



Bioavailability of Arsenic and Lead

Within Urban Environments (and other sites)

Definitions

Bioavailability – The amount of a contaminant absorbed, which, following ingestion, inhalation or dermal contact.

Relative Bioavailability - The comparative bioavailability of different chemical forms or for different exposure media containing the chemicals. RBA is the ratio of the absorbed fraction from an exposure medium (e.g., soil) to the absorbed fraction from a reference dose (e.g., lead acetate). RBA is used instead of default bioavailability assumptions when reliable, site-specific data is obtained.

$$BA = \frac{ABA_{test}}{ABA_{reference}}$$

Bioaccessibility - The fraction of a soluble compound following gastrointestinal extraction and, therefore, is available for absorption. This term refers to when in vitro chemical assessment models are used to estimate the relative bioavailability of a contaminant.

RBA and Bioaccessibility

- $RBA_{\text{arsenic}} = (0.79 \times IVBA + 0.03)$ (US EPA, 2017)
- $RBA_{\text{lead}} = (0.878 \times IVBA - 0.028)$ (US EPA, 2017)

Note: Above conversion only valid for using SBRC-G IVBA assay.

What is it bioavailability good for?

| NES Scenario | Low (>250 mg/kg) | Medium (250-500 mg/kg) | High (500-800 mg/kg) | Very High (800-2,500 mg/kg) | 2,500 - 5,000 mg/kg | 5,000-10,000 mg/kg |
|---|------------------|------------------------|----------------------|-----------------------------|---------------------|--------------------|
| Rural Residential/lifestyle block (25% produce) | Likely | Possible | Unlikely | Unlikely | Unlikely | Unlikely |
| Rural Residential/lifestyle block (10% produce) | Likely | Possible | Unlikely | Unlikely | Unlikely | Unlikely |
| Rural Residential/lifestyle block (0% produce) | Likely | Possible | Unlikely | Unlikely | Unlikely | Unlikely |
| Residential (10% produce) | Likely | Possible | Unlikely | Unlikely | Unlikely | Unlikely |
| Residential (0% produce) | Likely | Possible | Unlikely | Unlikely | Unlikely | Unlikely |
| High-density residential | Likely | Likely | Possible | Unlikely | Unlikely | Unlikely |
| Recreational | Likely | Likely | Likely | Possible | Unlikely | Unlikely |
| Commercial/industrial outdoor workers | Likely | Likely | Likely | Likely | Likely | Possible |

Note: This figure is general in nature and should not be construed as a prescriptive guide.

1. Colour shading indicates the likelihood that site-specific RBA will change the remedial decision.



Likely



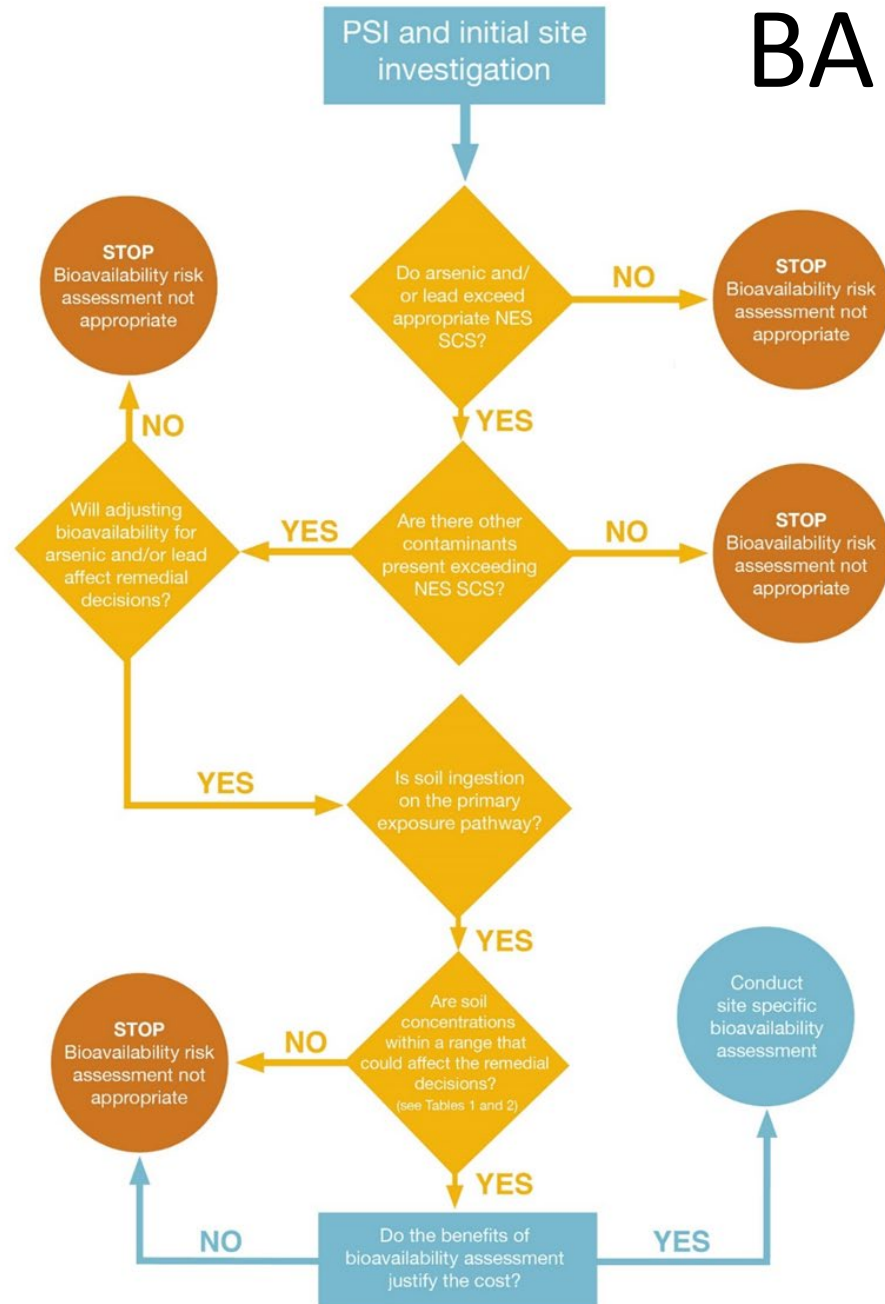
Possible



Unlikely

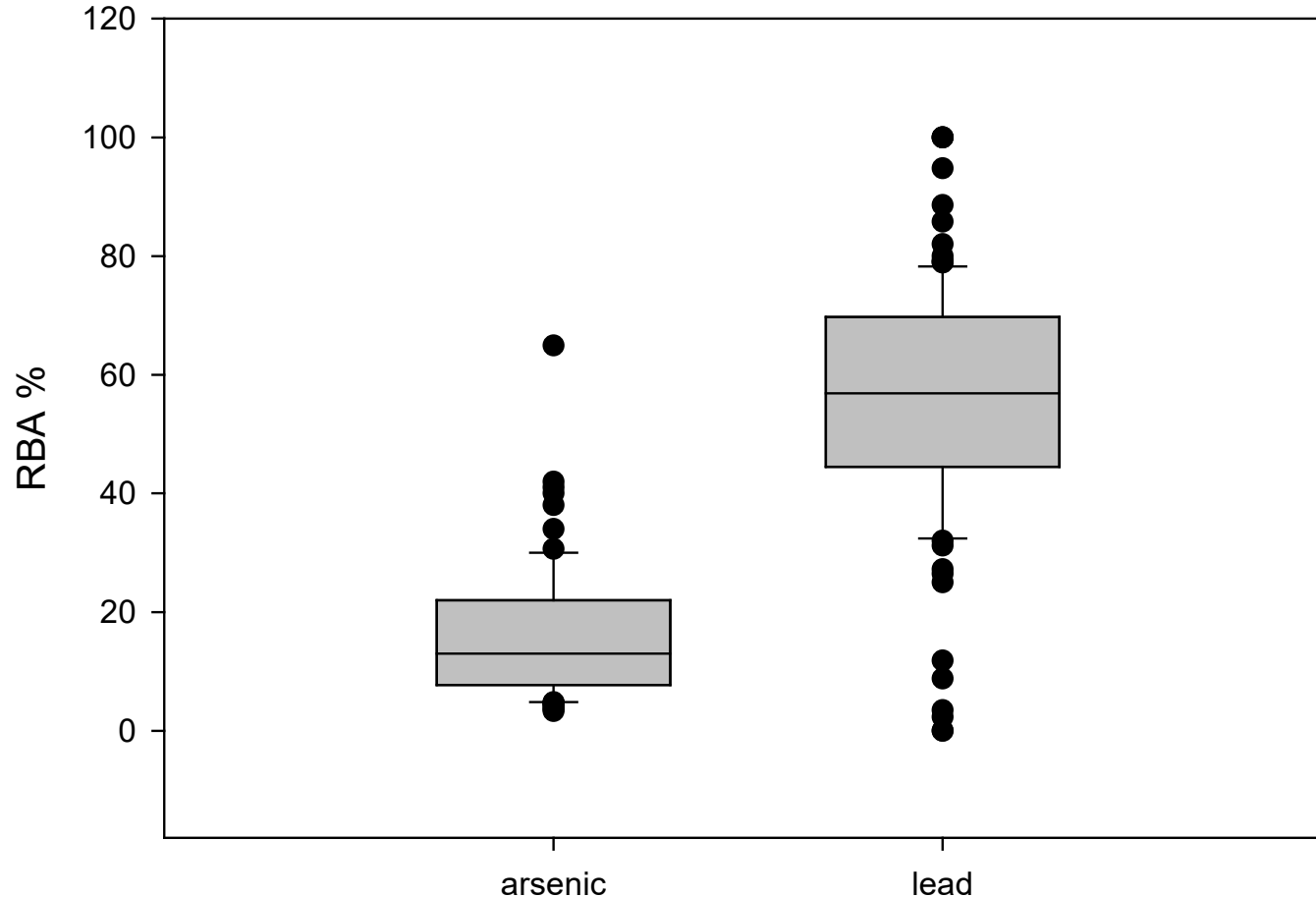
- Available for ingestion only
- Can modify site-specific soil guidelines (Tier 2 risk assessment).
- Minimise the amount of material needing removal from a site.
- Determining if HAIL category I apply.
- Determining if background concentrations are likely to be hazardous.

BA go/no go decision making



- Bioavailability is not a panacea
- Expensive – need to assess if it is going to help
- Need to discuss with the regulator
- Undertake a cost/benefit assessment
- Remember both Total and Gastric extraction -250 μm soil fraction

What is typical for Bioavailability



Overseas RBA data

Arsenic

- Vic EPA – allows arsenic (oral) RBA= 0.25-0.75
- BC – arsenic (oral) RBA = 0.6
- US – arsenic (oral) RBA = 0.6
- US Region 10 Arsenic (oral) smelting RBA= 0.8
- US Region 10 Arsenic (oral) mining RBA=0.6
- US Region 10 Arsenic (oral) other RBA=1.0
- Cal DTSC Arsenic (oral) RBA=0.6
- Soil Impacted by CCA-treated timber Arsenic (oral) RBA=25-66% (Pouschat & Zagury, 2006)

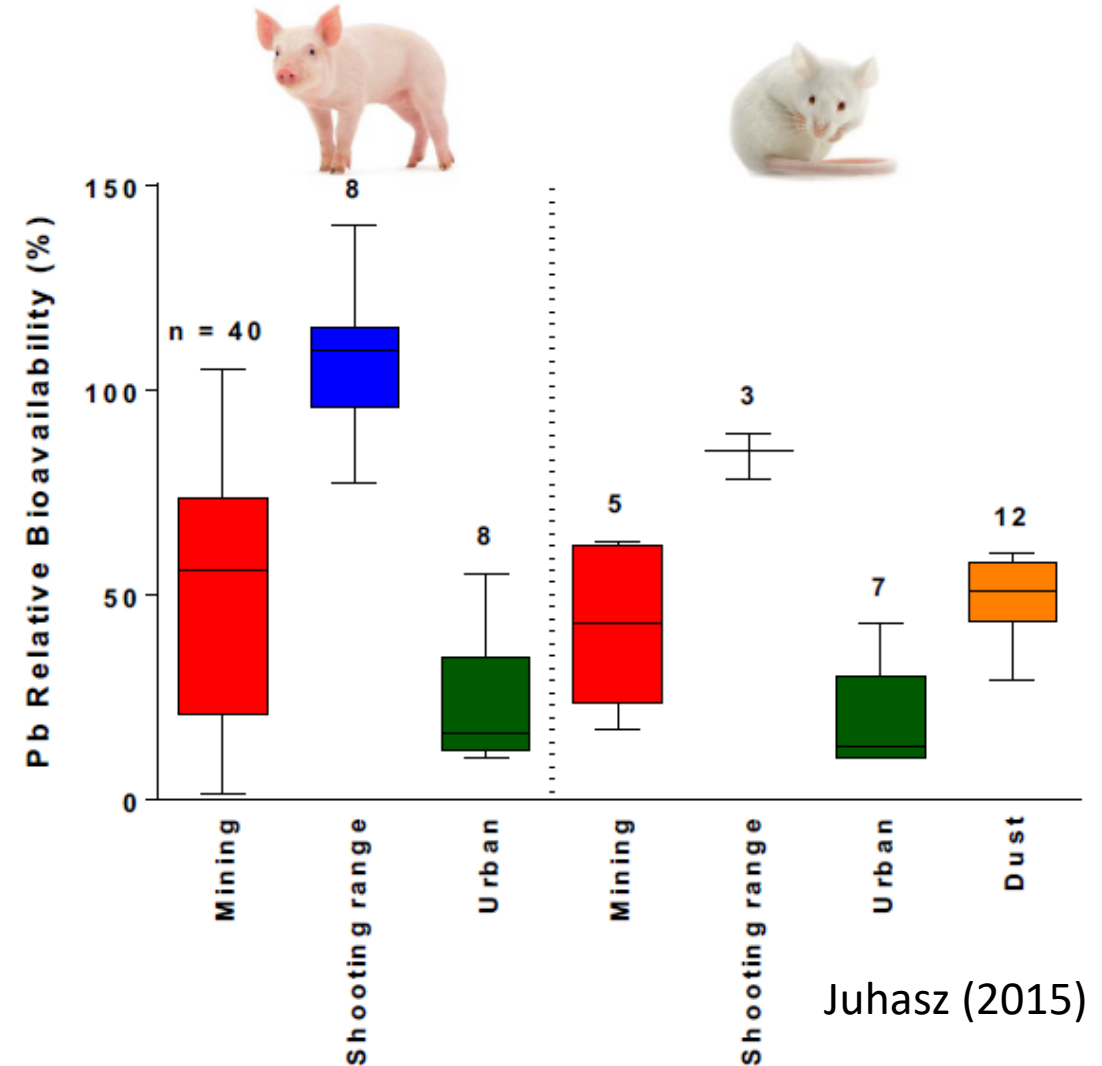
Lead

- Cal DTSC Lead(oral- adult) RBA=0.44
- US –lead (oral) RBA 0.6 (except firing ranges RBA =1.0)

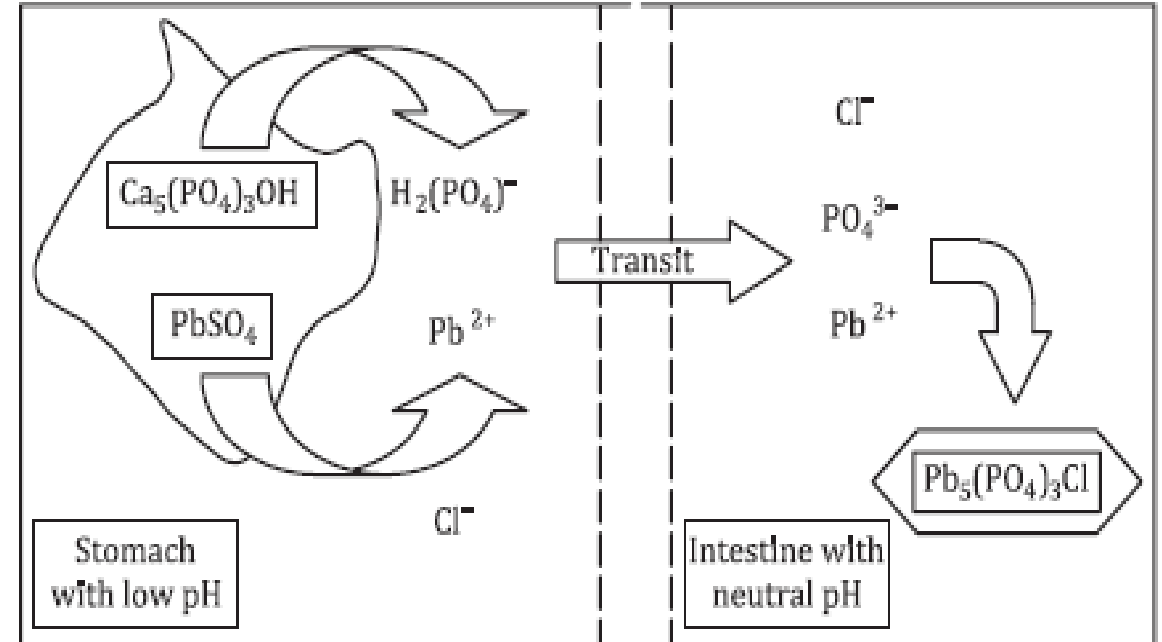
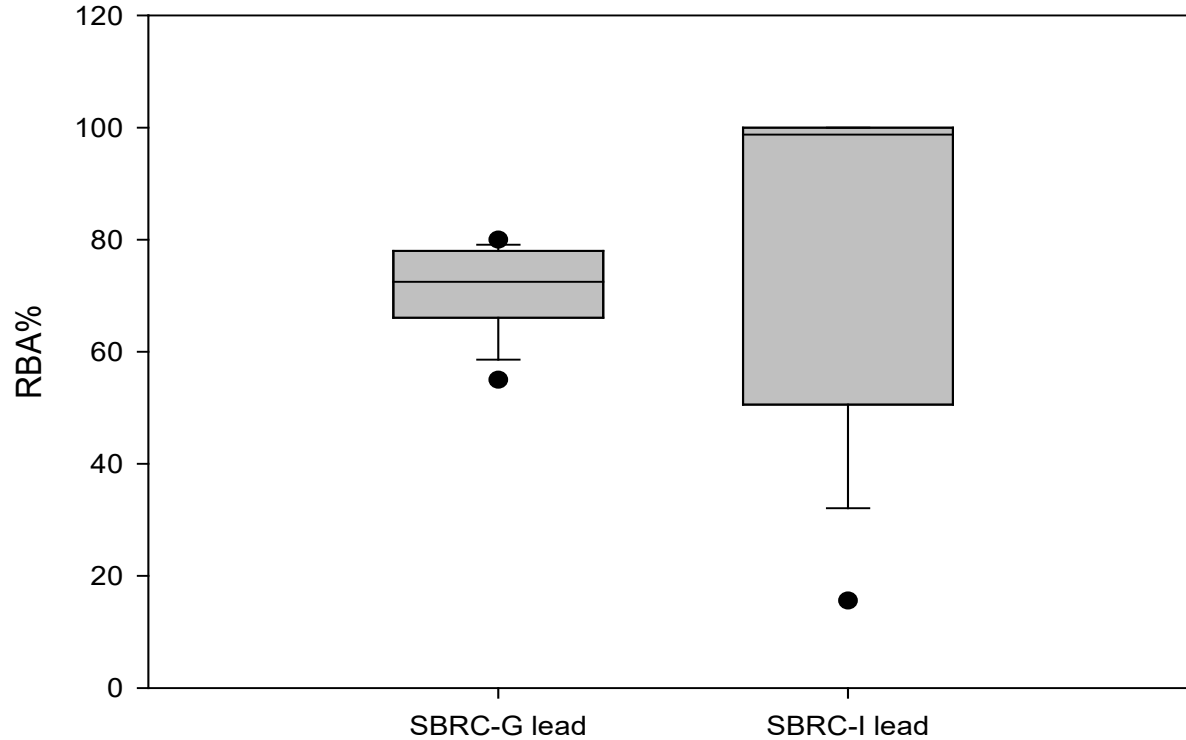
Relative Bioavailability Data – residential

Arsenic IQR RBA 7% to 18.8%
 95% UCL RBA 17.3%
 maximum 65%

Lead IQR RBA 44.5% to 68.8%
 95% UCL RBA 58.4%
 maximum 100%



Complexity with Lead – Gastric vs Intestinal



Calcium, iron and organic matter can also affect RBA (Kastury, 2019)

ISO 17294:2018

Can bioavailability be used in an NES Assessment?

- Methodology says site-specific risk assessment can be undertaken but 100% oral bioavailability must be used (Section 9.6).
- NES for Assessing and Managing Contaminants in Soil to Protect Human Health – only references *The Methodology* in Regulation 9.
- *Regulations 10 and 11* only refer to a risk assessment and does not provide further guidance on how that risk assessment should be conducted.