Dust in the Urban Environment: Human risk assessment

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US acknowledges link between toxic dust from 9/11 aftermath and cancer.
The US Government has for the first time acknowledged a connection between toxic dust at Ground Zero after the September 11 2001 terror attacks and several different kinds of cancer
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URBAN ENVIRONMENTS
Exposure pathways

• Direct: two main considerations

  – Via ingestion (deliberate or unintentional).

  – Via inhalation (e.g. < 10 μm particle size)

Dust - to - skin adherence

- Particle size decrease as ‘soil+dust’-to-skin adherence increases

- Grain size < 250 μm of dry ‘soil + dust’ is considered to be easily adhered on skin

Can assess TOTAL or oral bioaccessible intake
Health Risk Assessment

• Ingestion: oral bioaccessibility

• Inhalation: simulated epithelial lung fluid
**Results**

- **Ingestion:**
  - Pb in 5 cities (total versus bioaccessible fraction / air quality approach)
  - BaP in 1 city (total)
Box plot of lead in urban street dusts showing: median, mean, box boundary (25th and 75th) percentile and whiskers (10th and 90th) percentile. (NC – Newcastle; DU – Durham; LV – Liverpool; ED – Edinburgh; SD – Sunderland).

Box plot for the oral bioaccessibility (gastric only) of lead in urban street dust: indicating mean, median, box boundary (25th and 75th) percentile and whiskers (10th and 90th) percentile.
Estimated daily intake comparison
($\mu g \ kg_{bw}^{-1} \ day^{-1}$)

- Based on the equation:

$$DI = \frac{[EC \times SIR]}{BW}$$

$DI =$ maximum estimated daily intake
$EC =$ exposure concentration ($\mu g \ g^{-1}$) of Pb in $< 125 \ \mu m$
$SIR =$ soil ingestion rate ($0.1 \ g \ day^{-1}$)
$BW =$ body weight (kg)

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**Pb in five cities ($n = 15$ per location)**

- **Total Pb**
- **Bioaccessible Pb**
- **‘air quality’ Pb**

TDI$_{oral}$ for Pb = 3.6 $\mu g \ kg_{bw}^{-1} \ day^{-1}$

HEALTH RISK
Total Pb

TDI_{oral} for Pb = 3.6 \mu g \text{ kg}_{bw}^{-1} \text{ day}^{-1}

- All maximum values exceed the TDI_{oral}
- A child would need to consume:
  - 32 mg (Durham)
  - 53 mg (Edinburgh)
  - 73 mg (Liverpool)
  - 41 mg (Newcastle)
  - 30 mg (Sunderland)

A child would need to consume these amounts per day to exceed TDI_{oral}

- USEPA (2008)* guideline is based on a 100 mg/day ‘soil + dust’ ingestion rate.


Pb in five cities (n = 15 per location)

- Based on use of UBM*: using worst case scenario of gastric only phase.
- Majority of maximum values exceed the TDI_{oral}

Bioaccessible Pb (\mu g \text{ kg}_{bw}^{-1} \text{ day}^{-1})

TDI_{oral} for Pb = 3.6 \mu g \text{ kg}_{bw}^{-1} \text{ day}^{-1}

* UBM = Unified Bioaccessibility Method
**Pb in five cities** (n = 15 per location)

- Based on use of measured (UK-air.defra.gov.uk/data) average data (10 µm particle size) on specific dates between 10.00 and 15.00 hours
- No values exceed the TDI\textsubscript{oral}

\[
\text{TDI}_{\text{oral}} \text{ for Pb} = 3.6 \, \mu g \, kg_{bw}^{-1} \, day^{-1}
\]

**Polycyclic Aromatic Hydrocarbons**

- *In-situ* PFE – GC – MS
Total PAH Content of Urban Street Dust

Oral PAH intake (µg/day)*

<table>
<thead>
<tr>
<th>Compound</th>
<th>Soil particle size (µm)</th>
<th>Oral MDI (µg/day) food+</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-63</td>
<td>63-125</td>
</tr>
<tr>
<td>Benzo(a)pyrene</td>
<td>0.91</td>
<td>0.45</td>
</tr>
</tbody>
</table>

*USEPA (2008)* guideline is based on a 100 mg/day ‘soil + dust’ ingestion rate.

Health Risk Assessment

• Ingestion: oral bioaccessibility

• Inhalation: simulated epithelial lung fluid
Lung phase
0.3 g dust in 20 ml SELF solution *

*[NaCl, CaCl₂, NaHPO₄, NaHCO₃, KCl, MgCl₂, Na₂SO₄, ascorbic acid, uric acid, glutathione, albumin, cysteine, dipalmitoylphosphatidylcholine (DPPC), glycine and mucin; pH 7.4]*

Agitated 37 °C for 96 h
Centrifuged
Filtered
Analysed (ICP-MS)
Mean ± SD
0.58 ± 0.32 µg Pb / day (n = 21)

Mean ± SD
16.6 ± 9.6 µg Pb / day (n = 21)
Summary

• Pb is common in urban dust
• Particular concern for Pb from historic buildings
• Potential health risk is minimal based on the following approaches:
  – Oral bioaccessibility
  – Simulated epithelial lung fluid
• Exposure frequency is an important consideration in any health risk assessment

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