Massachusetts Department of ENVIRONMENTAL PROTECTION

t e c h n i c a l u p d a t e

Calculation of an Enhanced Soil Ingestion Rate

Updates: Appendix B, *Guidance for Disposal Site Risk Characterization – In Support of the Massachusetts Contingency Plan* (1995)

Introduction

Based on a review of recent literature regarding soil adherence to skin, Massachusetts Department of Environmental Protection (DEP) is updating its recommendation for a rate of enhanced incidental soil ingestion for use in risk assessments at 21E sites. Enhanced incidental ingestion of soil that contains oil or hazardous materials (OHM) is an important exposure pathway for utility/heavy construction workers operating at 21E sites. The rate of incidental soil ingestion is linearly proportional to the level of risk for a receptor. Therefore, estimating the rate of soil ingestion is an integral part of the risk assessment process. In the 1995 *Guidance for Disposal Site Risk Characterization,* DEP recommended an enhanced incidental ingestion rate of 500 mg/day. This value was based on the assumption that soil adheres to skin on the hands at a density of 3.5 mg/cm^2. However, a recent study by Holmes *et al.* (1999) that measured soil-skin adherence rates suggests that this assumption is overly conservative and leads to an overestimation of incidental soil ingestion.

Based on evidence that soil adherence is lower than previously assumed (Holmes *et al*., 1999), DEP concludes that the enhanced incidental rate should be revised accordingly. To calculate an ingestion rate corresponding to a lower adherence estimate, DEP refers to the assumptions and calculations previously used to relate adherence to ingestion (Hawley, 1985). In the process, DEP concludes that the previously assumed relationship between adherence and ingestion was poorly supported and highly uncertain. DEP believes that a more defensible approach is to simply estimate the enhanced ingestion rate in relation to the standard child incidental ingestion rate used to quantify residential exposures.

Conclusion and Recommendation

DEP believes that is reasonable to assume that an utility/heavy construction worker incidentally ingests approximately the amount ingested by a child. Based on this assertion, DEP recommends an enhanced incidental soil ingestion rate of 100 mg/day.

Discussion

Adult and child incidental ingestion rates currently recommended by the DEP are 50 and 100 mg/day, respectively. The values were obtained from a paper by LaGoy (1987). LaGoy recommended these rates based upon a review of nine relevant studies, some of which provide empirical data.

DEP's previous recommended value for enhanced incidental soil ingestion was 500 mg/day, based on a single paper by Hawley (1985). From the Hawley paper (1985), the following formula to calculate incidental soil ingestion can be inferred:

$$Soil\ Ingestion = AF_{hands} \times SA_{hands} \times FI$$

Parameter	Description	Value
AF_{hands}	adherence factor for soil on hands	assumes 3.5 mg/cm^2
SA_{hands}	surface area of hands	910 cm^2 (Diem and Lentner, 1973; Berkow, 1924)
FI	fraction of soil on hands that is ingested	assumes 14%; equals twice daily ingestion of half the soil from inside fingers and thumb (14% of total hands' surface area)

Using these values, a soil ingestion rate of 446 mg/day is calculated. The discrepancy between 446 mg/day and MA DEP's default value of 500 mg/day appears to be attributable to an error in Table II of Hawley's paper, which indicates a rate of soil ingestion of 480 mg/day without detailed calculation.

It is important to note that any recalculation of an enhanced soil ingestion rate using the Hawley approach would be based, at least in part, on assumptions that cannot be supported by available scientific studies. For example, only one of the values used by Hawley, SA_{hands}, is based on actual scientific data (Diem and Lentner, 1973; Berkow, 1924). The AF_{hands} and *FI* were based on the judgment of the author.

Subsequent to the publication of Hawley's study, data for AF_{hands} has become available for an enhanced soil ingestion scenario (Holmes *et al.*, 1999). While data from the Holmes, *et al.* study indicate that enhanced incidental soil ingestion is less than 500 mg/day, there are still no studies available that provide data on the fraction of soil present on the hands that is incidentally ingested ("*FI*"). Indeed, designing a study to measure *FI* would be extremely difficult; it would probably be more practical to quantify ingestion directly. Therefore, any enhanced incidental soil ingestion value based on dermal adherence would be heavily influenced by the assumptions made for *FI*.

Rather than use a combination of assumptions and measured data that imply a high degree of scientific validity, DEP has chosen the simple, and transparent, assumption that an enhanced incidental soil ingestion rate is equal to approximately that of a child playing outdoors, 100 mg/day. To put this value in perspective, the rate of ingestion is roughly equivalent to a worker ingesting 30% of soil from hands that have a total surface area of 990 cm^2 and a soil adherence factor of 0.3487 mg/cm^2 (based on Holmes *et al.*, 1999).

For Further Information

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