

5. Ingestion of Soil and Dust

5.1 Introduction

The ingestion of soil and dust is a potential route of exposure to environmental chemicals for both adults and children. Children, in particular, may ingest significant quantities of soil due to their tendency to play on the floor indoors and on the ground outdoors and their tendency to mouth objects or their hands. Children may ingest soil and dust through deliberate hand-to-mouth movements, or unintentionally by eating food that has dropped on the floor. Adults may also ingest soil or dust particles that adhere to food, cigarettes, or their hands. Thus, understanding soil and dust ingestion patterns is an important part of estimating overall exposures to environmental chemicals. At this point in time, knowledge of soil and dust ingestion patterns within the United States is somewhat limited. Chapter 5 of the *Exposure Factors Handbook* explains the concepts of soil ingestion, soil pica, and geophagy; defines soil, indoor and outdoor settled dust, and dust ingestion; and presents recommended values for amounts of soil and dust ingested for adults and children. This information is summarized here.

Definitions: The Centers for Disease Control and Prevention's (CDC) Agency for Toxic Substances and Disease Registry (ATSDR) held a workshop in June 2000 in which a panel of soil ingestion experts developed definitions for soil ingestion, soil-pica, and geophagy to distinguish aspects of soil ingestion patterns that are important from a research perspective (ATSDR, 2001). The *Exposure Factors Handbook* uses the definitions that are based on those developed by participants in that workshop:

- **Soil ingestion** is the consumption of soil. This may result from various behaviors including, but not limited to, mouthing, contacting dirty hands, eating dropped food, or consuming soil directly.
- **Soil-pica** is the recurrent ingestion of unusually high amounts of soil (i.e., on the order of 1,000-5,000 mg/day or more).
- **Geophagy** is the intentional ingestion of earths and is usually associated with cultural practices.



In the *Exposure Factors Handbook*, soil, indoor and outdoor settled dust, and dust ingestion are defined generally as:

- **Soil.** Particles of unconsolidated mineral and/or organic matter from the earth's surface that are located outdoors, or are used indoors to support plant growth. It includes particles that have settled onto outdoor objects and surfaces (outdoor settled dust).
- **Indoor Settled Dust.** Particles in building interiors that have settled onto objects, surfaces, floors, and carpeting. These particles may include soil particles that have been tracked or blown into the indoor environment from outdoors as well as organic matter.
- **Outdoor Settled Dust.** Particles that have settled onto outdoor objects and surfaces due to either wet or dry deposition. Note that it is not possible to distinguish between soil and outdoor settled dust, because outdoor settled dust generally would be present on the uppermost surface layer of soil.

For the purposes of providing recommended values in the *Exposure Factors Handbook*, soil ingestion includes both soil and outdoor settled dust, and dust ingestion includes indoor settled dust only.

5.2 Recommended Exposure Factors

Table 5-1 shows the central tendency recommendations for daily ingestion of soil, dust, or soil + dust, in mg/day. It also shows the high-end recommendations for daily ingestion of soil, in mg/day. The high-end recommendations are subdivided into a general population soil ingestion rate, an ingestion rate for “soil-pica,” and an estimate for individuals who exhibit “geophagy.” The soil pica and geophagy recommendations are likely to represent acute high soil ingestion episodes or behaviors at an unknown point on the high end of the distribution of soil ingestion.

The recommendations for children are based on various key studies presented in Chapter 5 of the *Exposure Factors Handbook* (Vermeer and Frate, 1979; Wong, 1988; Calabrese et al., 1989, 1991, 1997a,b; Barnes, 1990; Davis et al., 1990; Van Wijnen et al., 1990; Calabrese and Stanek, 1993, 1995; Stanek and Calabrese, 1995; Hogan et al., 1998; Stanek et al., 1998; Davis and Mirick, 2006; Özkaynak et al., 2010). Studies estimating adult soil ingestion are extremely limited, and only two of these are considered to be key studies (Vermeer and Frate, 1979 and Davis and Mirick, 2006). There are no available studies estimating the ingestion of dust by adults. Therefore, the assumption used by the U.S. EPA Integrated Exposure Uptake Biokinetic (IEUBK) model for lead in children (i.e., 45% soil, 55% dust contribution) was used to derive estimates for soil and dust using the soil + dust value derived from Davis and Mirick (2006).

The soil ingestion recommendations in Table 5-1 are intended to represent ingestion of a combination of soil and outdoor settled dust, without distinguishing between these two sources. The source of the soil in these recommendations could be outdoor soil, indoor containerized soil used to support growth of indoor plants, or a combination of both. The inhalation and subsequent swallowing of soil particles is accounted for in these recommended values, therefore, this pathway does not need to be considered separately. These recommendations are called “soil.”

The dust ingestion recommendations in Table 5-1 include soil tracked into the indoor setting, indoor settled dust, and air-suspended particulate matter that is inhaled and swallowed. Central tendency “dust” recommendations are provided, in the event that assessors need recommendations for an indoor setting or inside a transportation vehicle scenario in which dust, but not outdoor soil, is the exposure medium of concern. The soil + dust recommendations would

include: soil, either from outdoor or containerized indoor sources; dust that is a combination of outdoor settled dust, indoor settled dust, and air-suspended particulate matter that is inhaled, subsequently trapped in mucous and moved from the respiratory system to the gastrointestinal tract; and a soil-origin material located on indoor floor surfaces that was tracked indoors by building occupants. Soil and dust recommendations represent the mass of ingested soil or dust on a dry-weight basis. The overall confidence rating for the soil and dust recommendations is low.



Table 5-1. Recommended Values for Daily Soil, Dust, and Soil + Dust Ingestion (mg/day)

Age Group	Soil ^a				Dust ^b		Soil + Dust	
	General Population Central Tendency ^c	High End			General Population Central Tendency ^g	General Population Upper Percentile ^h	General Population Central Tendency ^c	General Population Upper Percentile ^h
		General Population Upper Percentile ^d	Soil-Pica ^e	Geophagy ^f				
6 weeks to <1 year	30	-	-	-	30	-	60	-
1 to <6 years	50	-	1,000	50,000	60	-	100 ⁱ	-
3 to <6 years	-	200	-	-	-	100	-	200
6 to <21 years	50	-	1,000	50,000	60	-	100 ^j	-
Adult	20 ^j	-	-	50,000	30 ^j	-	50	-

^a Includes soil and outdoor settled dust.

^b Includes indoor settled dust only.

^c Davis and Mirick, 2006; Hogan et al., 1998; Van Wijnen et al., 1990; Calabrese and Stanek, 1995; Davis et al., 1990.

^d Özkaynak et al., 2010; Stanek and Calabrese, 1995; rounded to one significant figure.

^e ATSDR, 2001; Calabrese and Stanek, 1993; Calabrese et al., 1989/Barnes, 1990/Calabrese et al., 1991; Calabrese et al., 1997a, b; Stanek et al., 1998; Vermeer and Frate, 1979; Wong, 1988.

^f Vermeer and Frate, 1979.

^g Hogan et al, 1998.

^h Özkaynak et al., 2010; rounded to one significant figure.

ⁱ Total soil and dust ingestion rate is 110 mg/day; rounded to one significant figure it is 100 mg/day.

^j Estimates of soil and dust were derived from the soil + dust and assuming 45% soil and 55% dust.

- No data.

For more information about the key studies used to derive the recommended ingestion of soil and dust values, refer to **Chapter 5 of the Exposure Factors Handbook** at <http://www.epa.gov/ncea/efh/pdfs/efh-chapter05.pdf>. Detailed information on methodologies and the studies on soil and dust ingestion is included in Section 5.3. Information regarding the limitations of the study methodologies is provided in Section 5.4.

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