EPA #540-F-00-008
OSWER #9285.7-34
June 1998

SHORT SHEET:
IEUBK MODEL MASS FRACTION OF SOIL IN INDOOR DUST (MSD) VARIABLE

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U.S. Environmental Protection Agency
Technical Review Workgroup for Lead

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IEUBK Model Mass Fraction of Soil in Indoor Dust (M_{SD}) Variable

STATEMENT OF THE ISSUE

The M_{SD} is a variable in the dust lead (PbD) *Multiple Source Analysis* module of the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children (see IEUBK model data entry window: *Data Entry for Soil/Dust, Multiple Source Analysis, Contribution of soil lead (PbS) to indoor household PbD [conversion factor]*). The M_{SD} represents the mass fraction of house dust that is derived from outdoor soil. It is used in *Multiple Source Analysis* to compute the contribution of outdoor PbS to the indoor PbD concentration. The default value for M_{SD} recommended by EPA is 0.70 g soil/g dust. The *Multiple Source Analysis* input screen for the IEUBK model (version 0.99d; 3/8/94) and IEUBK Model Guidance Manual (U.S. EPA, 1994; pp. 2-13) indicate that the M_{SD} can be expressed as a dust lead/soil lead concentration ratio (PbD/PbS; µg Pb/g dust per µg Pb/g soil). However, this guidance may be subject to misinterpretation; therefore, this report clarifies and supplements the IEUBK Model Guidance Manual.

M_{SD} is equivalent to the PbD/PbS concentration ratio under exposure scenarios where soil is the predominant source of Pb in house dust and where there is no enrichment of the Pb in soil materials transported indoors in comparison with sampled soils (U.S. EPA, 1994; pp. 2-13). In scenarios where non-soil sources are also important contributors to indoor PbD (*e.g.*, lead-based paint, non-soil airborne particulates), M_{SD} represents the contribution of soil to dust; and total PbD levels will exceed those resulting from the soil pathway alone. In order to promote consistency in the use of site-specific data to determine IEUBK model inputs, the M_{SD} should be interpreted as the mass fraction of household dust that is derived from soil; and the PbD /PbS ratio should be viewed as a potentially useful estimator of M_{SD} that is subject to various sources of bias.

BACKGROUND

Soil is a primary source of indoor dust in many residences. Because of the potential for Pb in soil to be transported indoors and contribute to the concentration of Pb in dust, the IEUBK model incorporates a soil-to-dust variable (M_{SD}). The M_{SD} is defined as the mass fraction of soil-derived particles in indoor dust (g soil/g dust).

Values of the M_{SD} are fractions bounded by the values 0 and 1. A relatively low value would reflect a scenario in which soil contributes little to indoor dust mass, whereas a relatively high value would suggest that soil is the predominant source of dust.

The M_{SD} may be used to approximate the concentration of Pb in indoor dust based on the concentration of Pb in nearby soil if the following assumptions are valid at the site:

(1) Soil lead is the major source of indoor dust lead.

(2) The soil data are representative of that portion of the soil fraction and matrix which contributes to indoor dust. There is no enrichment or reduction of Pb in the soil fraction that is transported to indoor dust.

(3) The areas where soil samples are collected coincide with the major source areas for soil derived indoor dust. If the above assumptions are appropriate for a site and the exposure scenarios under consideration, then the dust Pb concentration can be estimated from Equation 1:

$$Pb_D = M_{SD} \cdot Pb_S \qquad \text{Equation (1)}$$

where:

PbD = indoor dust lead concentration (µg Pb/g dust)
PbS = outdoor soil lead concentration (µg Pb/g soil)
M_{SD} = mass fraction of soil in dust (g soil/g dust)

When there are also other significant sources of Pb in indoor dust, the M_{SD} is useful for estimating the contribution that soil makes to house dust levels. This estimate will often be important to soil cleanup goals, where M_{SD} can be used to estimate the amount by which PbD concentrations can be reduced through soil cleanup. However, where there are other significant sources of Pb in dust, attempts to use measured Pb concentration data for soil and dust to estimate M_{SD} become more problematic.

The default value of 0.70 for M_{SD} in the IEUBK model reflects an analysis of empirical relationships between soil and dust Pb concentrations measured in a variety of residential communities (U.S. EPA, 1994; pp. 2–42). An intuitive understanding of the movement of outdoor soil is that the contribution to the total indoor dust mass from outdoor soil is also approximately of the same magnitude or greater when there are no other significant sources of indoor dust; that is, the primary contributor to the indoor dust mass is outdoor soil. However, further studies are needed to confirm the magnitude of the mass movement

with a unit change in PbS concentration. If non-soil sources are suspected of contributing significantly to indoor PbD, multiple regression analysis of data on the contributing pathways can be considered. However, the development of statistical models to predict the impact of paint Pb levels and paint condition on Pb in house dust is likely to be problematic.

It should be kept in mind that even in scenarios in which soil appears to be the major contributor to Pb in indoor dust, a regression analysis of outdoor PbS and indoor PbD concentrations may result in a biased (low) estimate of the M_{SD} due to the effects of measurement error in fitting these models. Standard statistical theory for regression analysis assumes that independent variables (in the present case PbS levels) are known without error. When there is significant error in the independent variables, regression slopes will underestimate the true relationships (and intercept terms will be artificially elevated). In this context, measurement error represents the variability in empirical measurements of the soil levels or other "independent" exposure variables, compared to the "actual," but unobserved, levels contacted by children. This type of measurement error is a broader concern than errors that may occur in sample collection or in the processing and chemical analysis of the samples. Examples of typical sources of measurement error that should be considered when exploring PbS and PbD relationships include: (1) the soil particle size fraction contributing to indoor dust may not be the same fraction that is sampled and sieved to estimate PbS concentrations; (2) the soil sampling locations in a residential yard may not be the same locations where children (and pets) primarily contact soils which are subsequently transported indoors; and (3) neighboring properties and other community soil sources may contribute to indoor dust. The above sources of measurement error will introduce a negative bias into the estimate of the M_{SD} derived from a regression analysis; that is, they will contribute to a reduction in both the regression slope and correlation estimates for indoor PbD and outdoor PbS concentration relationships. Use of an underestimate of the M_{SD} in the IEUBK *Multiple Source Analysis* would result in an underestimate of indoor PbD concentrations (Equation 1).

Lead Speciation

Chemical speciation and physical examination of particulates in house dust may support more direct approaches to determining the contribution of soil derived Pb in house dust. Several methods involving different levels of complexity can be considered. While these methods would require further research and evaluation, they have much potential to strengthen site specific estimates of M_{SD}.

- Analyses using tracer elements and/or particle speciation could be developed to directly estimate fractional amount of soil derived dust that is present in house dust without reliance on Pb measurements.
- Particle identification and micro analytical techniques could be applied to estimate the contribution of dust from lead-based paint to the total Pb content of house dust. If lead-based paint is the major non-soil contributor to house dust, the residual Pb would be attributable to soils.
- Source apportionment of indoor PbD may be possible in some residential scenarios by comparing elemental fingerprints of lead-bearing particles in indoor dust to characteristic fingerprints of source materials (Hunt *et al.*, 1993). If lead-bearing particles in dust are found to be characteristic of soil sources, this approach could be used to estimate the relative contributions of soil sources to total indoor PbD, and, accordingly, support estimation of M_{SD}. The approach would require the development of a library of characteristic fingerprints for possible sources of indoor PbD at the site, in addition to soil sources, since there will be some overlap in the elemental compositions of various sources. Complications will arise where different site soils diverge in their mineralogical composition.

Applications of the M_{SD} to Baseline Lead Risk Assessments

The TRW recommends using measured indoor PbD concentrations in risk assessments for estimating Pb intake from exposure to indoor dust. If adequate PbD concentration data are available, these data may be used as inputs to the IEUBK model rather than using the *Multiple Source Analysis* menu options (including the M_{SD}). In situations where indoor dust sampling is precluded or data gaps exist, calculations using M_{SD} may be used to estimate likely PbD concentrations under appropriate circumstances. However, site risk assessments should consider all potential sources of indoor PbD such as exterior and interior lead-based paint, deposition of non-soil airborne particulates, and outdoor soil.

Applications of the M_{SD} to Soil Lead Cleanup Goals

Unlike Pb risk assessments, in which measured indoor PbD concentrations are preferentially used over estimates based on the M_{SD}, PbS cleanup goals require assumptions about the soil-to-dust transport pathway, and other pathways that may contribute PbD after remediation is completed. The default value of 0.70 for the M_{SD} is intended to be representative of the mass fraction of soil in indoor dust for typical residences. As described previously in the *Background* section, there are many factors that may influence the transport and deposition of soil-derived dust into the indoor environment, and there is usually limited information on the effects that soil remediation might have on these factors. For example, at most sites, it would be difficult to predict what impacts remediation would have on the transport of soil into homes, unless the quantitative impacts of remediation on the principal factors that influence soil transport could be assessed. If site specific estimates of M_{SD} are developed, careful consideration needs to be given to the methodological issues that were previously discussed. In setting remediation goals, consideration also needs to be given to the impact of non-soil sources of dust lead. Soil lead exposures will generally present additional risks to children who also have Pb exposures from other sources (*e.g.*, dust from lead-based paint). The Superfund Lead Directive (OSWER Directive #9355.4-12) provides important guidance relevant to these issues.

RECOMMENDATIONS

The TRW recommends that measurements of Pb concentrations be used as inputs to the IEUBK model when conducting residential Pb risk assessments. In the absence of site-specific data on PbD concentrations, the *Multiple Source Analysis* may be used with a default estimate for M_{SD} of 0.70. The TRW recognizes that the M_{SD} value may vary depending on site-specific factors that control the transport, deposition, and removal of soil and other sources of indoor dust. If there is compelling evidence to suggest that the mass fraction of soil in indoor dust differs from 0.70, this information should be presented in the risk assessment. Given the complexity of the dust exposure pathway, the TRW further recommends that, for the time being, EPA assessors and managers seek TRW review of site M_{SD} values when considering using values other than the IEUBK model default of 0.70 (for use in either baseline risk assessment or for estimating soil cleanup levels). At the present time information is limited regarding both the practical applications of techniques to estimate M_{SD} and the range of valid values for this parameter. The review of additional site data will also assist the TRW in providing further guidance regarding a plausible range of values for M_{SD}. The TRW will appreciate receiving feedback from model users regarding the technical guidance provided in this document as well as their experiences in addressing M_{SD} at Pb sites.

REFERENCES

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