In Vitro Bioaccessibility Assays in Soils for Human Health Risk Assessments

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With acknowledgements to Andrew Rumsby CEnvP-SC, EHS Support

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Bioavailability and bioaccessibility

Oral bioavailability is the fraction of a chemical absorbed into the body following ingestion.

In vivo parameter – what happens to a contaminant in a living human body.

Oral bioaccessibility is the fraction of a chemical that dissolves on gastrointestinal extraction.

In vitro parameter – what happens to a contaminant in a laboratory extraction intended to simulate the human digestive tract.

Why do we care?

In New Zealand the default assumption in calculating generic soil contaminant standards is that a child takes up all* of a contaminant in ingested soil.

This is a conservative approach that may overestimate risk.

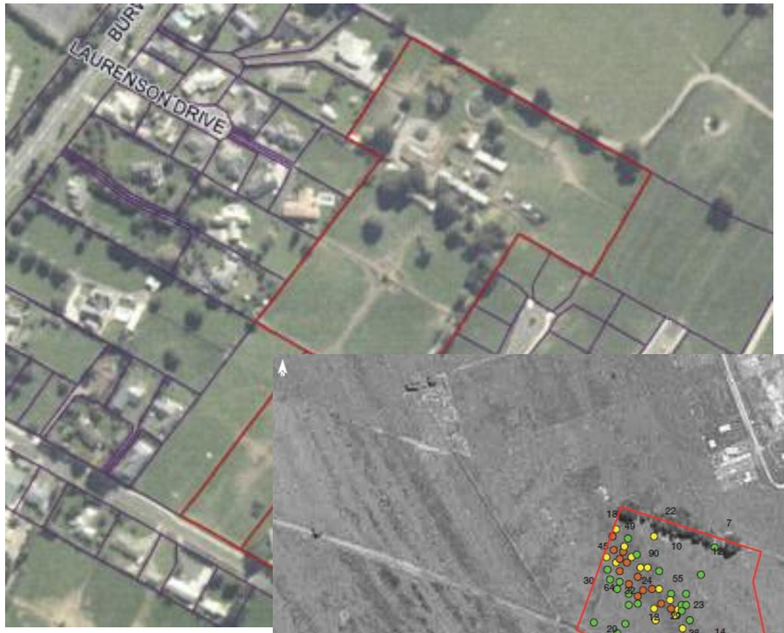
A more accurate estimate of risk would improve decisions around the management or remediation of a contaminated site, reducing cost, time, waste, emissions.

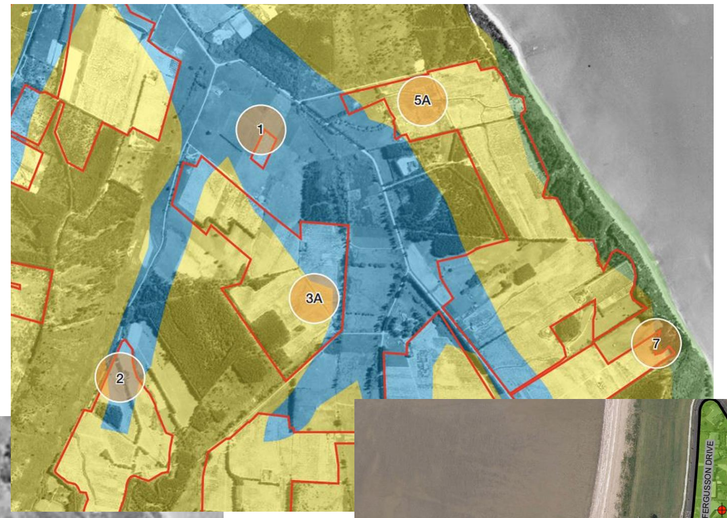
In 2011 the *Methodology* stated that "the test methods available in New Zealand for estimating site-specific bioavailability are not yet good enough."

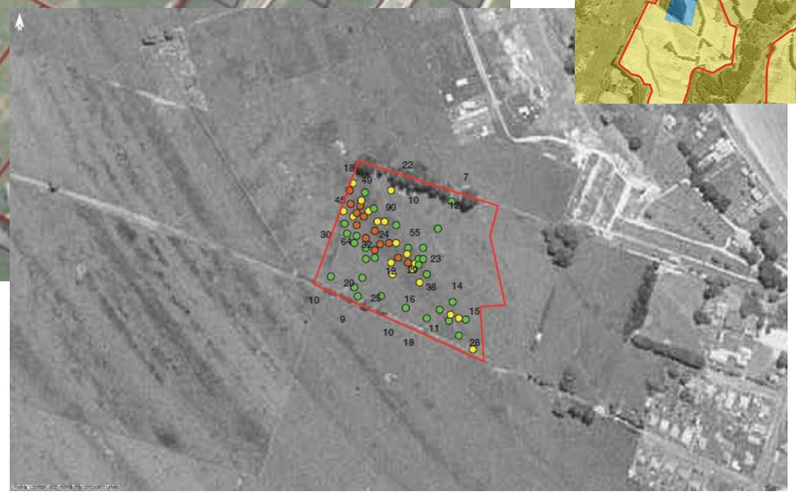
Since then, validated bioaccessibility methods have become available for arsenic and lead, which can be significantly less than 100 % bioavailable.**

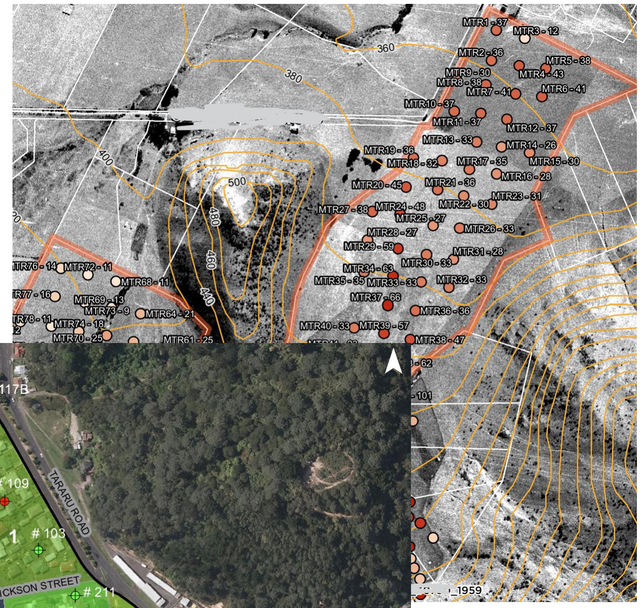
So we should consider incorporating bioavailability into our soil arsenic and lead assessments where there are moderate exceedances of generic SCS.

Successful examples









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What determines bioavailability?

The form that the contaminant was released in

- Soluble, like pesticides? Poorly soluble, like pigments? Mineral, like sulphides? Metallic?
- Are there multiple sources?

Soil geochemistry, including any amendments

- Particle size / area, pH, E_H, organic matter, iron, manganese, aluminum oxides, phosphate
- **Do not assess bioavailability in acid sulphate soils.**
- Are there multiple geochemical environments?

Investigating bioavailability

- Conceptual site model!
  - What problem is the bioavailability assessment expected to resolve?
  - What lines of evidence will establish
    - That the source had low or moderate bioavailability
    - That soil geochemistry favours low or moderate bioavailability
    - That soil has not been / is unlikely to be highly modified to increase bioavailability
  - What QAQC is required?
- Target soils that exceed SCS
  - Total and SBRC bioaccessible arsenic / lead (single or dual phase?)
  - Supporting chemical and physical parameters (mineralogy?)
- Enough samples for a robust 95 % UCL
  - At least six for each source × soil type

Assessing bioavailability

Revise conceptual site model

- Was bioaccessibility low to moderate?
- Can you make sense of the geochemistry?
- Does the bioaccessibility correlate with the sources and the geochemistries?

Assess data quality

- Precision, accuracy, representativeness, comparability, completeness, sensitivity

Calculate UCL_{95}s

Convert bioaccessibility to bioavailability using published relationships

$RBA_{arsenic}$ = (0.79 x IVBA + 0.03) RBA_{lead} = (0.878 x IVBA -0.028)

Site-specific risk assessment

MfE model – apply to **soil ingestion pathway only**

$$SGV_{ing} = \frac{RHS \times 27375 \times 10^6}{IR_{adj} \times EF} \text{ mg/kg} \times RBA$$

$$SGV_{ing} = \frac{(RHS - BI) \times BW \times 365 \times 10^6}{IR \times EF} \text{ mg/kg} \times RBA$$

$$\text{Combined soil guideline value} = \frac{1}{\left(\frac{1}{\text{ingestion soil guideline}} + \frac{1}{\text{dermal soil guideline}} + \frac{1}{\text{produce soil guideline}} + \cdots\right)}$$

Biokinetic models?

Reporting bioavailability assessment

Site inspection and visual observation (photographs)

Review of historical and geological information

Conceptual site model

Sampling plan

Field descriptions of soils

Laboratory reports

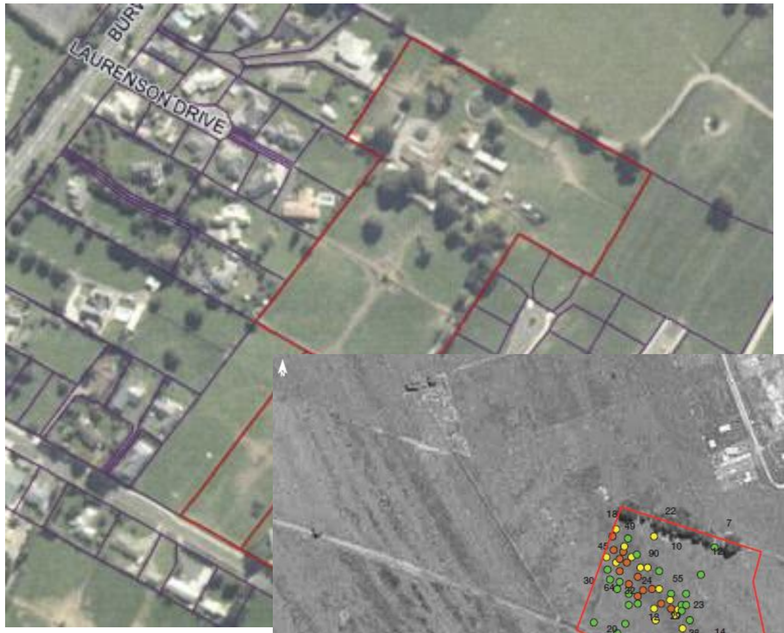
Summary tables

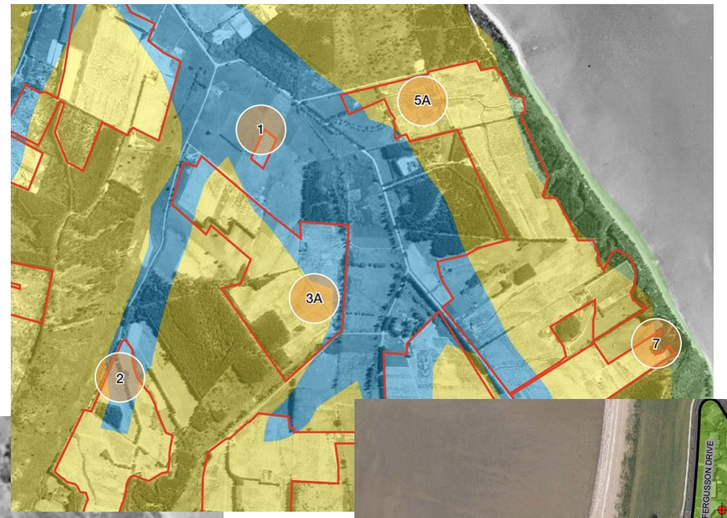
Calculations (statistics, conversions)

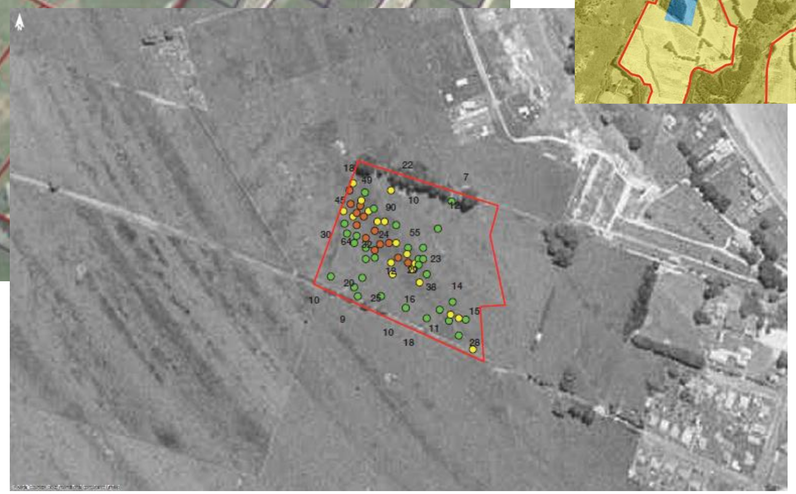
Data quality assessment, limitations statement

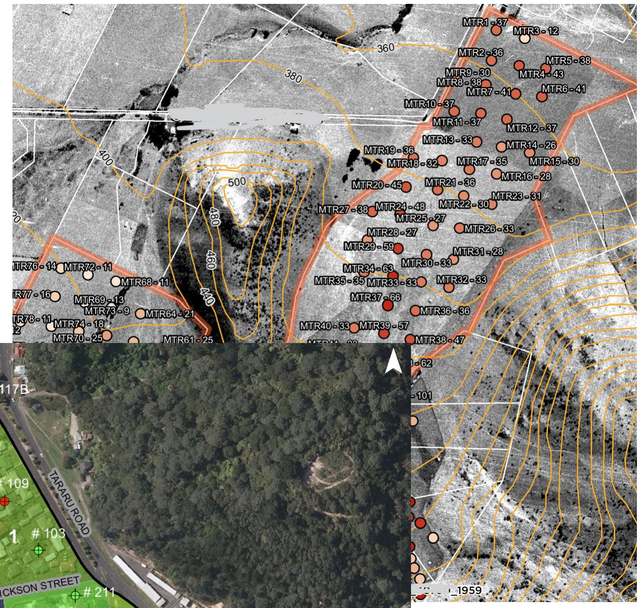
Ongoing management plan?

Successful examples









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