Soil Geochemistry and impacts on human health

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Presentation Outline

- Brief review of importance of soil to health
- Review Pathways from soil to body
- Examples of how Baseline Geochemical Surveys can be used in health issues
    - Trace element nutrition – Selenium
    - Soil Radon
    - High natural element concentrations
- Conclusions

Why is soil important to human health?

1. Soils are a major source of mineral nutrition

- The majority of our mineral nutrition comes via our food – plants and animals – soil derived mineral nutrition
- Drinking water is filtered through soil
- Health problems can be caused by deficiencies or toxicities associated with trace elements
- Elements essential for human health include Fe, Mn, Ni, Zn, Cu, V, Co, Cr, Mo, Sn, Se, I, & F
- Potentially harmful elements include As, Cd, Pb, Hg & U

Why is soil important to human health?

2. Soils can be a source of natural hazards detrimental to health

- Radioactive gases e.g. radon
- Pathogens e.g. tetanus (*Clostridium tetani*), Hookworm,
- Heavy metals associated with mineral deposits

3. Soils are a sink for contaminants

- Heavy metals & metalloids e.g. Cd, Pb, As (mining, sewage sludge disposal, industry)
- Organic chemicals e.g. Pesticides, PAH's, PCB
- Manufactured chemicals (>100,000)

- These can be re-mobilised and enter body via different pathways

Direct Pathways: Soil - Humans

- Geophagia
  - eating soil
  - soil on vegetables
- Dust Inhalation (PM_{10})
  - crystalline sillica from soil
  - particles from contaminated soils
  - particles with sorbed pesticides or herbicides
  - What is the soil contribution to household dust ?
- Soil Absorption through skin lesions (Route of pathogens)
- Inhalation of soil gases - Radon

Geoscience and human health

- Geoscientists tend to use ‘Aggregate level’ approach broadly relating spatial soil characteristics to geographic incidence of disease – ‘Hypothesis forming’
- Epidemiologists use ‘Individual level approach’
- Difficulties with ‘Aggregate level’ approach
  - Iodine deficiency
  - Sometimes effects can be obvious e.g. goitre, cretinism, However most effects mainly sub-clinical e.g. IQ reduction
  - Most ailments generally related to chronic or sub-chronic exposure / deficiency over many years,
  - People move about, many factors could contribute to ailments
- Poor public health costs a lot of money

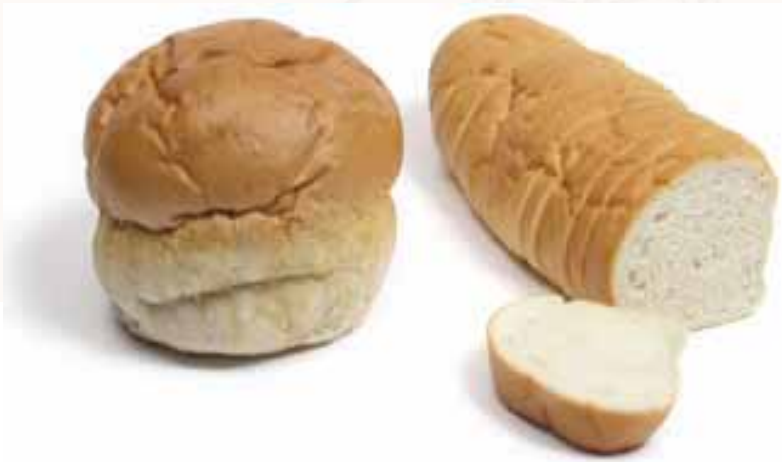
Health and Baseline Geochemical Surveys

High resolution geochemical surveys such as Tellus are useful in assessing public health issues because they highlight

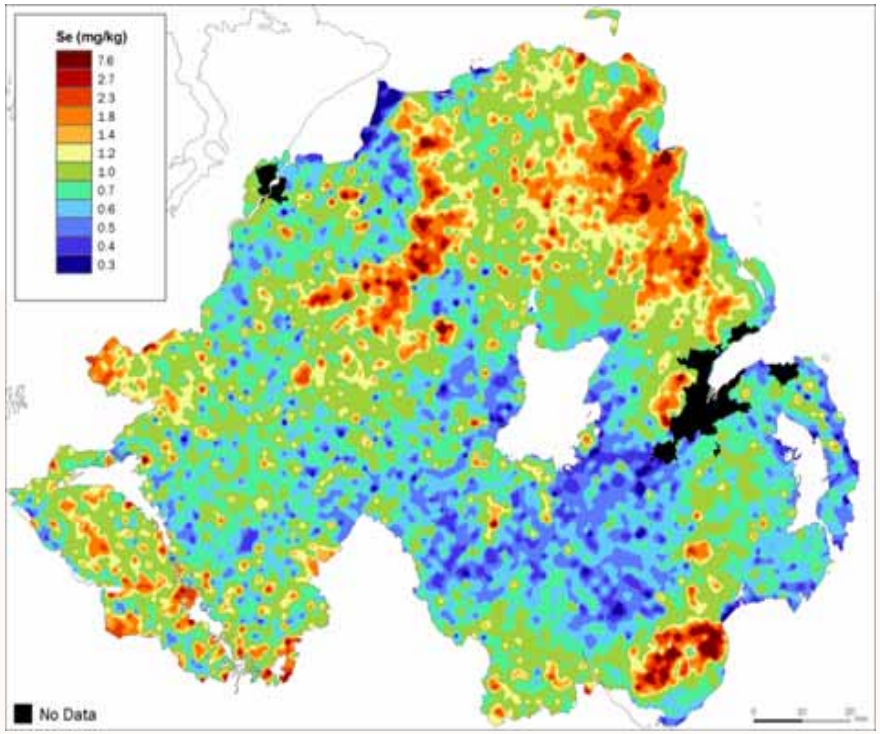
- **Spatial and temporal (time zero for monitoring) relationships between soil elements and geology**
- **They delineate where issues associated with geochemistry may occur in the source → pathway → receptor relationship**
- **They often locate unknown historical contamination problems and provide basis for follow up work**
- **They provide a basis for the development and use of new methodologies to assess health risks**

1. Trace elements Nutrition in humans – Se

- Essential micro-nutrient in humans and animals
- Se plays important protective role in the immune system and in the prevention and suppression of a number of specific orders including carcinomas, cardio-vascular diseases, cystic fibrosis and low fertility
- Recommended daily Se intake for adults are between 55 and 75 µg for men and women respectively
- Se levels in UK diet fell from 60 ug day^{-1} in 1970's to 29-39 ug day^{-1} in 1995
- Use of UK wheat instead of US wheat that has higher concentrations of Se.



Baseline soil geochemistry maps can help guide decision making

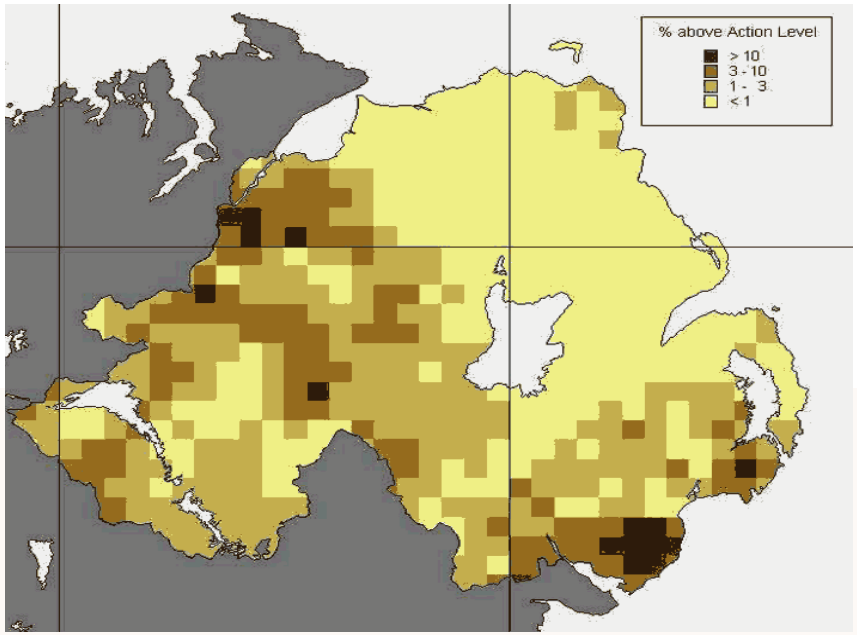


- Baseline soil geochemistry provides information with respect to total Se concentrations and distributions
- Typical UK value ~ 0.4 mg kg^{-1}
- Northern Ireland range = 0.2 – 7.6 mg kg^{-1}
- Soils considered deficient in Se at levels of 0.1- 0.6 mg kg^{-1} (Fordyce, 2005)
- However, knowledge of Se biogeochemistry, plant uptake and human absorption rates is required
- Options – bio-fortification, supplements or fertilisation?

2. Radon

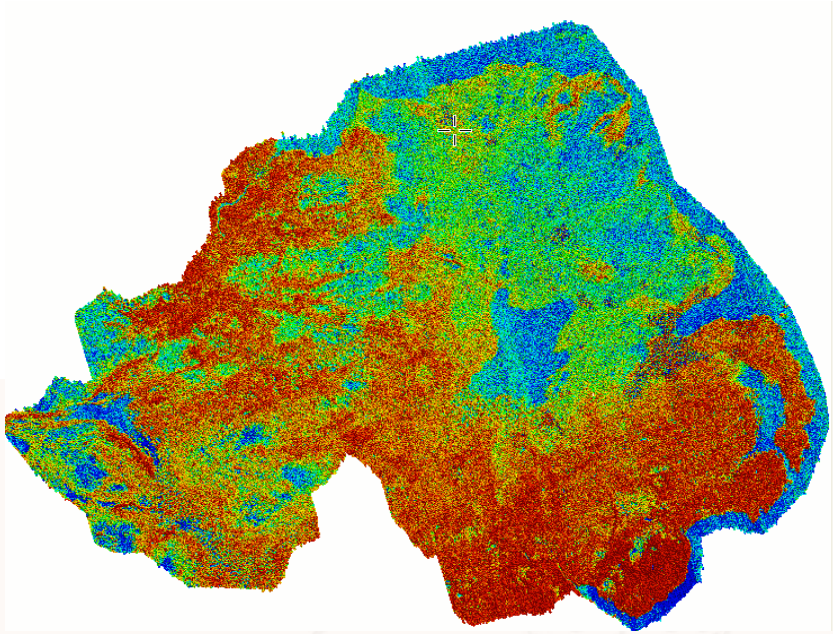
- Radon is a radioactive gas that comes from ^{238}U and decays to daughters ^{218}Po, ^{214}Pb, ^{214}Bi and ^{214}Po
- Gas forms in soils and rocks and is a problem where they are enriched in Uranium
- Half life of radon is 3.83 days – therefore formation in soil is a more likely source than rock because of migration time through the soil
- More likely to be found over granitic, sandstone or carboniferous limestone rocks in UK.
- Rate of weathering release from the rock is important.
- Soil factors such as permeability, CO_2 concentration and moisture affect migration rates

Radon Potential in Houses



100 Km

5 km Radon Potential Map
Northern Ireland (Action Level 200 Bq m^{-3})



100 Km

Airborne U detection by gamma spectrometry
2005-6 every 2 km^2

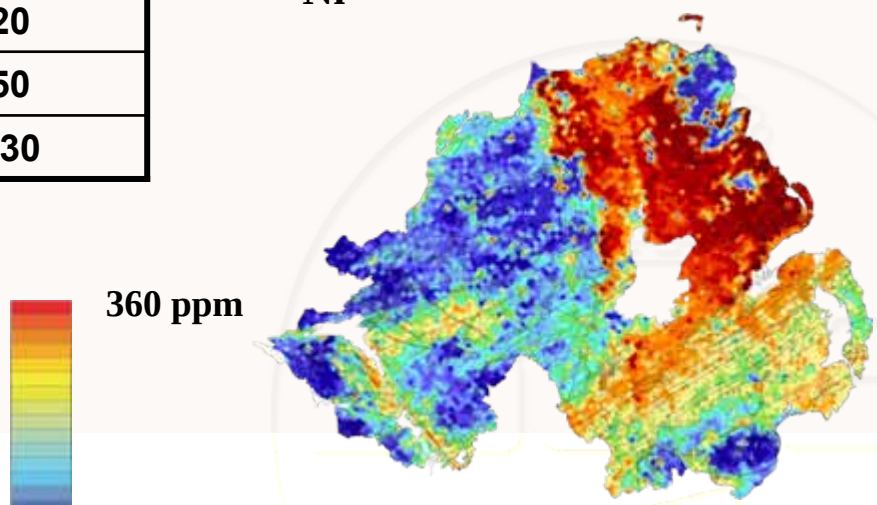
Baseline geochemistry can improve produce maps and allocation of resources

3. Northern Ireland Ni, Cr, As soil issues

In Northern Ireland some areas have natural Ni, Cr & As concentrations that exceed the Soil Guideline Values (SGV)

	NI Range mg kg^{-1}	Median mg kg^{-1}	SGV (Residential) mg kg^{-1}
As	0.9 - 271	8.7	20
Ni	1.4 - 333	29	50
Cr	4.1 - 1229	94	130

Ni



Soil Guideline values

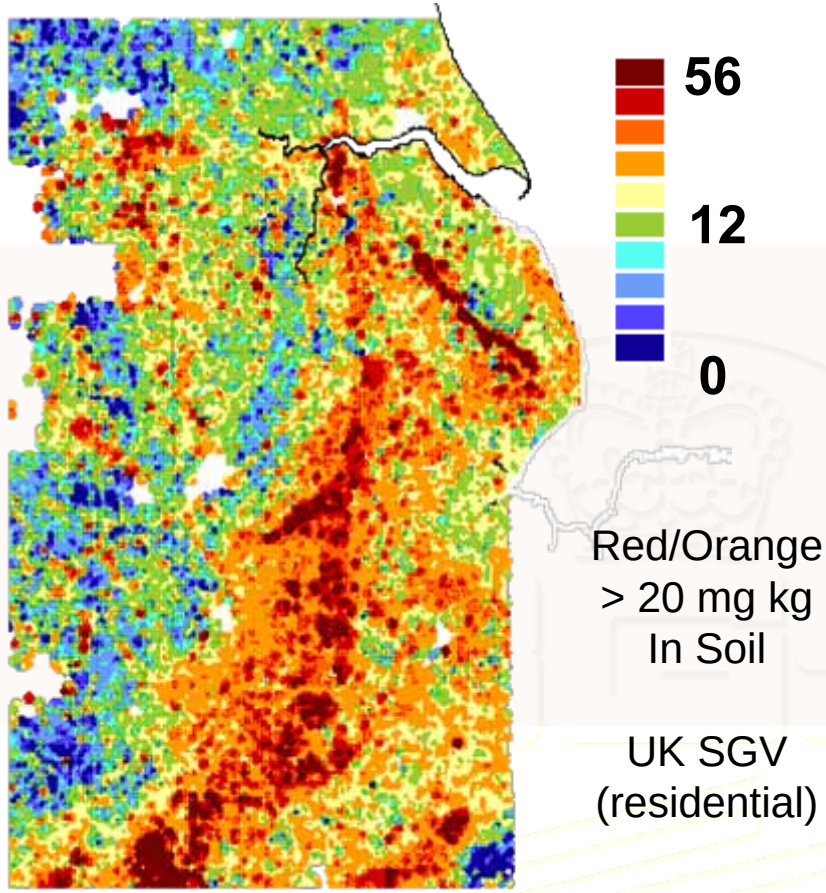
- **act as a guide to when further investigation is needed**
- **are a large driver for baseline information**

As issues in the East Midlands of England

- The Ni, Cr and As situation in Northern Island is similar to one in England associated with soils formed over the Jurassic Ironstones in the East Midlands

Issues involved

- Financial
- Sustainable
- Social - Equity
- Health
- Resources
- > million people potentially impacted
- > 300,000 households



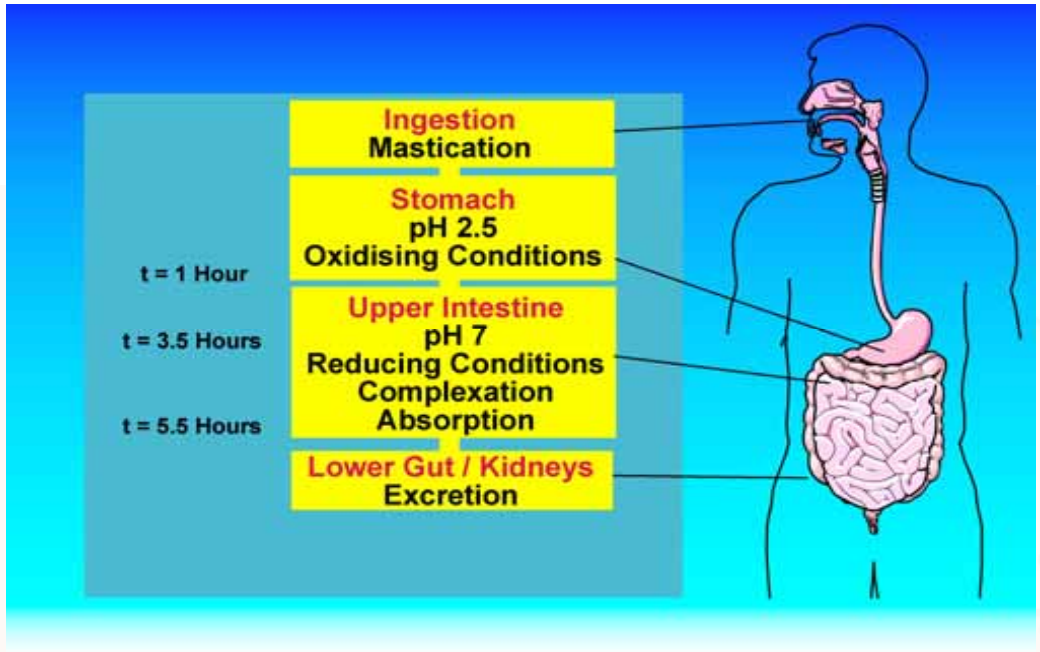
The BGS Physiologically Based Extraction Test (PBET) - a physiologically based assay to assess the bioaccessibility of As

Bioaccessibility

Defined as the fraction of a substance which is accessible for uptake via a specific pathway

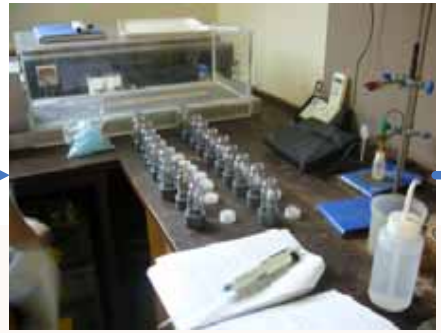
e.g. Solubility in gastric or lung fluids

Can be used by Environmental health and planning officers to help inform decisions when the SGV is exceeded



The BGS- PBET test

Stomach and Intestine reagents are prepared according to the protocol



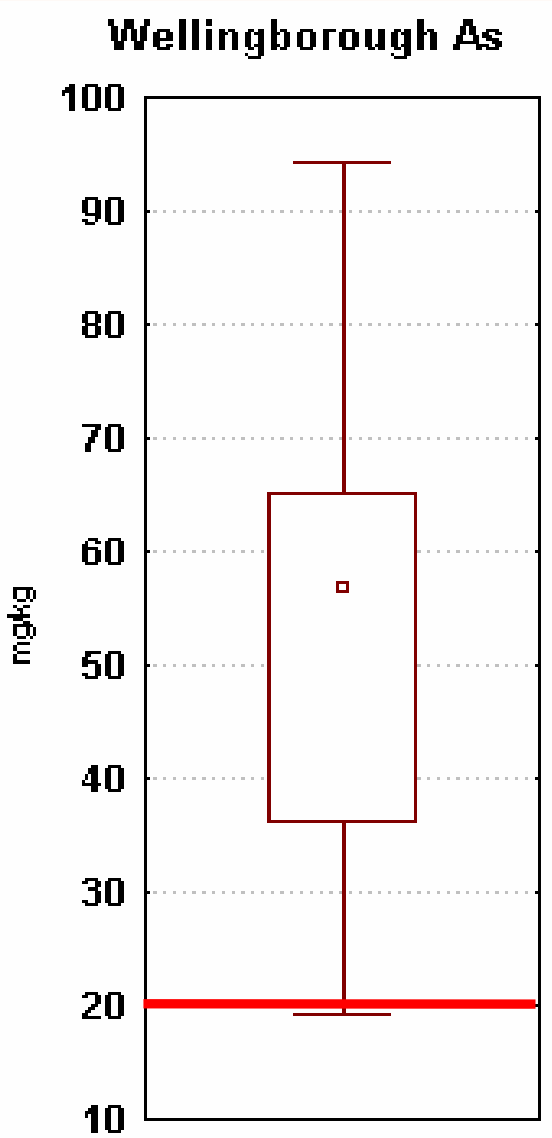
Soil samples are weighed into centrifuge tubes

Soils are extracted with gastric and intestine solutions in a water bath at 37^0 C

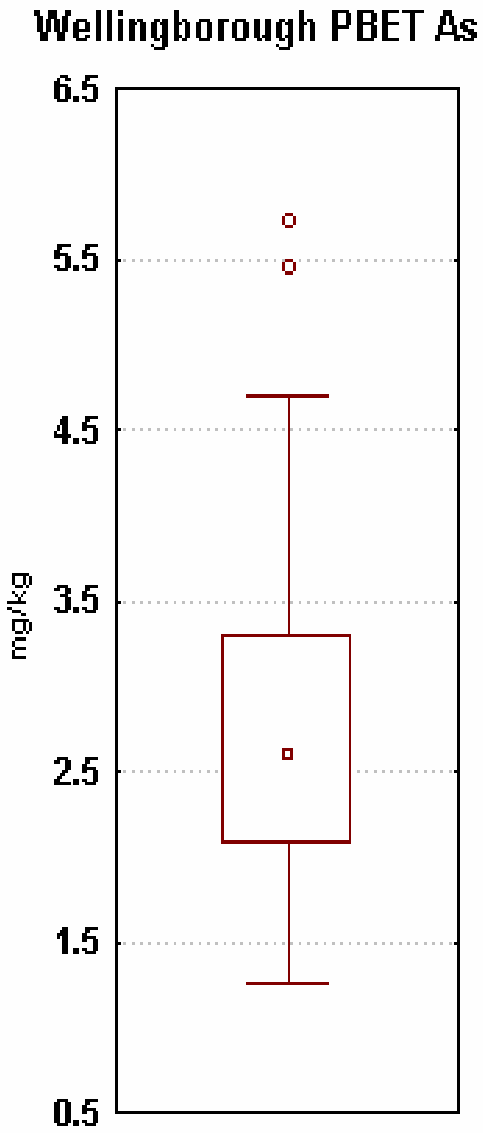
Samples are Centrifuged

Decanted samples are diluted and preserved in 0.1 M HNO_3

Samples are analysed by ICP-AES



- Arsenic in urban soil, 5-20cm depth and < 250µm.
- Typically > 90% of Applied Dose is due to As derived from the soil and dusts ingestion pathway
- PBET suggests that in the time soil would take to pass through the gut a potential concentration of ~ 2.5 mg kg^{-1} As would be accessible to enter blood
- PBET is conservative



Conclusions

Baseline geochemical surveys

- **Provide an important resource in understanding health issues related to soil especially with complementary data such as soil pH and organic C**
- **Provide context and data to support regulation, research and policy**
- **Should be a focal point for developing multi-disciplinary research involving geochemists, health researchers, engineers and sociologists**

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