Contaminated Land Remediation Goals

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Introduction to James Potter

- **James has over 13 years experience in contaminated land investigation, risk assessment and remediation.**
- **He worked for 7 years with the UK Environment Agency as Thames Regional contaminated land officer and was involved in the implementation of the Contaminated Land Regulations.**
- **He has worked as a consultant since 2001 and has been involved in the investigation and remediation of contaminated land sites, including the 2012 London Olympics site and sites in China, Hong Kong and the Philippines.**
- **He is a registered Specialist in Land Condition (SiLC). One of only 120 and the only one in Asia. (www.silc.org)**

Content of the presentation

- **What is risk?**
- **Obtaining data to calculate risk**
- **Remediation Goals**

Risk based approach

- **Standard global approach**
- **Pollutant linkage - SOURCE of contamination is causing (or potentially may cause) a significant impact to a RECEPTOR via a PATHWAY**
- **Conceptual site model**

Conceptual model varies for each site

Industrial use

Future use

Ecological?

Ground surface?

Humans ?

Groundwater / surface water

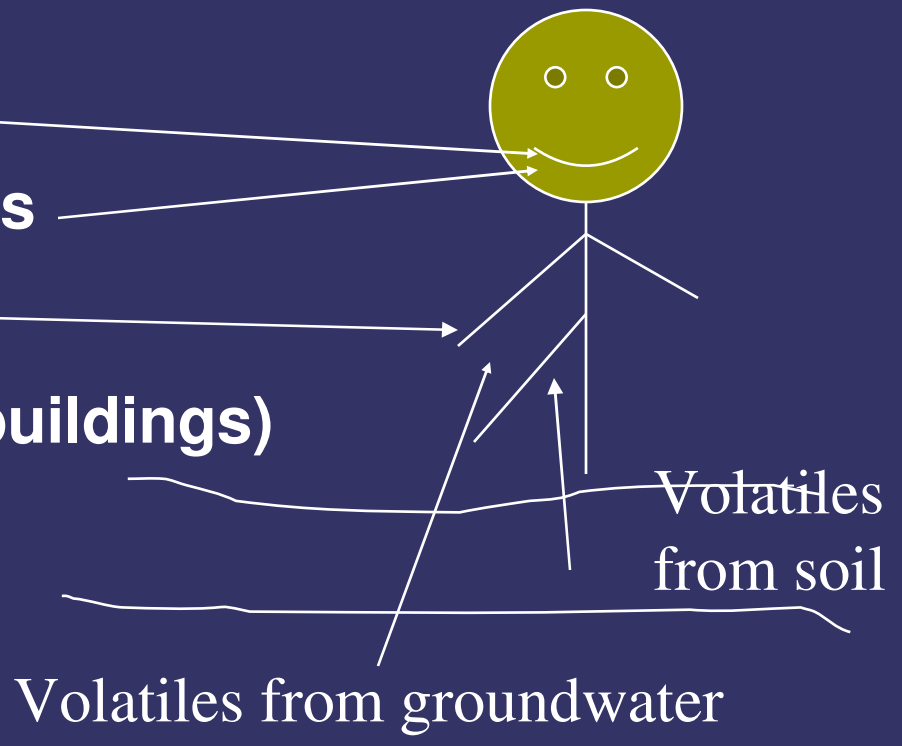
Basements?

Risk to humans

- **How toxic is the contaminant**
- **Exposure factors – ingestion, dermal and inhalation based on human behaviour**
- **Risk threshold – chance / probability**

Exposure pathways – humans

- **Ingestion**
- **Inhalation particulates**
- **Dermal contact**
- **Volatiles (entry into buildings)**



Sources of information

- **Toxicity data / generic soil data / exposure data– US EPA, DEFRA, TPH criteria working group, WHO**
- **Site specific data**
  - CISED
  - PBET
  - Cropping trials
- **Input data into chosen model**

Toxicity / model values

- **Critical health effects – threshold ? Tolerable daily intake**
- **No threshold – index dose, increased level risk to health**
- **Authoritative organisations –**
  - World Health Organisation,
  - Joint Food and Agricultural Organisation
  - USEPA (USA)
  - American Society Testing and Materials (ASTM)
  - DEFRA (UK)

Chemometric identification of substrates and element distributions (CISED)

- **SITE SPECIFIC**
- **CISED tests provide information on chemical forms of potentially harmful elements**
- **Arsenic study – found two major categories of components in soil**
  - Soil calcium dominated
  - Soil iron dominated

Soil calcium dominated

- Found a general trend of increasing extractable arsenic with increasing extractable calcium
- Calcium components are relatively soluble under acid conditions
- Acidic conditions are found in the human gut thus arsenic associated with the calcium carbonate component is likely to be highly bioaccessible and as such may be more available for adsorption into the body.

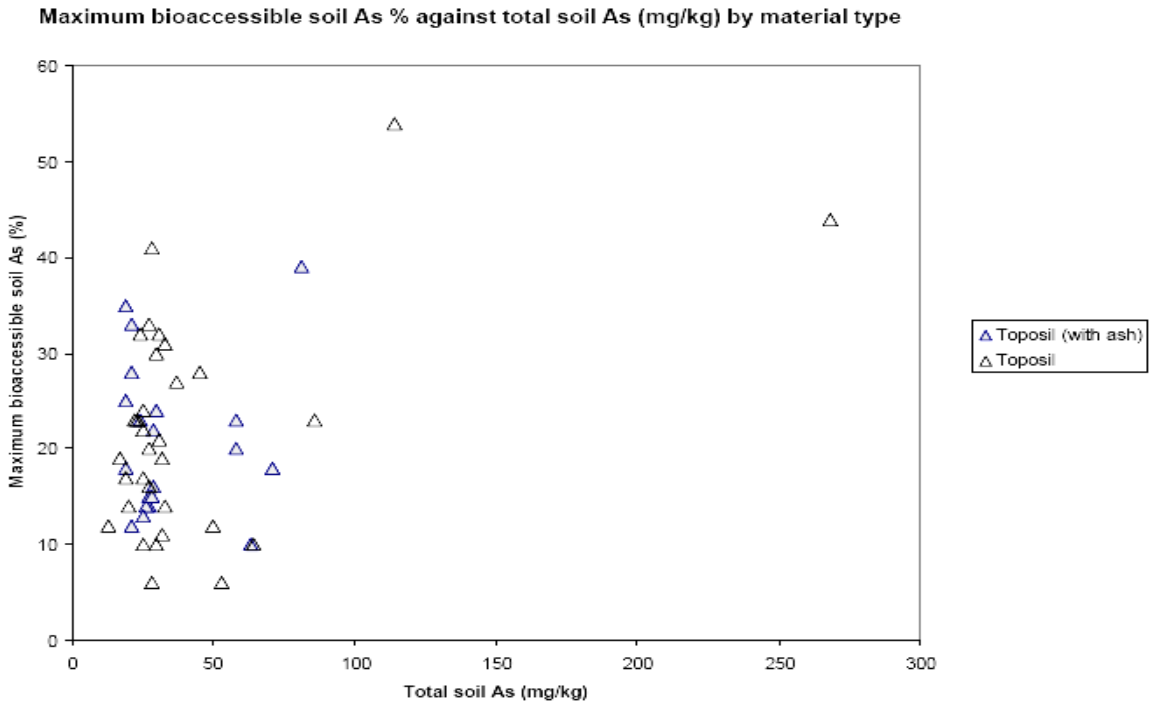
Iron dominated components

- In the samples where most of the arsenic was associated with the less soluble iron components
- Arsenic mobility is lessened and is likely to be less accessible

Physiologically based extraction test (PBET tests)

- **SITE SPECIFIC**
- **Bioaccessible fractions of contaminant**
- **PBET tests simulates gastrointestinal tract conditions in humans**

PBET findings



PBET

- **The maximum top soil bioaccessibility factors ranged from 6% to 54% whilst those for the made ground ranged from 1% to 47%. There was no relationship observed between the maximum PBET derived bioaccessibility factors and either the total soil arsenic or sample depth.**

Cropping Trials – site specific

- **Consumption homegrown vegetables forms a potentially significant exposure pathway**
- **Significance increases as bioaccessibility via direct soil ingestion decreases**
- **Compare Conversion Factor for Root and CF Leafy with defaults in your model**
- **Refinement of CF values was obtained, reducing the As exposure via homegrown vegetables.**

Use of data used

- **Use in model to calculate your exposure concentration**
- **Calculation of site specific targets – SSAC often not practical or possible**
- **Use available toxicity data to calculate targets for the proposed FUTURE USE of the site**

Hong Kong - land use scenarios - what is the future use of the site going to be ?

- **Urban residential - high rise, landscaped, children**
- **Rural residential - low rise, soil contact, vegetable consumption**
- **Industrial Scenario – adult receptors, industrial estates**
- **Public parks - open space, children, hardstanding with landscaped soil. Volatiles indoors not considered**

Risk based Remediation Goals

- **Developed by ERM for EPD for use in HUMAN HEALTH RISK ASSESSMENT**
- **Dutch B not applicable**
- **Not applicable to other receptors**

Developing RGRB's

- **Toxicity source data – international and local sources**
- **Model equations**
  - USEPA / ASTM
  - Building – ventilation , volatilisation – Johnson and Ettinger 1991

Developing RBRG's

Risk = exposure concentrations x exposure factors x toxicity

- **Exposure concentrations = RBRG**
- **Exposure factor = how humans exposed**
- **Toxicity = chemical toxicity of chemical of concern**
- **Risk = level of risk perceived to be acceptable**

Development of RBRG's

- **Chemicals of concern**
- **15 metals**
- **13 volatile organic compounds**
- **19 semi volatile organic compounds**
- **2 dioxins and poly chlorinated biphenols**
- **3 total petroleum hydrocarbon ranges**
- **Free cyanide**
- **Tributyl-tin oxide**

Development of RBRG's

- **Physical and chemical properties**
- **Toxicity data**
- **Based on this data the parameter values for each receptor could be assessed**

Development of RBRG's

- **Calculations based on**
  - Soil threshold for adult (dose above which an effect is seen)
  - Soil non threshold for adult / child (as dosage increase likelihood of effect expected to increase)
- **Using ingestion, dermal inhalation in combination with body weight, exposure frequency**

Models – similar approach

- **Target value for soil involves**
  - Dividing values derived from receptor information (body weight / averaging time, Exposure frequency/ duration) BY
  - Soil ingestion (ingestion rate / oral absorption factor / oral reference dose (RfDo) plus
  - Dermal pathway (skin surface area/soil to skin adherence/ dermal absorption factor / RfDo
  - Inhalation – particulates / vapour (soil density / porosity factors / inhalation reference dose

RBRG's

- **Soil RBRG – all land use / receptor categories**
- **Groundwater – indoor air RBRG –risk from volatiles**

RBRg's and NAPL

- **NAPL may be present – site observations**
- **Can compare against Csat and Solubility values generated to determine if further action is required.**

Receptors other than humans

- **Groundwater**
- **Surface water**
- **Ecosystems – flora and fauna**
- **Buildings**
- **Commercial crops - timber / grains**
- **Cattle / other**

Groundwater risk assessment

- **Groundwater is very precious in some countries and vital source of drinking water**
- **In UK if groundwater considered a receptor would compare against Drinking Water Standards**
- **Then undertake Tier 1, 2 and 3 assessment**

Groundwater remedial targets - SOIL

- **Tier 1 - pore waters / soil eluate / perched water quality.**
- **Tier 2 – attenuation in soil / unsaturated zone and dilution by groundwater under site**
- **Tier 3 – attenuation between source and compliance point**
- **Tier 4 – dilution in receptor / compliance point**

Groundwater remediation targets – groundwater

- **Tier 1 – not applicable**
- **Tier 2 – groundwater data is compared directly with the target concentrations**
- **Tier 3 – attenuation between site and downgradient receptor / compliance point**
- **Tier 4 – any dilution effects at receptor**

Ecological risk assessment

- **Tier 0 – pollutant linkage**
- **Tier 1 – initial screening does contamination present an eco-risk**
- **Tier 2 – site specific characterisation – biologically based – bioavailability (cropping / PBET/other)**
- **Tier 3 – specific additional measurements to characterise risk – MAGNITUDE OF RISK**
- **Tier 4 – risk un-acceptable management action required**

Other receptors

- **Building standards – e.g. sulphate / manganese levels – foundations designed appropriately**
- **Commercial crops and herds – similar to ecosystems**

end of overview

- **www.erm.com**