Using Acute Toxicity Soil Guidelines to Protect Human Health

Applications, Challenges and Case Studies

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DEFINITIONS – ACUTE, INTERMEDIATE AND CHRONIC

- Acute: Effects from a single or short-term exposure (hours to days).
- Intermediate: Effects from repeated exposure over weeks to months.
- Chronic: Effects from long-term exposure (months to years).

WHEN TO USE ACUTE GVS

- Acute guideline values (GVs) are used when short-term, high-exposure scenarios are plausible (e.g., children's playground or sandpit in contaminated soil, pica type exposure).
- Used to set a maximum (not to exceed limit) in conjunction with 95% UCL using a chronic exposure scenario.
- Very unlikely that repeat exposure will occur (remote site).
- Protection against short-term high exposure scenario (i.e., during a site remediation – may require additional protection measures).
- Can be used to set a maximum allowable chronic value (i.e., mercury).

KEY RECEPTORS – ACUTE VS CHRONIC

- Acute Focus: Children, pregnant women, transient populations.
- Chronic Focus: Residents, workers with long-term exposure.
- Receptor Differences: Acute GVs are often lower due to higher ingestion rates and sensitivity.

HOW TO CALCULATE ACUTE GUIDELINES?

Inputs:

- Soil ingestion rate (mg/day)
- Body weight (kg)
- Acute toxicity reference dose (RfD)
- Bioavailability (set as 100%)
- Conversation Factor (if necessary)

$$Acute\ GV = \frac{RfD_{oral} \times Child\ body\ weight}{Soil\ ingestion \times Bioavail. \times CF}$$

WHAT DO ACUTE SOIL GUIDELINES LOOK LIKE?

Lethal dose		**Antimony**	**Arsenic**	**Cadmium**	**Copper**	**Lead**	**Nickel**
Acute Oral SCS (Child 5g)	mg/kg	1950	2600	65000	NL	NC	NL
Acute Oral SCS (Child 10g)	mg/kg	975	1300	32500	NL	NC	NL
Acute Oral SCS (Child 25g)	mg/kg	390	520	13000	223080	NC	296400
Non-lethal dose							
Acute Oral SCS (Child 5g)	mg/kg	1373	39	182	234	52	23.4
Acute Oral SCS (Child 10g)	mg/kg	686	19.5	91	117	26	11.7
Acute Oral SCS (child 25 g)	mg/kg	275	8	36	47	10	5
NES (Chronic) Residential	mg/kg	1400	20	3	NL	210	1800

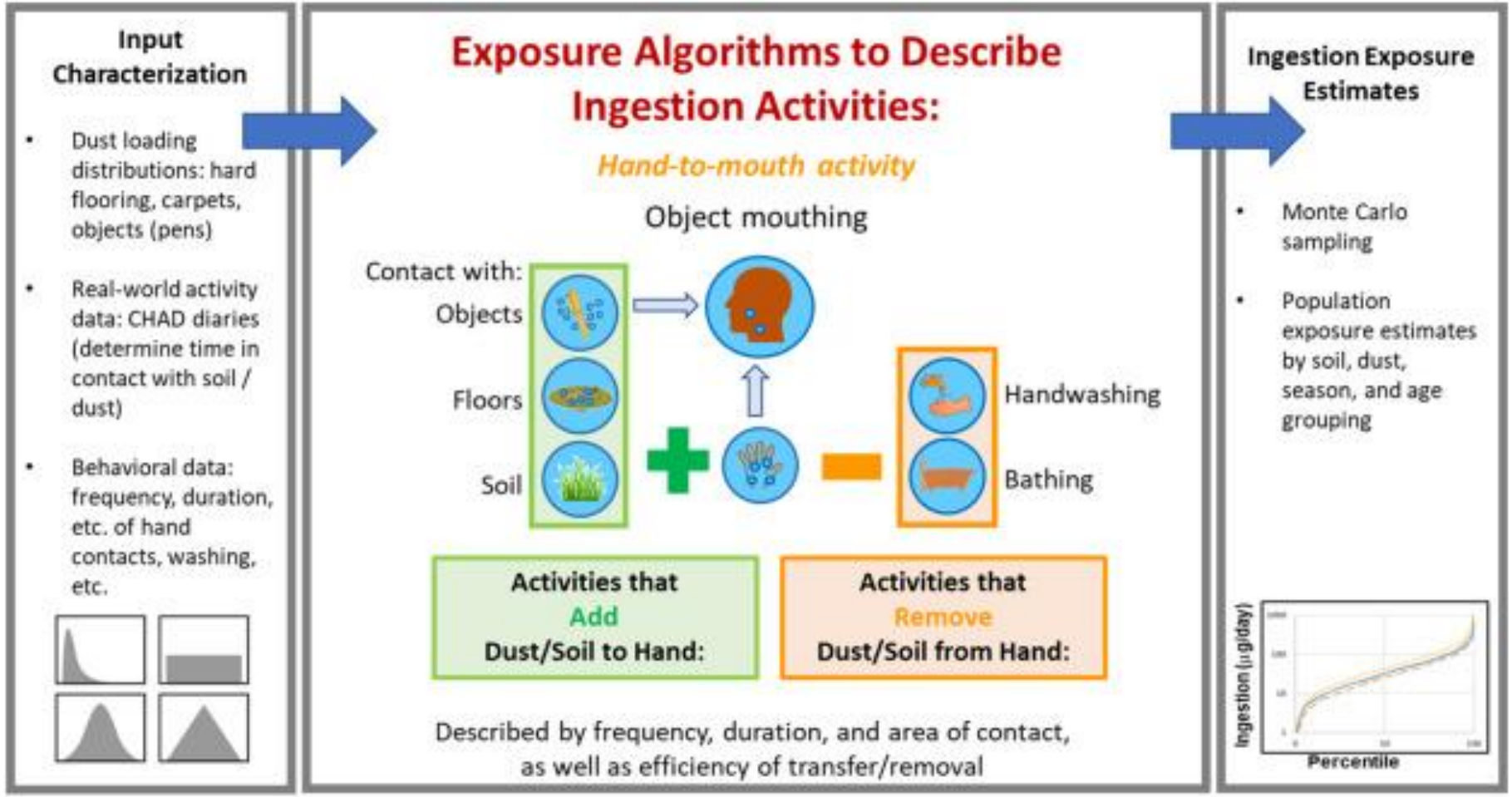
IMPORTANCE OF SOIL INGESTION RATES

- Children: Up to 400 mg/day (Calabrese 1997).
- Children: 1,000 to 5,000 mg/day up to 3 times per week (ATSDR, 2018).
- Adults: Typically 100 mg/day but may be higher in certain settings.
- Certain jobs might have higher soil ingestion rates, i.e., agricultural workers, landscape gardeners, drainage workers, groundskeepers, and wilderness exposure (up to 200 mg/day) (MfE, 1997; US EPA, 2018 ; Hubbard, 2021).

Implication: Higher ingestion rates = lower guideline values.
Important for identifying the mechanism of potential soil exposure for determining soil ingestion rates

US EPA Exposure Factor Handbook – Chapter 5 Soil and Dust Ingestion is an important source of information on soil ingestion rates.

SHEDS-SOIL/DUST INGESTION MODEL



Source; Hubbard, H., Özkaynak, H., Glen, G., Cohen, J., Thomas, K., Phillips, L., & Tulve, N. (2022). Model-based predictions of soil and dust ingestion rates for U.S. Adults using the stochastic human exposure and dose simulation soil and dust model. Science of The Total Environment, 846, 157501. https://doi.org/10.1016/j.scitotenv.2022.157501

WHY NOT USE BIOAVAILABILITY IN ACUTE GV?

TOXICITY VALUES FOR ACUTE GUIDELINES

- Endpoints: Neurotoxicity, gastrointestinal distress.
- Sources: ATSDR MRLs, EPA IRIS, WHO, EFSA.
- In 2017, ESR published guidance on the maximum acceptable values for New Zealand drinking water (useful for pesticides and organic compounds).

THE CURIOUS CASE OF COPPER

- Observation: Copper has both essential and toxic roles.
- Acute Toxicity: GI irritation at high doses
- Challenge: Setting a GV that avoids deficiency but prevents toxicity
- Sensitive Population: Menke's and Wilson's disease (rate of 1:50,000 to 1:100,000 people)

Acute toxicity of copper: Gastrointestinal symptoms, including nausea, abdominal pain and vomiting.

Seeley et al (2013) estimated acute GV of 3,600 mg/kg cf. NES –CS Chronic greater than 10,000 mg/kg.

ATSDR acute (oral) MRL (0.02 mg/kg bw/day) is less than MfE,2011 (0.15 mg/kg bw/day)

Taylor (2019) suggests using an RFD of 0.04 mg/kg for both acute and chronic

TIME TO REVISE NES-SCS?

- If we adopt Taylor (2019) then what might a Copper SGV look like?

Scenario	No Produce	10% Produce	25% Produce
Residential	10,200 mg/kg	8,400 mg/kg	6,600 mg/kg

- Dropped from 38,000 mg/kg to 8,400 mg/kg
- Still potentially have acute lower than chronic SCS (due to soil ingestion rate being higher)

VEXING ISSUE OF LEAD

- No safe threshold for children.
- Acute effects: Encephalopathy at very high levels.
- Chronic effects: Cognitive impairment, developmental delays.
- Problem: No Acute Reference Dose, IEUBK and ALM models not suitable for less than 1 day per week and of duration shorter than 90 consecutive days .
- Approach (?): Modified Leggett model / AALM – too complex to really use.

SUMMARY

- Acute GVs are critical for protecting sensitive populations.
- Also useful in a number of other specific situations (GV development, maximum not to exceed value, remote sites, remediation Health and Safety planning).
- Must consider ingestion rates, toxicity endpoints, and exposure scenarios.
- Not all metals behave the same—context matters.

KEY REFERENCES

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