exposure pathways.

Key observations, conclusions, and uncertainties are:

1) The most critical input parameters influencing estimations of exposure media concentrations are the source strength terms, which include soil concentrations, stack emissions, and effluent discharges. Nearly always, there is a direct linear correlation between concentration estimated and source strength term - doubling the source strength doubles the concentration, and so on. Second most important are the parameters describing the fate, transport, and transfer of the dioxin-like compounds. These include Henry's Constants, partition coefficient, and bioconcentration/biotransfer parameters. The third category noted, those describing the transfer of dioxin-like compound from environmental into exposure media, are: empirically developed from literature data, highly uncertain and variable, and most often have the same linear and direct impact on exposure media concentrations as was noted above for the source strength terms.

2) Like background exposure estimates developed using measured concentrations data (done as part of EPA's reassessment of dioxin and other assessments), these demonstration scenarios also show that exposures through ingestion of food are the most critical. Ingestion of home-grown beef, fish, milk, vegetables/fruit (listed in order of prevalence to total exposure) accounted for between 76 and 96% of all exposures when all were included in the demonstration scenarios. A childhood pattern of soil ingestion also was noteworthy, as was soil dermal contact. Water ingestion and inhalation generally were very small in comparison to the other pathways considered.

3) Although uncertainties are identified for all parts of the estimation procedures from source characterization to environmental fate, transport, and transfer to exposure characterizations, much of the critical focus EPA has received on estimation methodologies described in this exposure document center on models for estimating concentrations in food products. This is to be expected since ingestion of food products has been speculated as the most critical pathway for exposure to dioxin-like compounds from essentially all literature on the subject. Points of contention include: the appropriate assignment of bioconcentration/biotransfer parameters for dioxin-like compounds, use of an organic carbon normalized sediment concentration-to-fish lipid approach for fish tissue concentration estimation, the existence and prevalence of atmospheric dioxin-like compounds in the vapor phase, and the quantification of atmospheric transfers of vapor and particle phase dioxin-like compounds to plant matter and subsequently to farm animal products (beef, dairy, etc.).

An exercise was undertaken in order to evaluate the model structure and parameter assignment for estimation of beef concentrations of dioxin-like compounds for background exposure estimations. Specifically, a profile of "observed" air concentrations of dioxin-like compounds was routed through the food chain model to arrive at "observed" beef concentrations. The following was recognized as particularly uncertain for this exercise: 1) the "observed" concentration of beef (TEQ concentration profiles that were developed for estimating background exposures based on measured data), 2) the profile of TEQ air concentrations that would exist in a rural environment where beef cattle are raised for slaughter and distribution through grocery stores (the observed beef concentrations originated from beef sample where researchers obtained the samples from grocery stores; two air profiles tested include an urban profile as developed based on measured air data, and a "remote countryside" profile measured in Sweden), 3) given this profile, the partitioning into a vapor phase and a particle phase reservoir (two profiles were tested), 4) given a particle bound reservoir, the velocity of deposition for particle bound dioxin-like compounds which impacts soil concentrations and vegetation concentrations (0.2 cm/sec was used), 5) the vapor phase air-to-leaf transfer coefficient, B_{vpa} (two likely extremes were looked at), 6) an exposure profile for beef cattle (a assumed diet included roughly equal parts grass and cattle fodder, 4% soil ingestion rate, and a specific fattening diet prior to slaughter which reduced body concentrations), and 7) the beef bioconcentration factor, BCF (two BCF assignment profiles for TEQs were tested and both gave comparable results). With these uncertainties identified, it would be presumptuous to claim that the exercise was a model validation exercise. Nonetheless, a best estimate of parameter values for these uncertain parameters was made. With these best estimate parameters, including best estimates of rural air concentrations, the modeled concentration of TEQs in whole beef was 0.53 ppt. This compared against the monitored data in the United States showing an average TEQ concentration of 0.48 ppt.

REFERENCES

1. U.S. Environmental Protection Agency. Guidelines for Exposure assessment. Office of Health and Environmental Assessment, EPA/600-Z-92/001. Federal Register May 29, 1992.

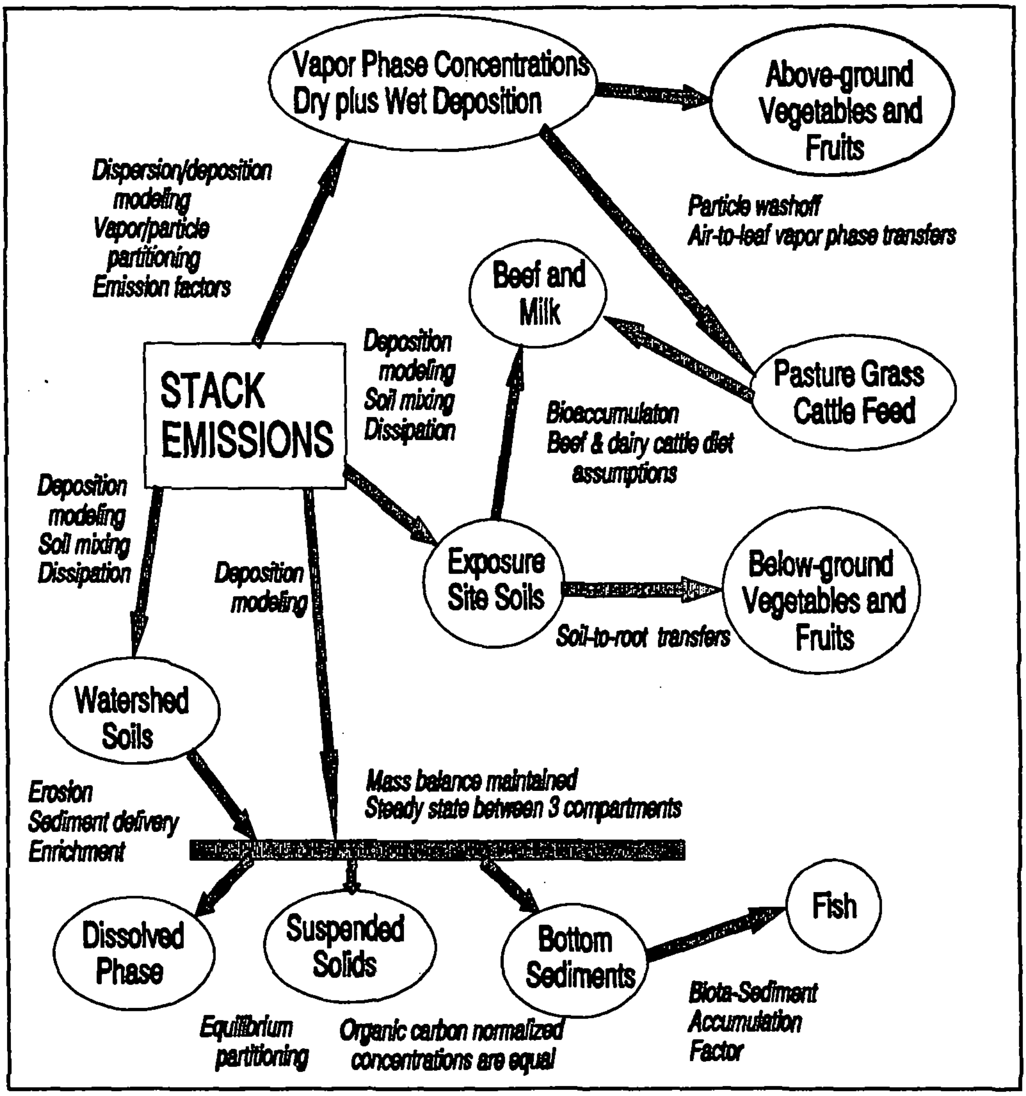

Diagram of the fate, transport, and transfer relationships for the stack emission source category