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Lead, bioaccessibility and health

British Geological Survey

Pb

- Non-threshold contaminant
- May cause adverse health effects when after exposure to any concentration
  - Gastrointestinal (GI) system
  - Nervous system
  - Renal function
  - Neurological
    - Crime
    - Deprivation

Pb and health

- UK
  - July 5th 2021
  - Health Security Agency lowered the public health intervention concentration for lead
  - 5 ug/dL

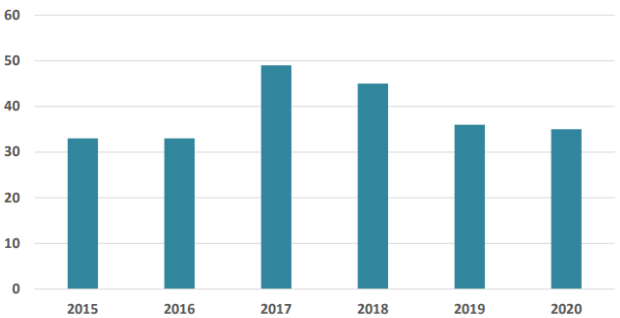
- The Conversation “A new, lower threshold for lead poisoning in children means more kids will get tested – but the ultimate solution is eliminating lead sources”
  - The U.S. Centers for Disease Control and Prevention has updated its blood lead reference value
    - 5 ug/dL of blood Pb (2012) reduced to 3.5 ug
    - ca. double the number of children who are classified as at highest risk for lead poisoning

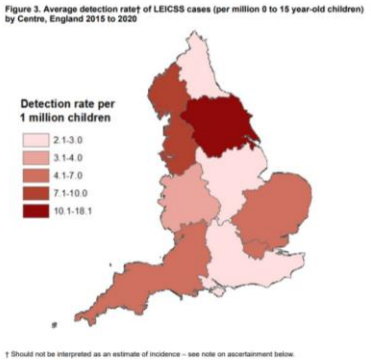
https://theconversation.com/a-new-lower-threshold-for-lead-poisoning-in-children-means-more-kids-will-get-tested-but-the-ultimate-solution-is-eliminating-lead-sources-170929
https://www.gov.uk/government/publications/lead-exposure-in-children-surveillance-reports

UK Pb surveillance

- Formal surveillance of Pb exposure in children in England started in 2010
  - a joint research project between the British Paediatric Surveillance Unit and the Health Protection Agency
- Lead Exposure in Children Surveillance System (LEICSS) – 2021 report
  - 35 cases, 1 to 4 years old boys, resident in more deprived areas
  - Median blood lead concentration of cases was 0.71µmol/L (14.69 µg/dL) in 2020

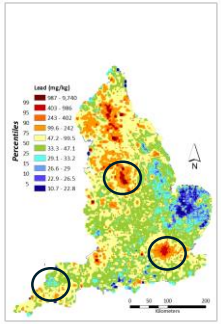
Figure 1. Count of LEICSS cases, England 2015 to 2020

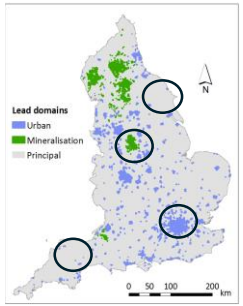


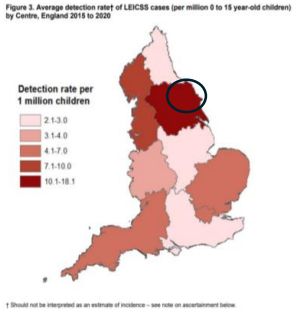


Pb in UK soils

- Geochemical Baseline Survey of the Environment (GBASE)
  - 10 – 10,000 mg/kg
- Normal background concentrations for soil Pb in England
  - ca. 180 mg/kg (94% of UK)
  - 820 mg/kg (urban)
  - 2,400 mg/kg (Pb mineralisation)







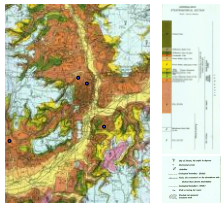
- High blood Pb where lower mineralisation and urbanisation

- Urban Agriculture Gardening (allotments) on the increase
  - growing concerns over food security
  - greater attention on healthy eating and lifestyles
  - health promoting activity
- Legacy Pb = most common contaminant in allotments
  - Paint
  - Automotive Pb emissions
  - Ashes from residential fires and industrial emissions
- A need to provide regulators with greater confidence to decide if sites are suitable for use

Sources of confidence

Understanding the soil

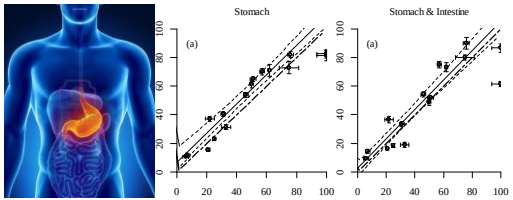
Geology
Mineralogy
Land use



PHE content

Element concentrations
Bioaccessibility

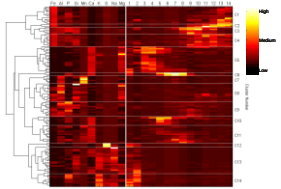
- Physiological relevance
- Validation status



Physico-chemical understanding

CISED

- Acid extraction
- Data modelling



Example: Entwistle et al., 2019

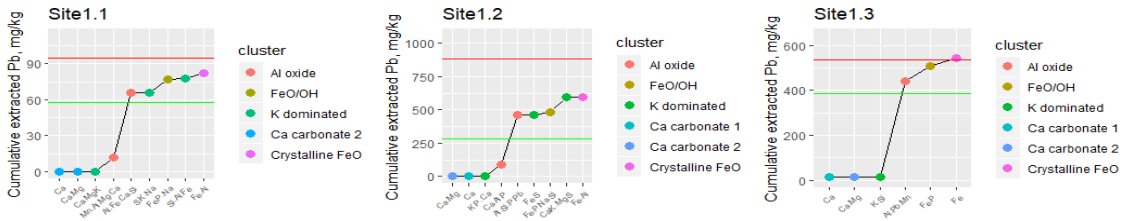
- Growing food in contaminated urban areas could increase our exposure to Pb

- Newcastle Allotments Biomonitoring Study (NABS)[1]
  - To improve the derivation of soil assessment criteria at allotment sites
  - Paired soil and crop samples from 31 gardens
  - Participant blood lead measurements
- High total and bioaccessible Pb concentrations (324 mg/kg, 57% bioaccessibility)
  - BLL were<4.1 µg/dL
  - No statistically significant difference between gardeners and their non-gardening neighbours

1. An apple a day? Assessing gardeners' lead exposure in urban agriculture sites to improve the derivation of soil assessment criteria, Environment International, Volume 122, January 2019, Pages 130-141

Low BLL, why?

- Paired bioaccessibility (UBM) and physico-chemical understanding (CISED)[1]
  - Understand bioaccessibility and inform sustainable site management planning
- Pb is primarily associated with Al oxide phases
- The co-presence of a P component indicated the presence of Pb phosphate type minerals e.g. plumbogummite ($PbAl_3(PO_4)_2(OH)_5 \cdot H_2O$)
  - a consequence of natural “soil aging” processes.



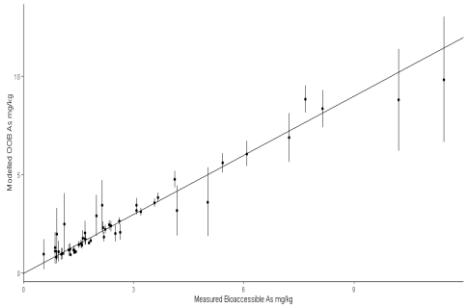
- The presence of Pb phosphates and lack of elevated blood Pb levels in gardeners compared to their non-gardening neighbours, suggests the (legacy) Pb has been left relatively immobile

1. Investigating the Geochemical Controls on Pb Bioaccessibility in Urban Agricultural Soils to Inform Sustainable Site Management, Geosciences 2020, 10, 398; doi:10.3390/geosciences10100398

Predictive modelling for land use planners

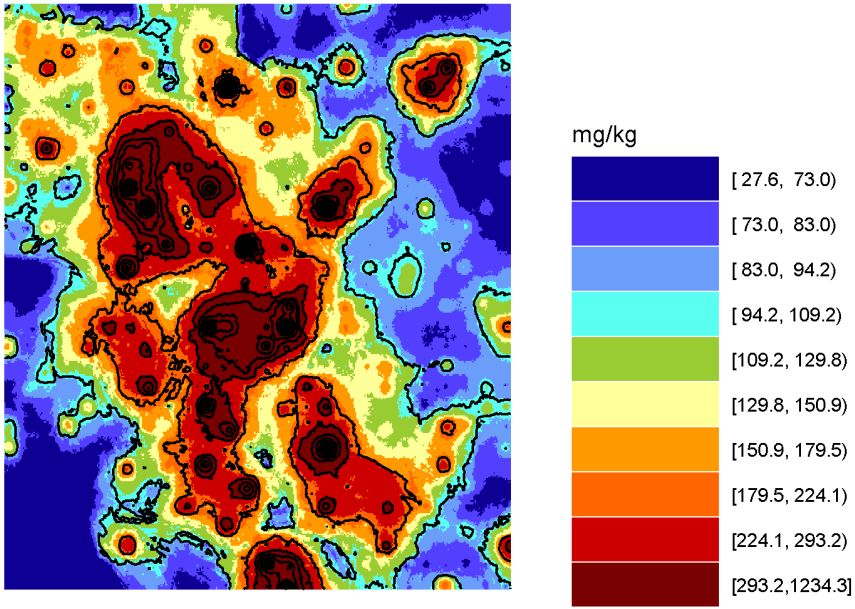
- Home of the UK pottery Industry
  - 1700's to today
  - Abundance of clay and coal
- Industrial activity
  - foundries, steelworks, brick and tile works
- Regeneration
  - Open and greenspace
    - Previously used land e.g. steelworks, potteries

- Geochemical Baseline Survey of the Environment
- Random Forest bioaccessibility model
  - Dependant variable: measured bioaccessibility
  - Predictor variable: total element concentrations, sample elevations, superficial and subsurface geology
- Comparison of predicted values against the measured bioaccessible values for the selected soils used to set up the model for all sampling locations

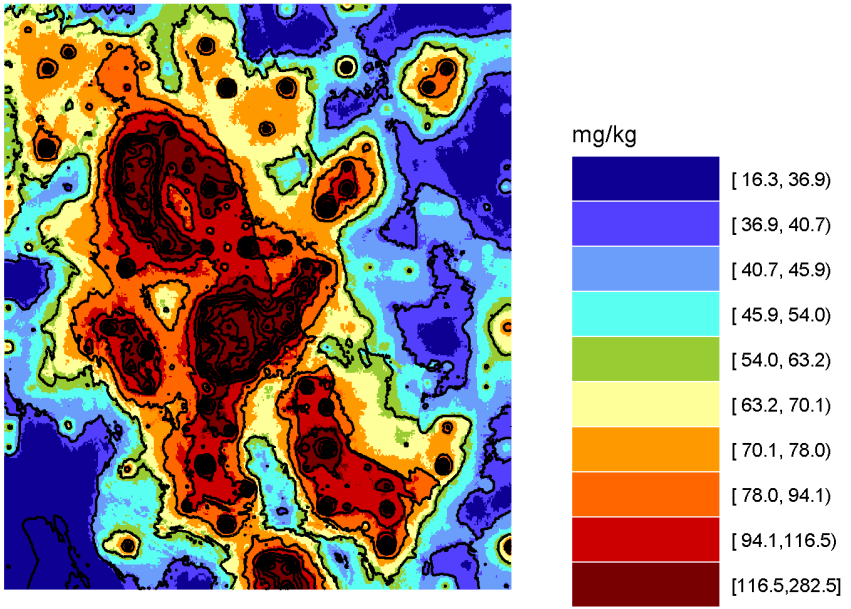


Bioaccessibility mapping

Total Pb



Bioaccessible Pb



- Similar pattern
- Significant reduction in available Pb

Issues with Pb in the environment are not going away despite changes e.g. banning of sources

We have a long legacy of pollution to overcome

Understanding the links between soil geochemistry and bioaccessibility support health risk assessment and risk based decision making for different land uses

Predictive modelling to produce bioaccessibility maps provides a spatial tool for local planners without the need for extensive sampling, testing and remediation

British Geological Survey

THANK YOU

Any questions?