



**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL



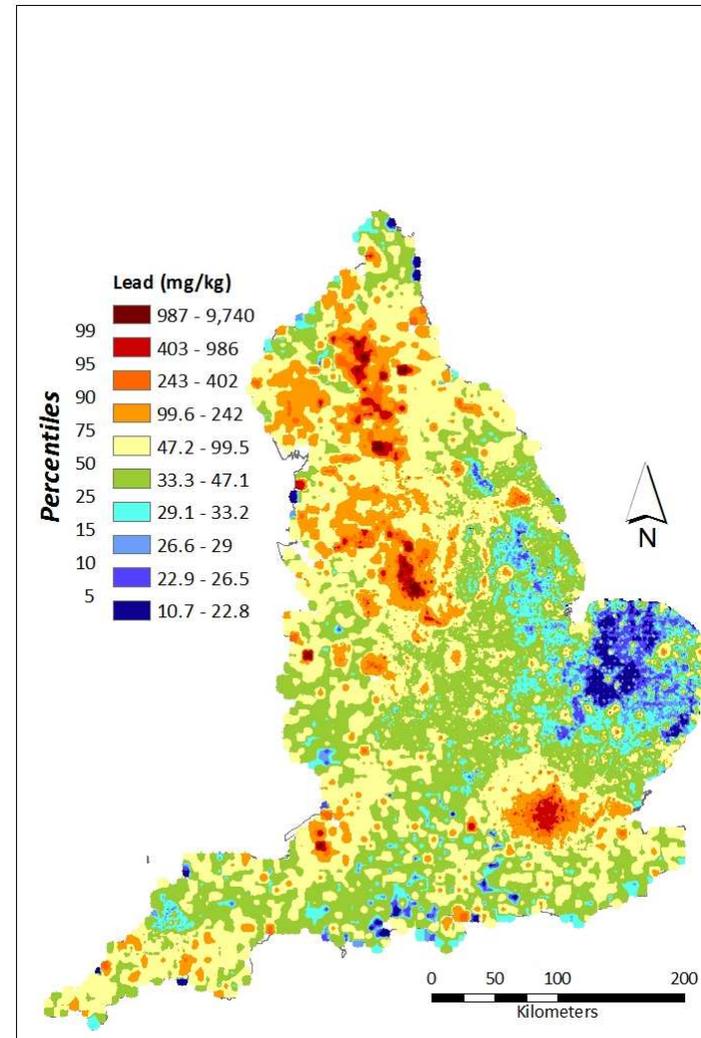
Applied geoscience for our
changing Earth

Sources, Mobility and Bioaccessibility of Potentially Harmful Elements in UK Soils

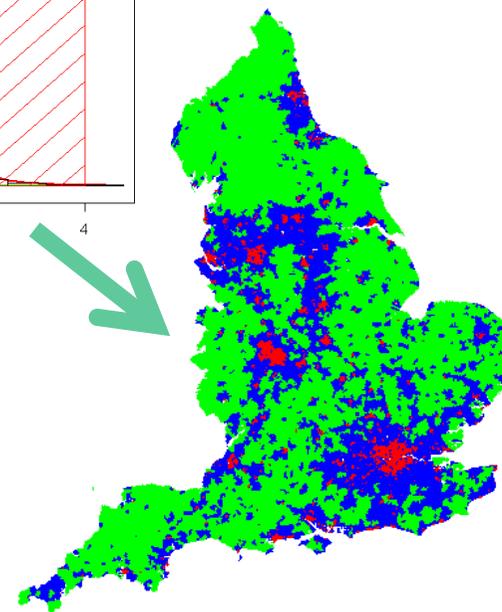
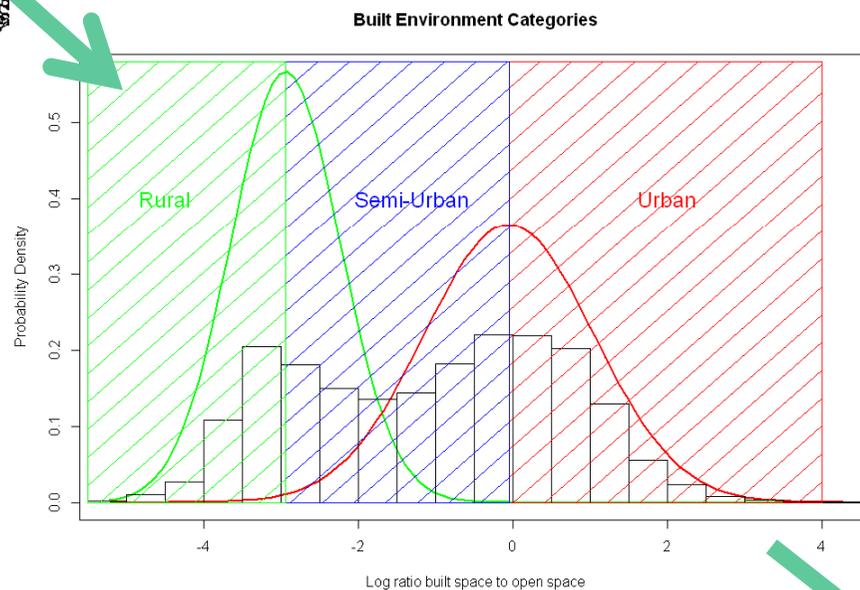
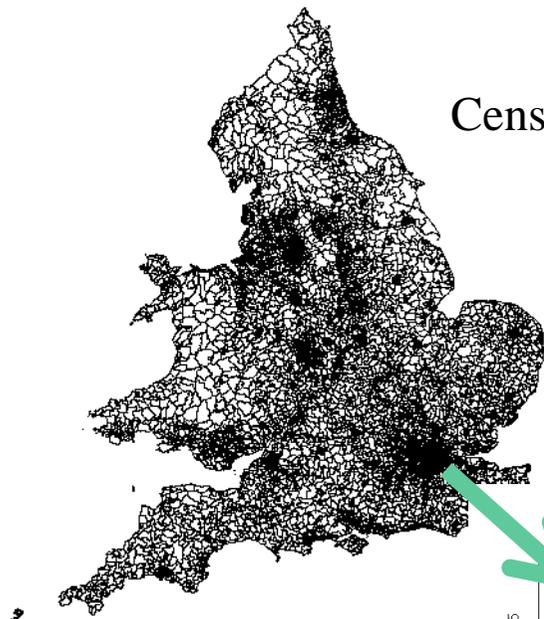
Mark Cave
British Geological Survey

Sources of Potentially Harmful Elements in soils

- Natural geogenic sources
- Anthropogenic pollution
 - Point source (single identifiable source)
 - Diffuse pollution (dispersed over a wide area)



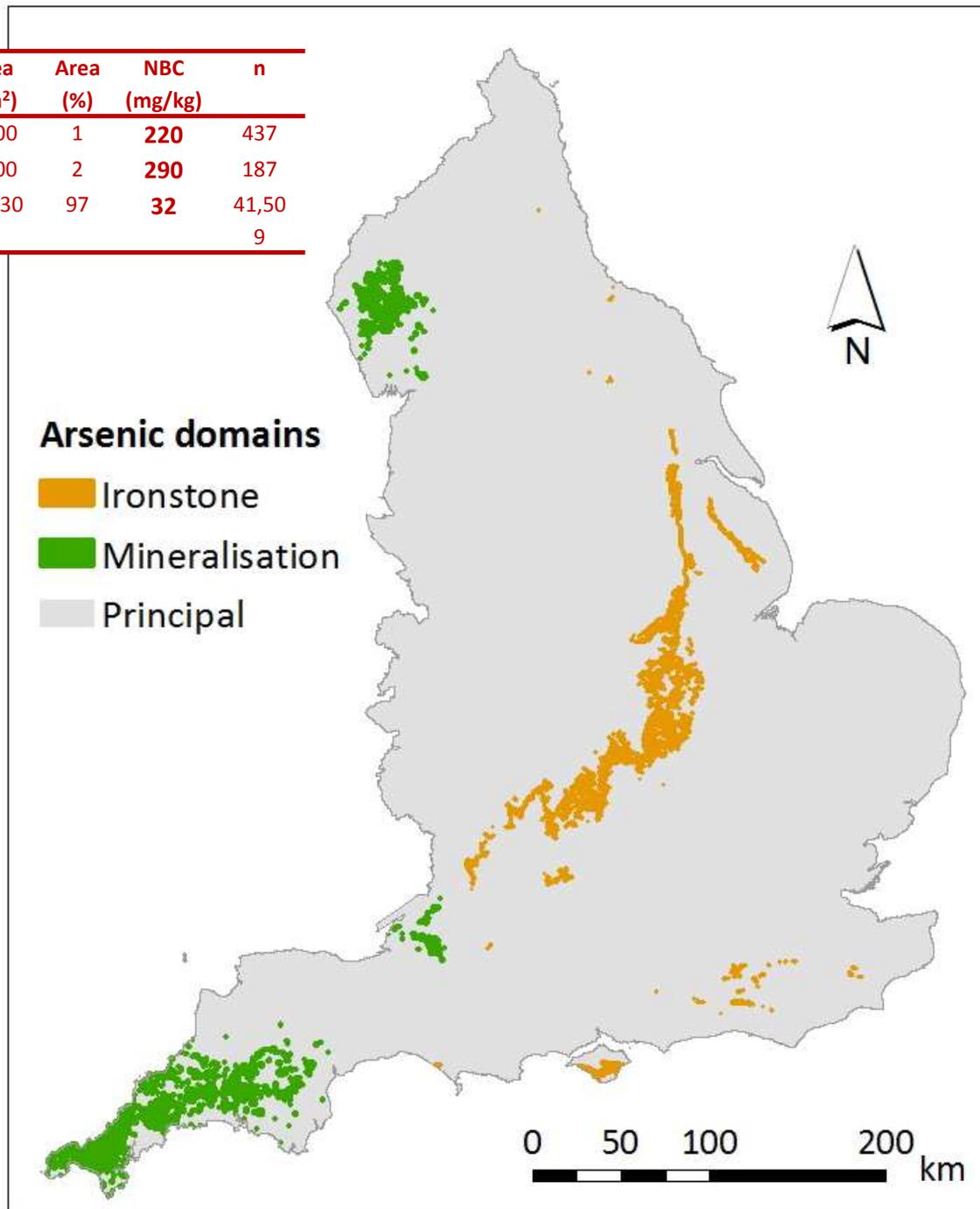
Census Area Statistical Wards 2003



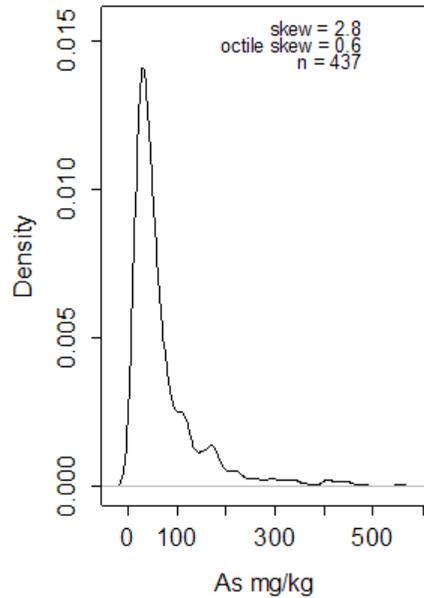
Domain	Area (km ²)	Area (%)	NBC (mg/kg)	n
Ironstone	1,300	1	220	437
Mineralisation	2,300	2	290	187
Principal	129,300	97	32	41,509

Arsenic domains

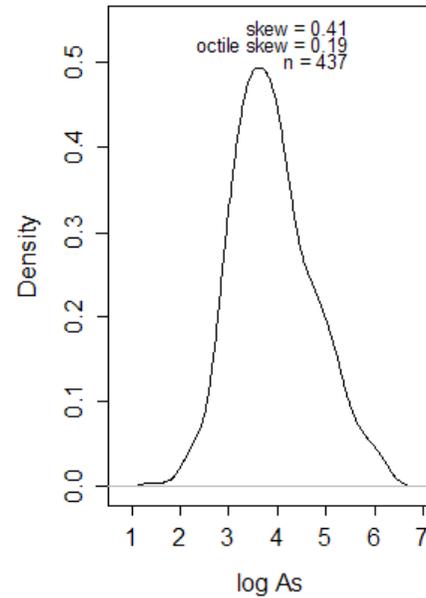
- Ironstone
- Mineralisation
- Principal



Untransformed data



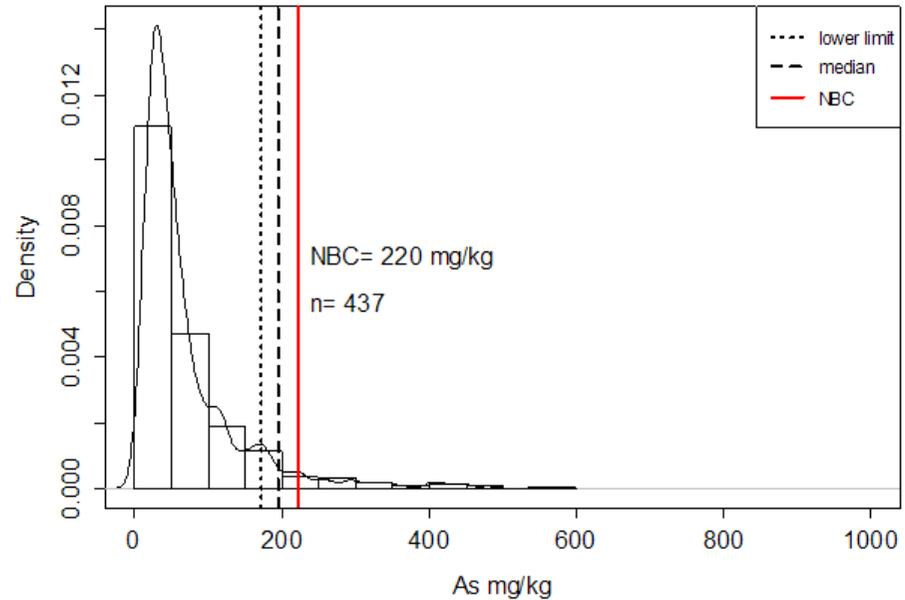
Log Transformed



Establishing a Normal Background Concentration (NBC)

Arsenic in the Ironstone domain

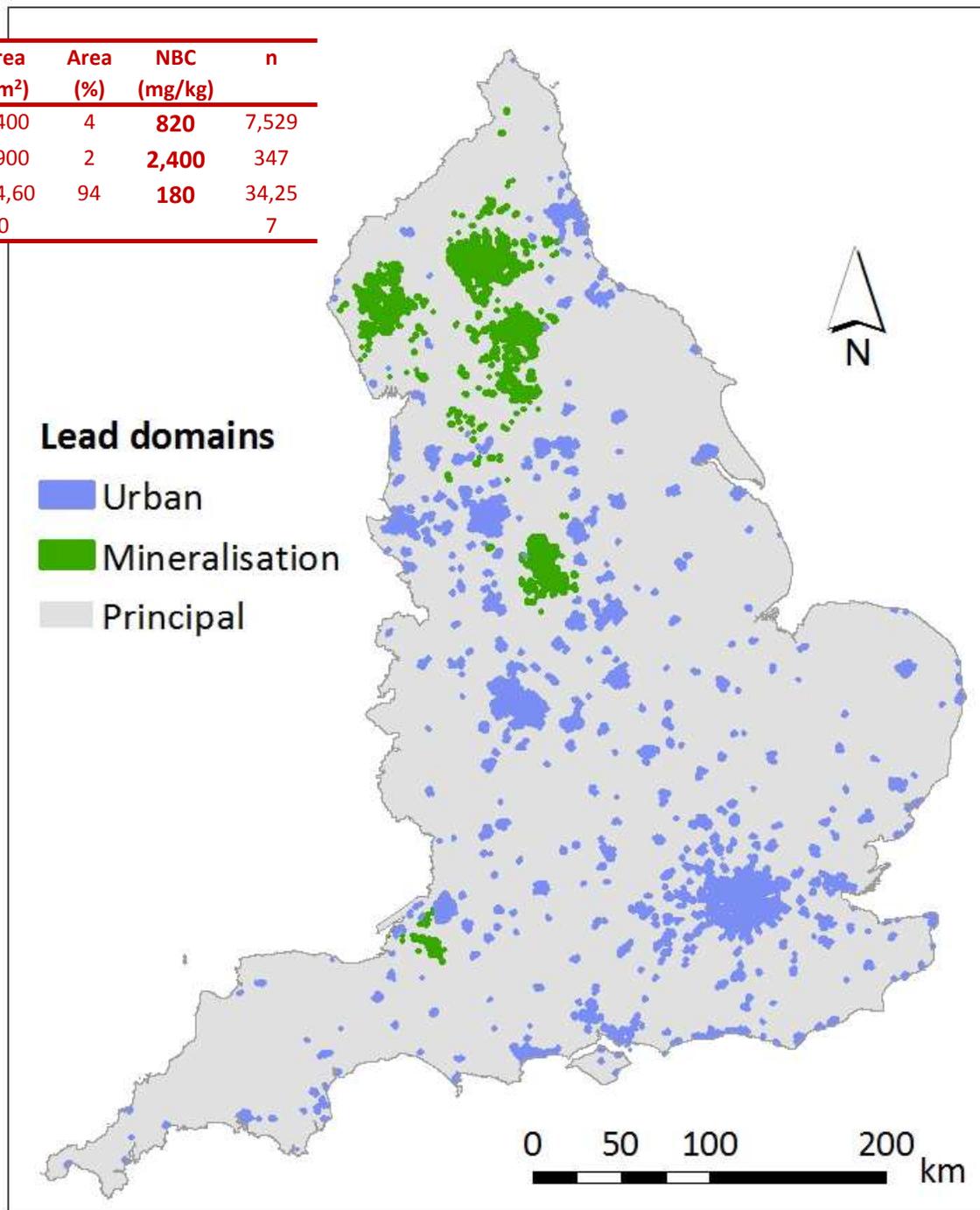
As Ironstone Domain



Domain	Area (km ²)	Area (%)	NBC (mg/kg)	n
Urban	5,400	4	820	7,529
Mineralisation	2,900	2	2,400	347
Principal	124,600	94	180	34,250

Lead domains

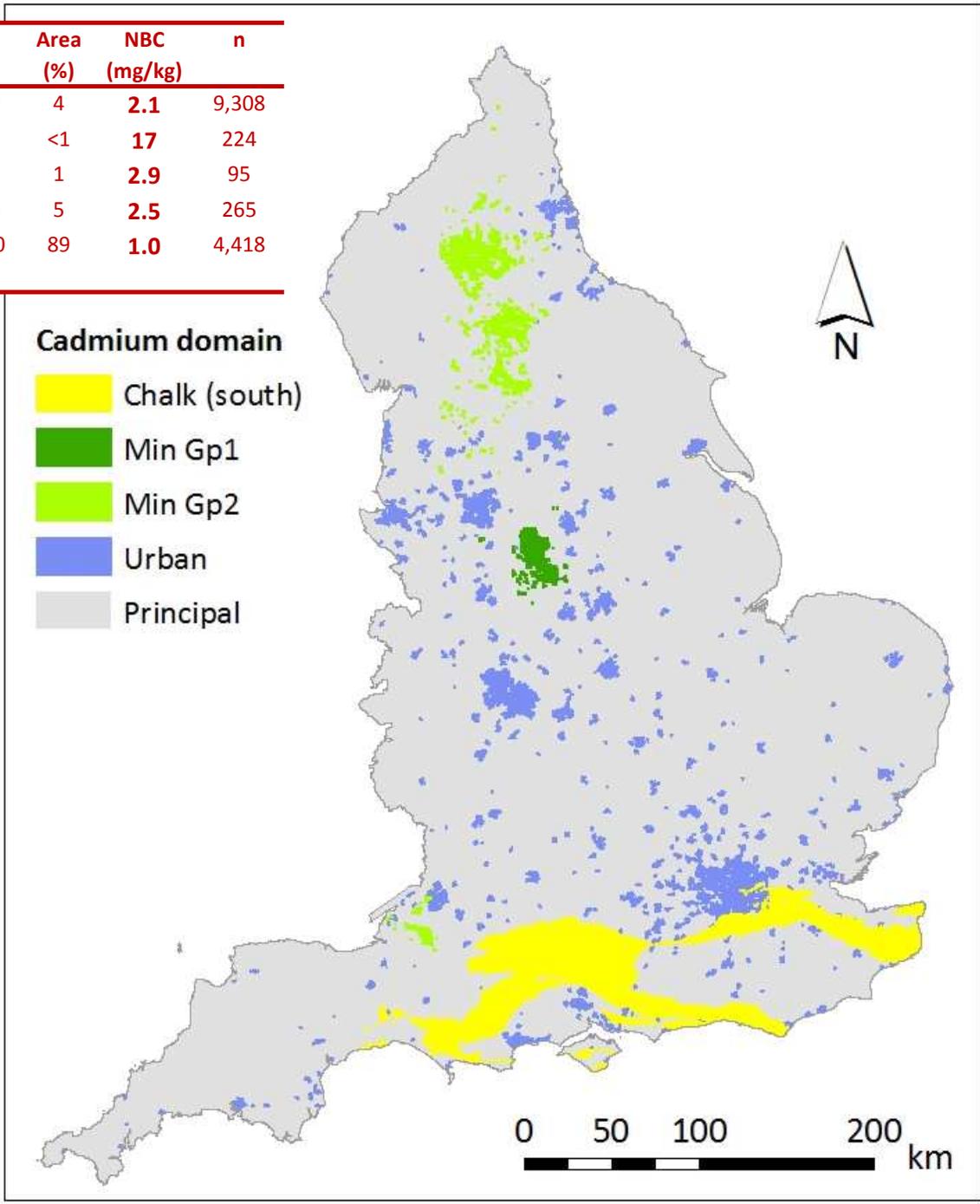
- Urban
- Mineralisation
- Principal



Domain	Area (km ²)	Area (%)	NBC (mg/kg)	n
Urban	5,200	4	2.1	9,308
Min. Group 2	500	<1	17	224
Min. Group 1	1,600	1	2.9	95
Chalk South	6,900	5	2.5	265
Principal	118,700	89	1.0	4,418

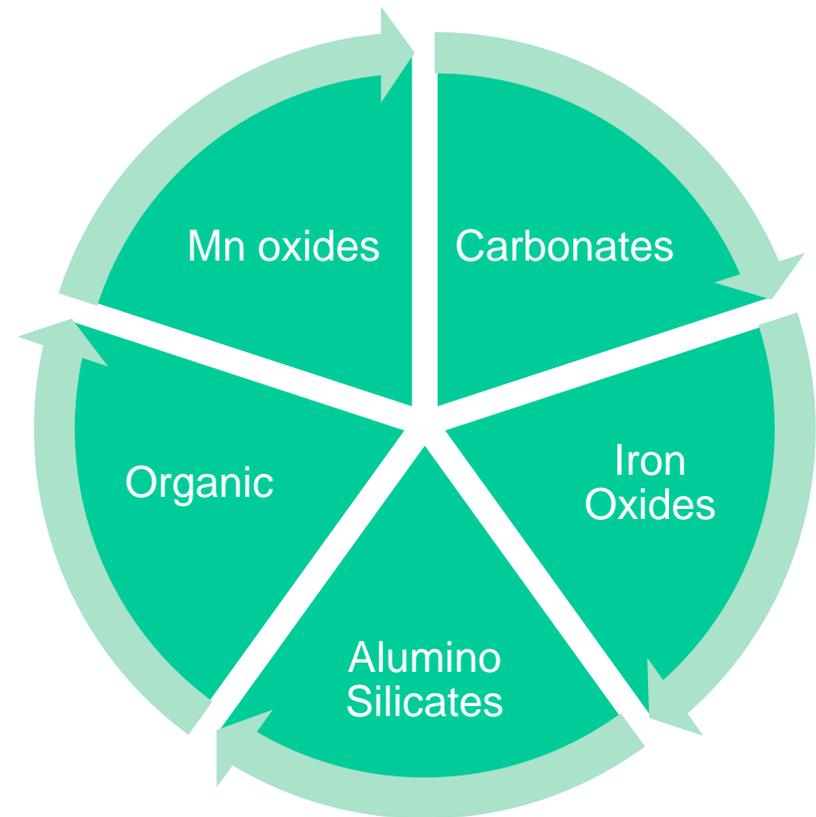
Cadmium domain

- Chalk (south)
- Min Gp1
- Min Gp2
- Urban
- Principal

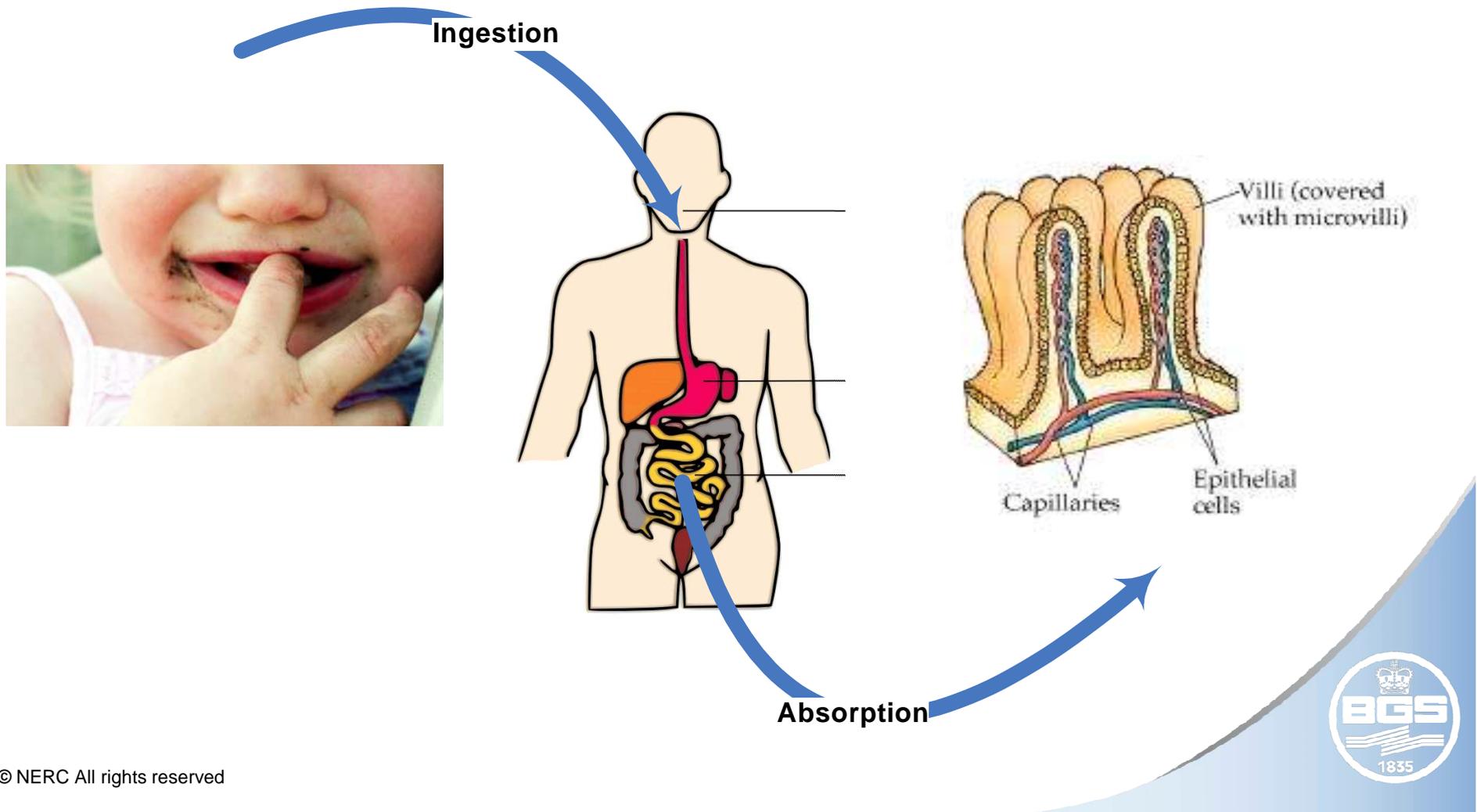


How do we measure PHE mobility?

- Geo availability – PHE fractionation, mineralogy, sequential extraction, SEM, XAFS, XANES
- Bioaccessibility/bioavailability – measure in-vivo or mimic inhalation, ingestion, dermal contact.



What are we trying to achieve?



Exposure biomarkers

Biological markers (biomarkers) can be utilised to estimate levels of exposure to harmful substances.

Following exposure, soluble arsenic is adsorbed from the gastro-intestinal tract and distributed to all bodily systems in the blood, accumulating in many body parts.

Short-term (recent exposure)

Blood



Urine



Long-term (past exposure)

Toenails



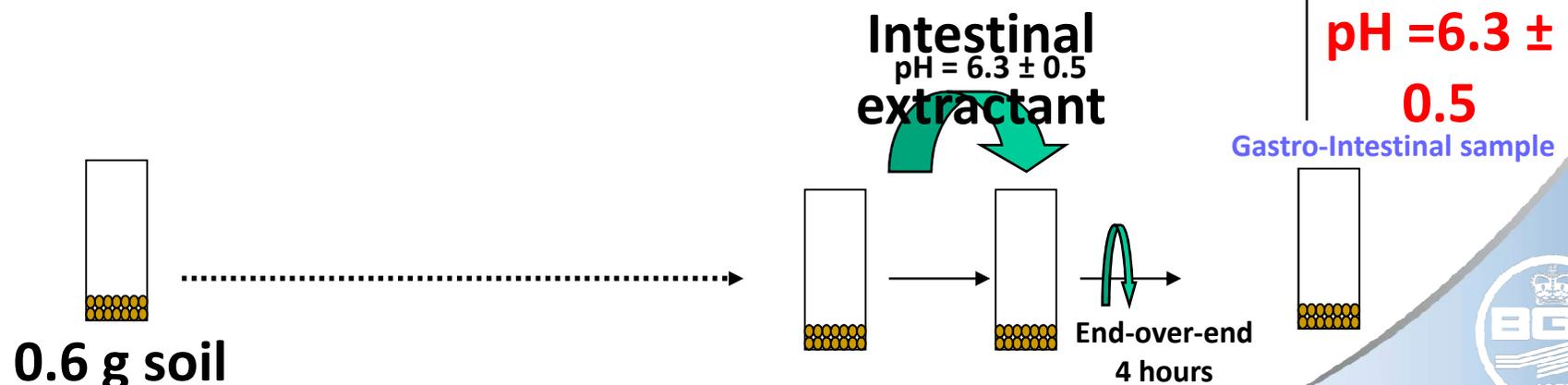
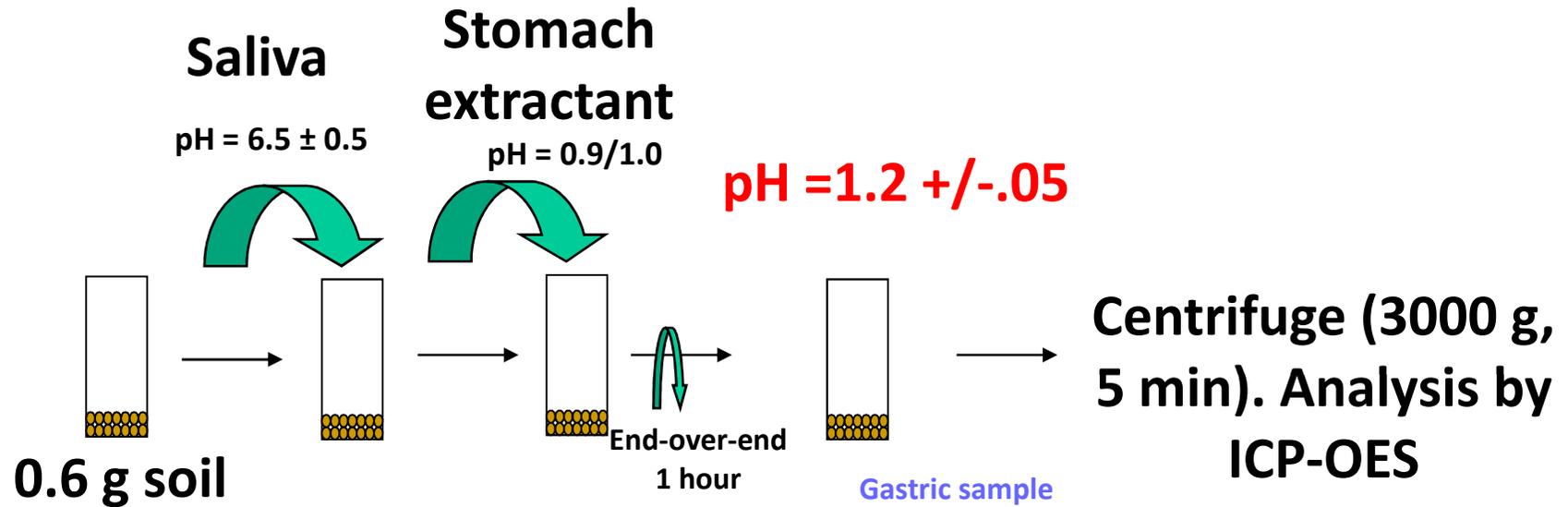
Fingernails



Hair



Bioaccessibility : Unified BARGE Method (UBM)



The PBET method



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^o C



Samples are analysed by ICP-AES

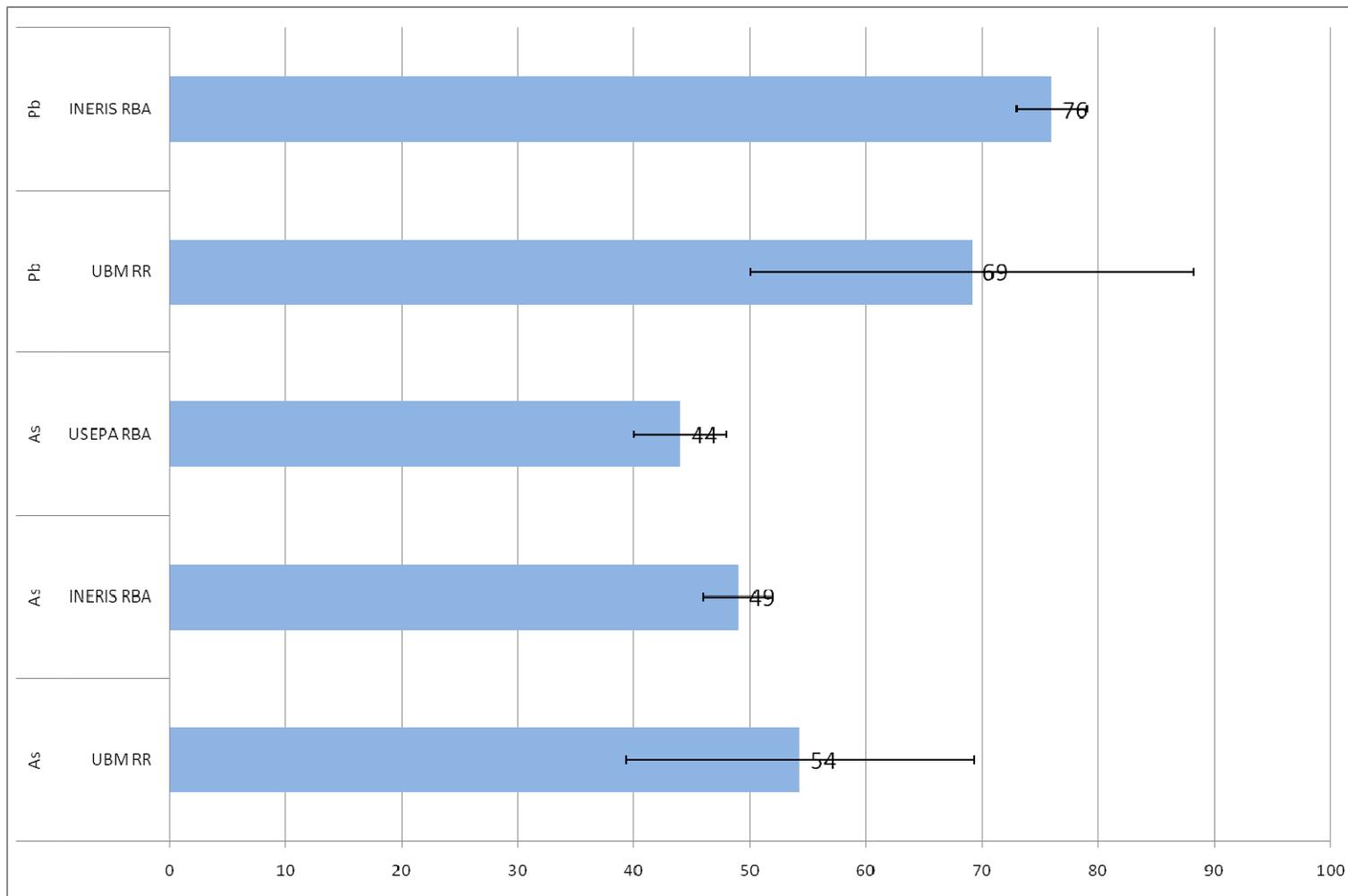


Decanted samples are diluted and preserved in 0.1 M HNO₃



Samples are Centrifuged

Comparison of *in vivo* and *in vitro* data for NIST 2710 for the UBM inter-laboratory trial (2006/2007)



In Vivo Validation of the Unified BARGE Method to Assess the Bioaccessibility of Arsenic, Antimony, Cadmium, and Lead in Soils

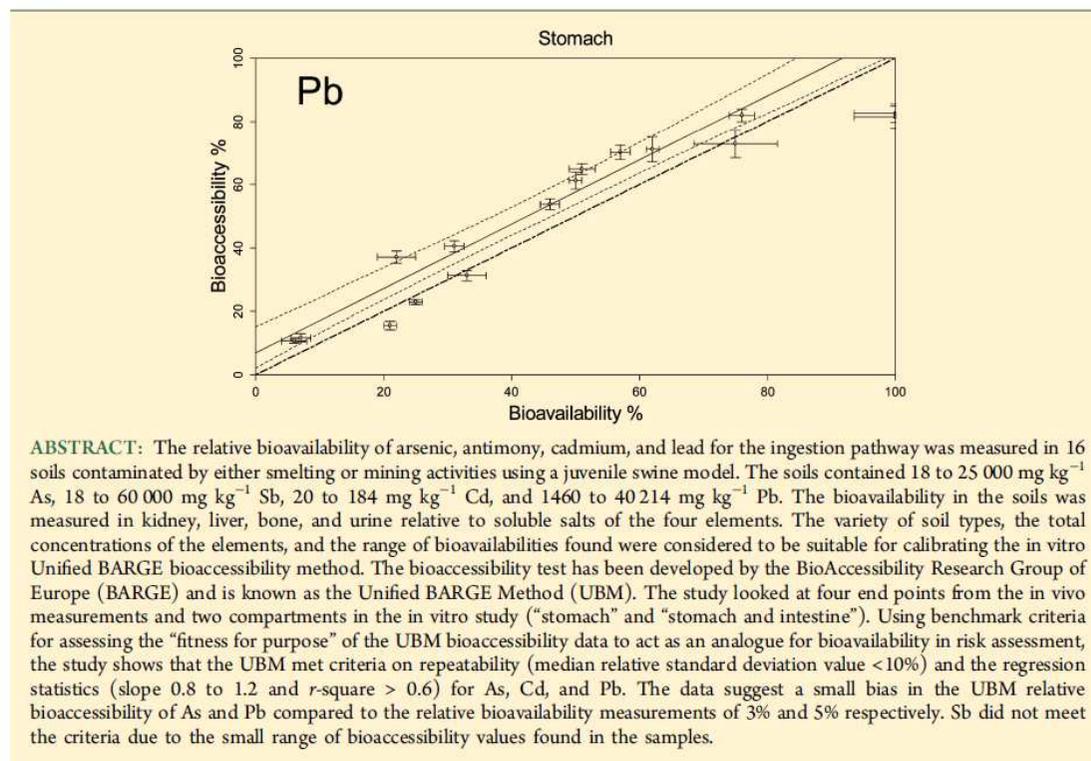
Sébastien Denys,^{‡,*} Julien Caboche,^{‡,‡} Karine Tack,[‡] Guido Rychen,[†] Joanna Wragg,[§] Mark Cave,[§] Catherine Jondreville,[†] and Cyril Feidt[†]

[†]URAFPA, Unité de Recherche Animal et Fonctionnalités des Produits Animaux, Nancy Université, INRA, 2 avenue de la Forêt de Haye BP172, 54505 Vandœuvre-lès-Nancy, France

[‡]INERIS, Parc Technologique ALATA, BP 2, 60 550 Verneuil-en-Halatte, France

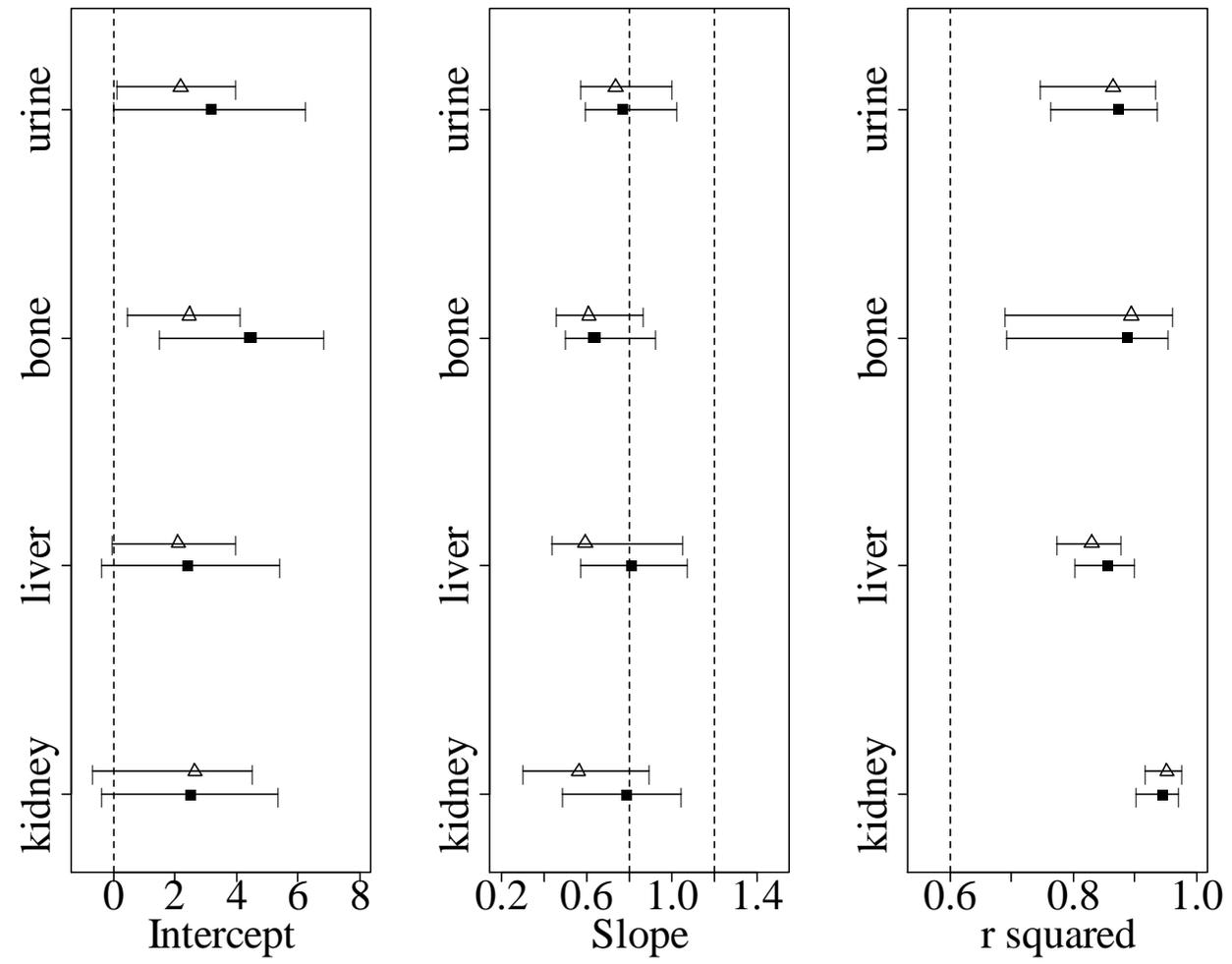
[§]British Geological Survey, Keyworth, Nottingham, United Kingdom, NG12 5GG

 Supporting Information

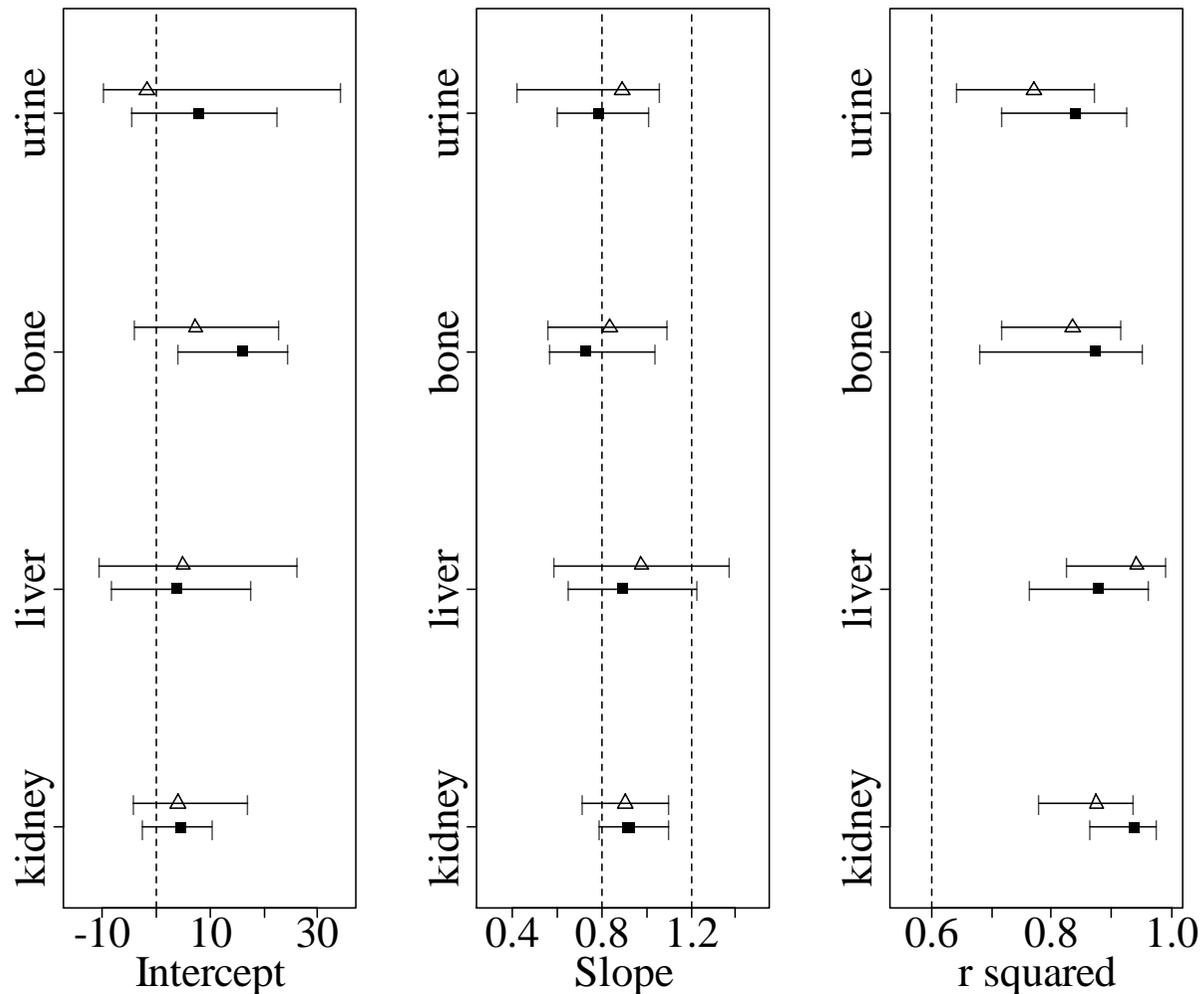


2012,46, pages 6252-6260

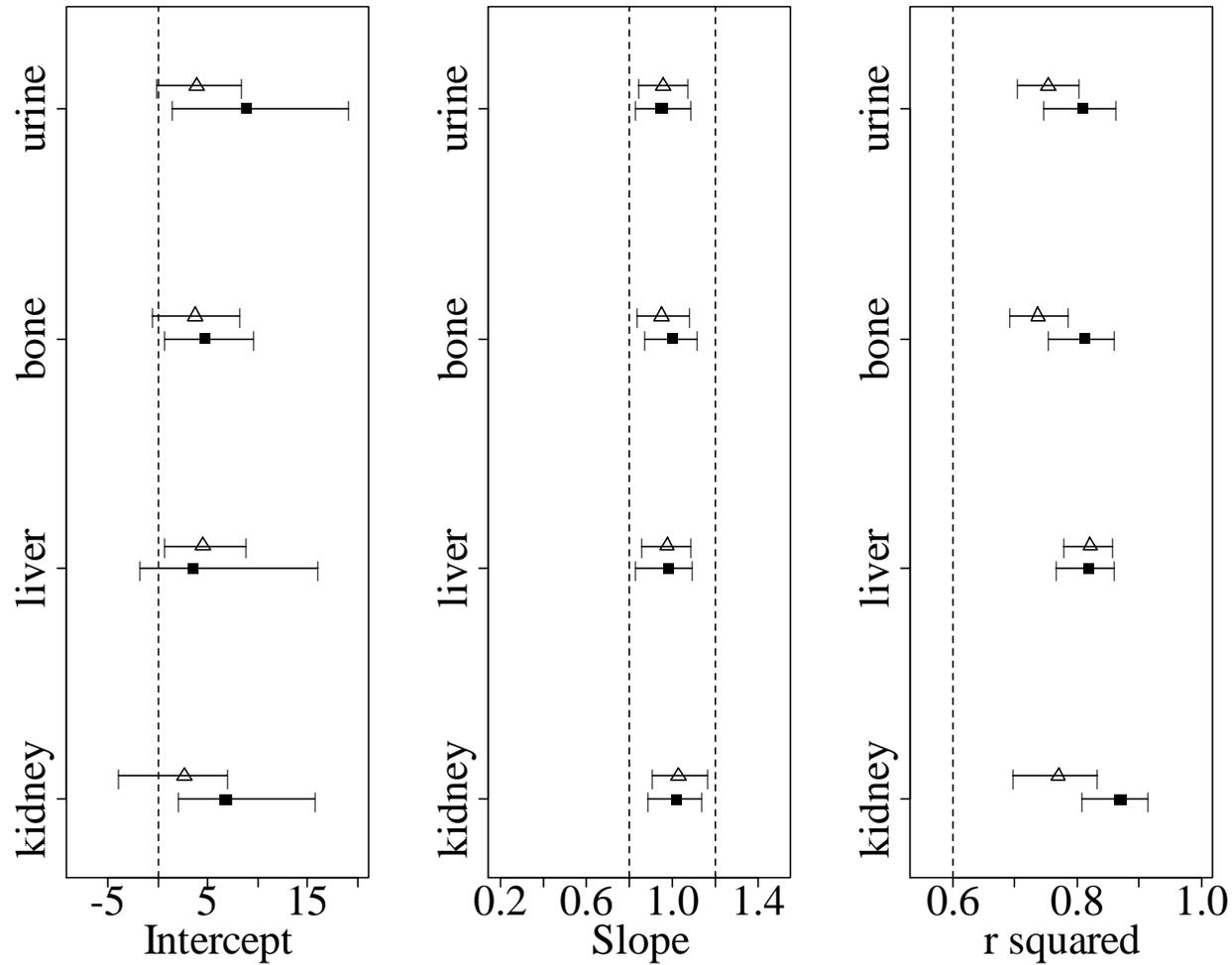
Summary of the RBA vs RBAC regression statistics for the four end points for As. Black squares show data for the 'stomach' phase and white triangles for the 'stomach & intestine' phase. Error bars represent 95% confidence limits dotted lines show benchmark values.



Summary of the RBA vs RBAC regression statistics for the four end points for Cd. Black squares show data for the 'stomach' phase and white triangles for the 'stomach & intestine' phase. Error bars represent 95% confidence limits, dotted lines show benchmark values

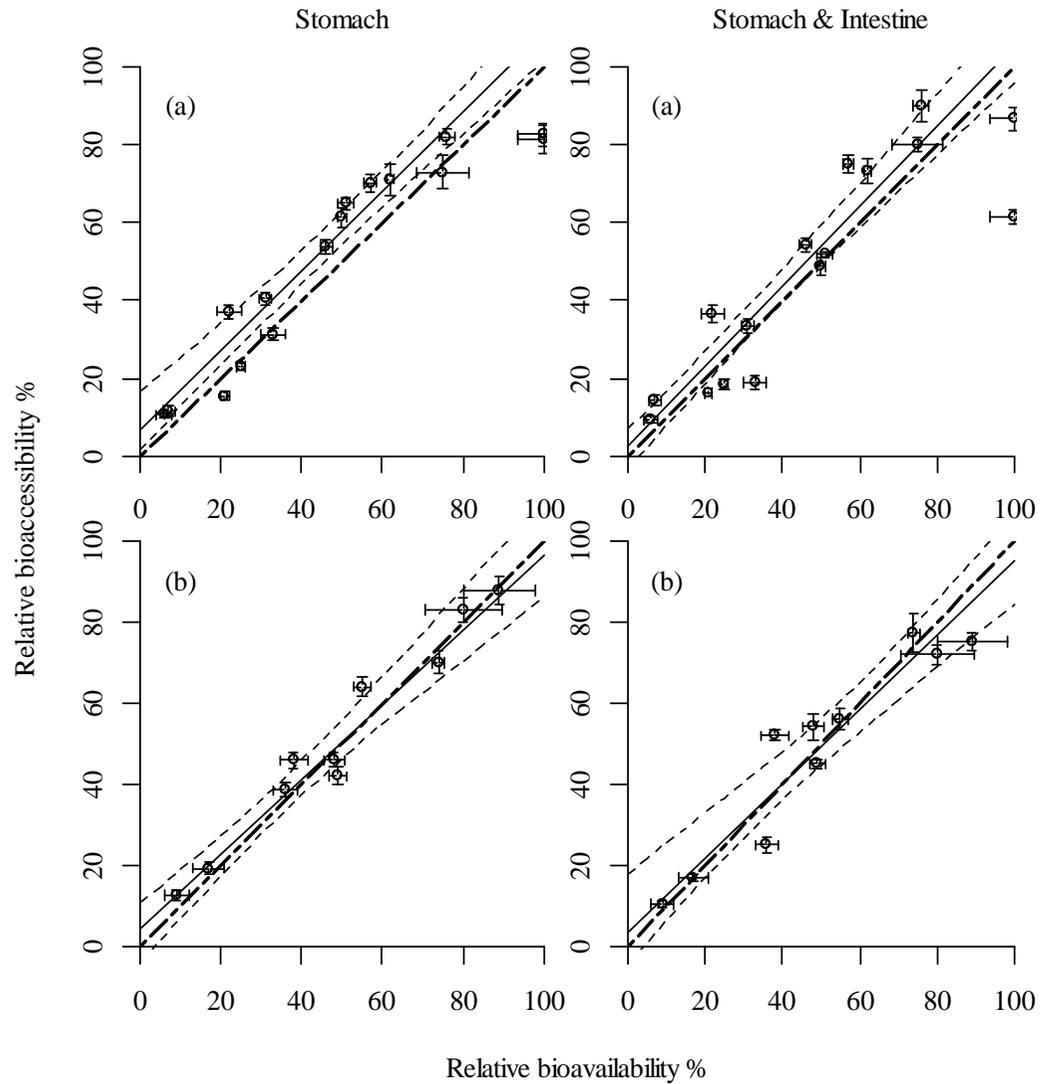


Summary of the RBA vs RBAC regression statistics for the four end points for **Pb**. Black squares show data for the 'stomach' phase and white triangles for the 'stomach & intestine' phase. Error bars represent 95% confidence limits, dotted lines show benchmark values.



RBAc against RBA for (a) Pb and (b) Cd for the 'stomach' and 'stomach & intestine' phases for the kidney endpoint. Bold dashed dotted line is the line of equivalence, dashed lines are the 95% confidence intervals and the solid lines is the best line of fit

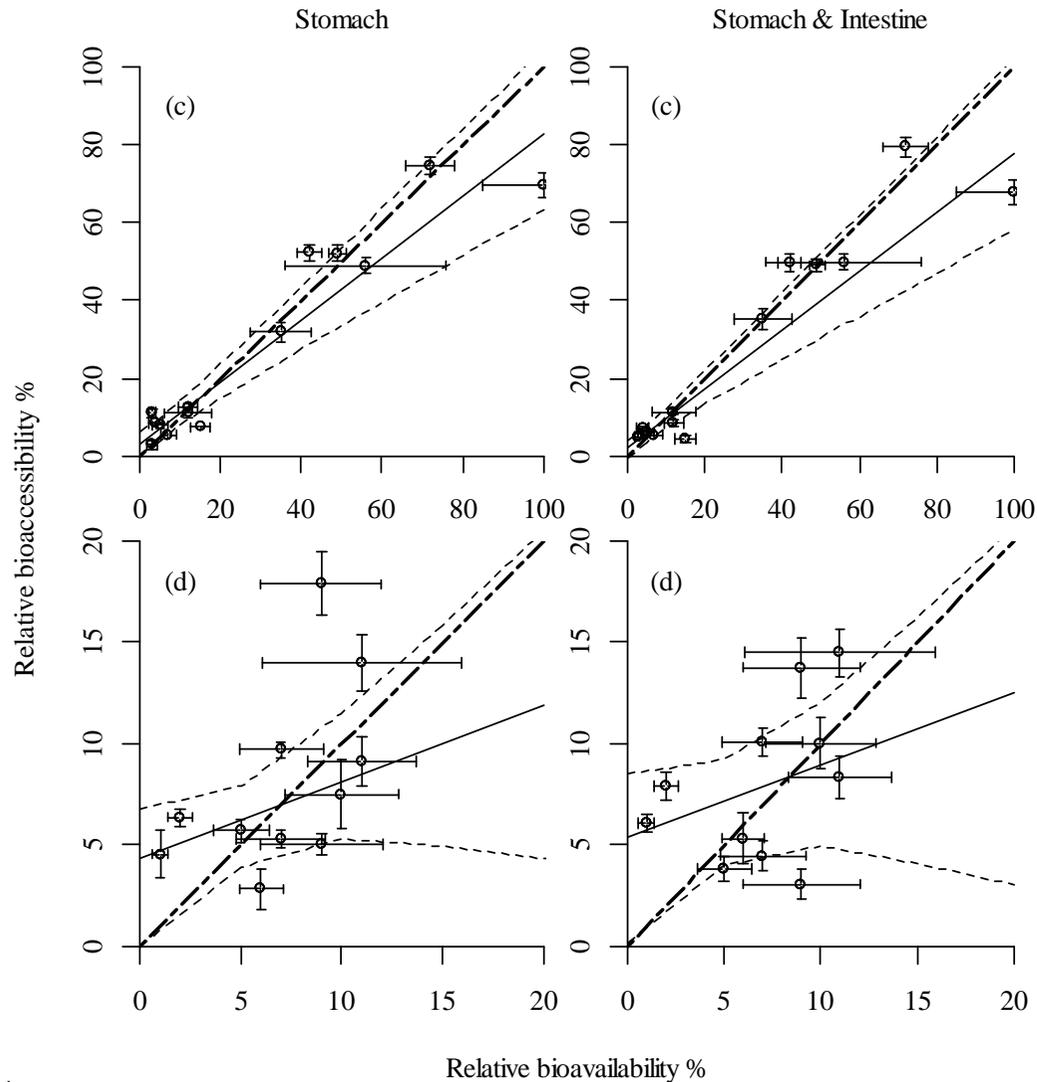
Pb



Cd

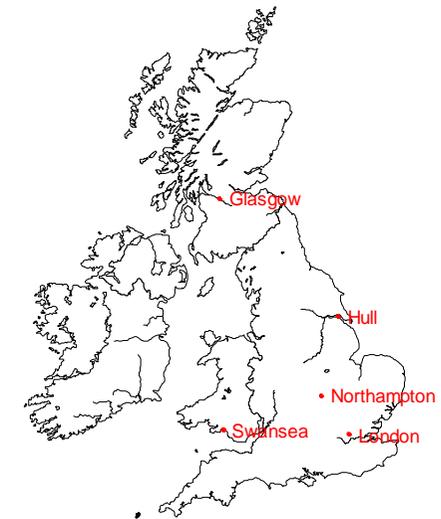
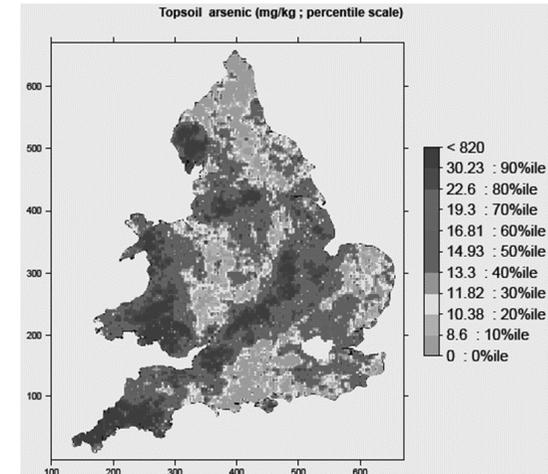
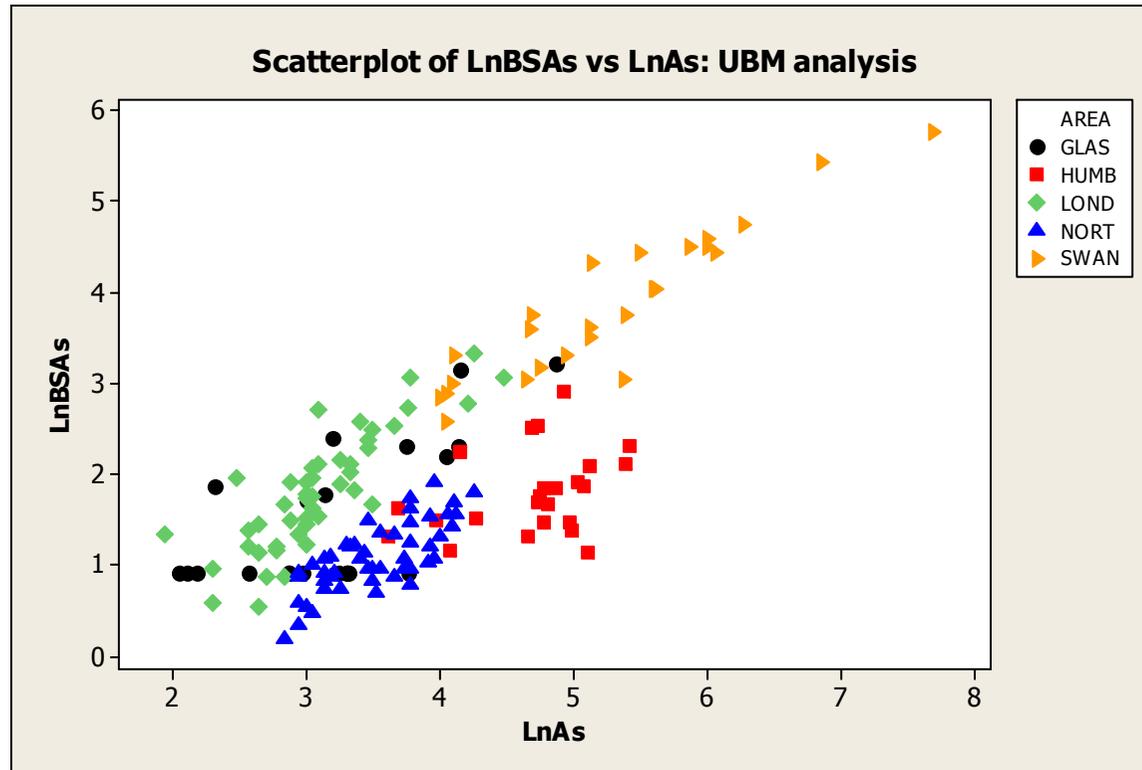
RBAc against RBA for (c) As and (d) Sb for the 'stomach' and 'stomach & intestine' phases for the urine end point. Bold dashed dotted line is the line of equivalence, dashed lines are the 95% confidence intervals and the solid line is the best line of fit.

As



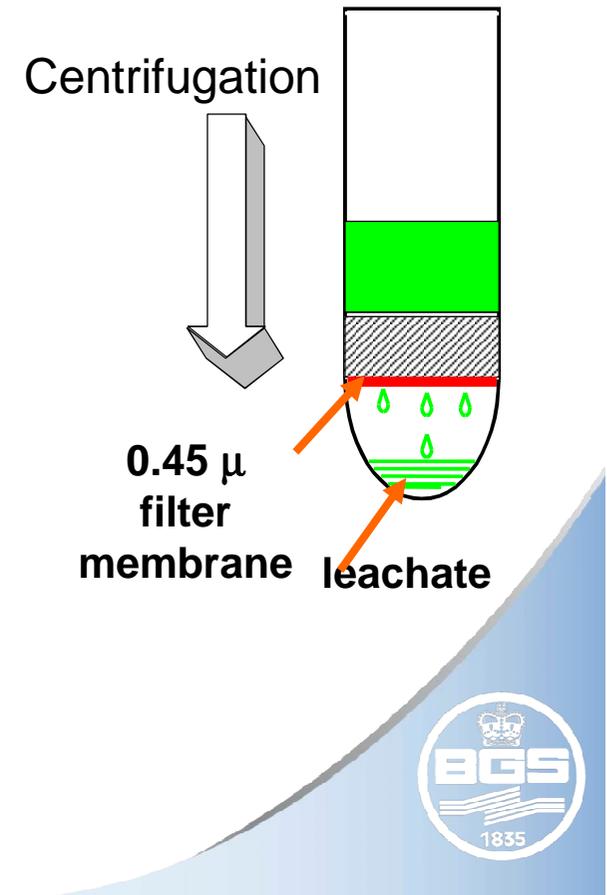
Sb

Comparison of the Relative Bioaccessibility of As in the UK



Don't just rely on the bioaccessibility test

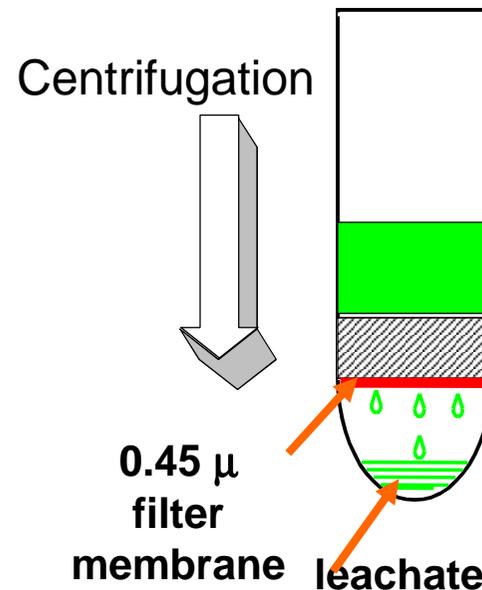
- Always use geochemical tests to back up your bioaccessibility results.
- Helps the risk assessor put the bioaccessibility value in context.
 - Bioaccessibility is no longer just a 'black box' or a black art in the eyes of the regulators and policy makers
- Allows decisions to be made regarding current and future land use.
- Gives the regulator added confidence in the risk assessment.



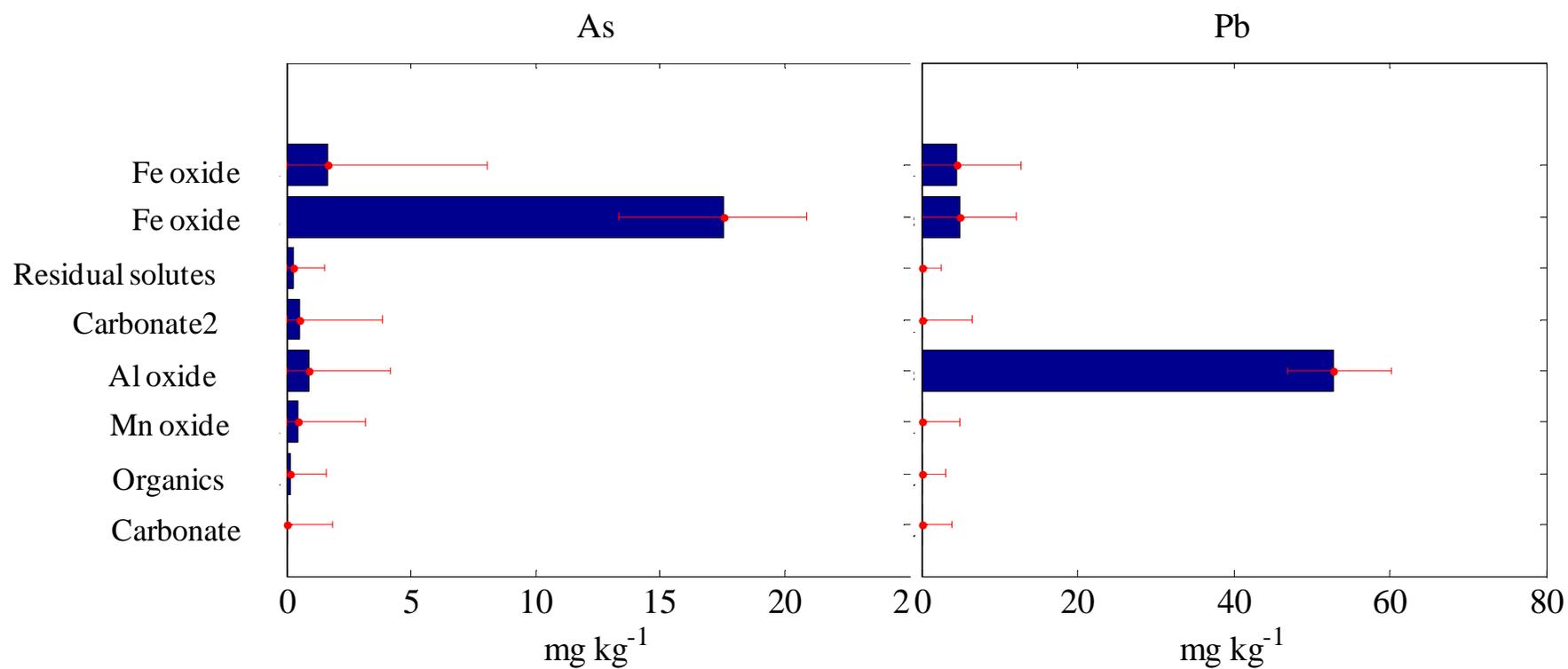
How are PHE distributed in the soil components?

CISED Test Chemometric Identification of Substrates and Element Distributions

- Separate aliquots of aqua regia of increasing concentration.
- Passed through the sample under centrifugal force.
 - Determination by ICP-AES.
 - Chemometric data processing .
- Identification of physico-chemical hosts and the metal distributions within the sample under test.



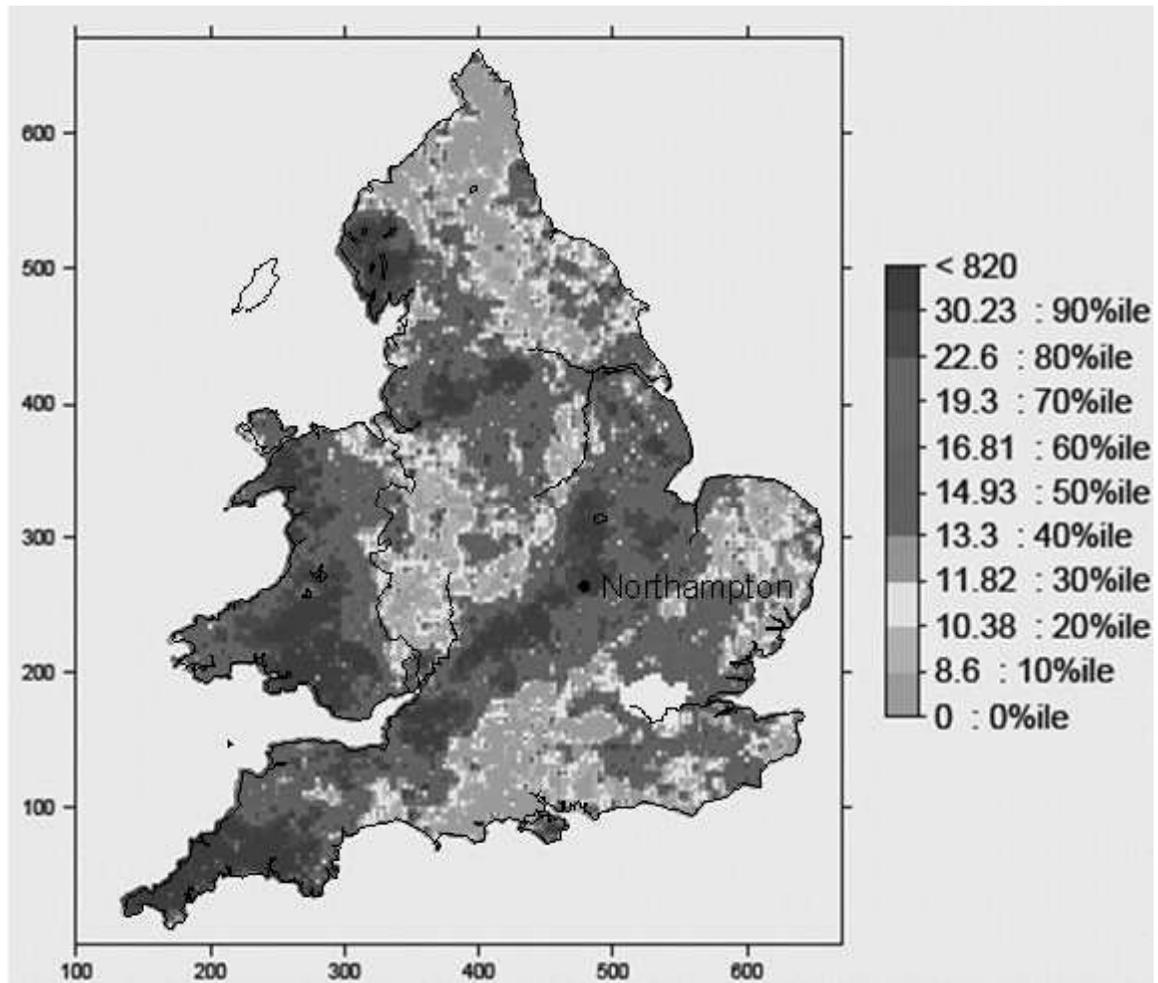
Example of CISED

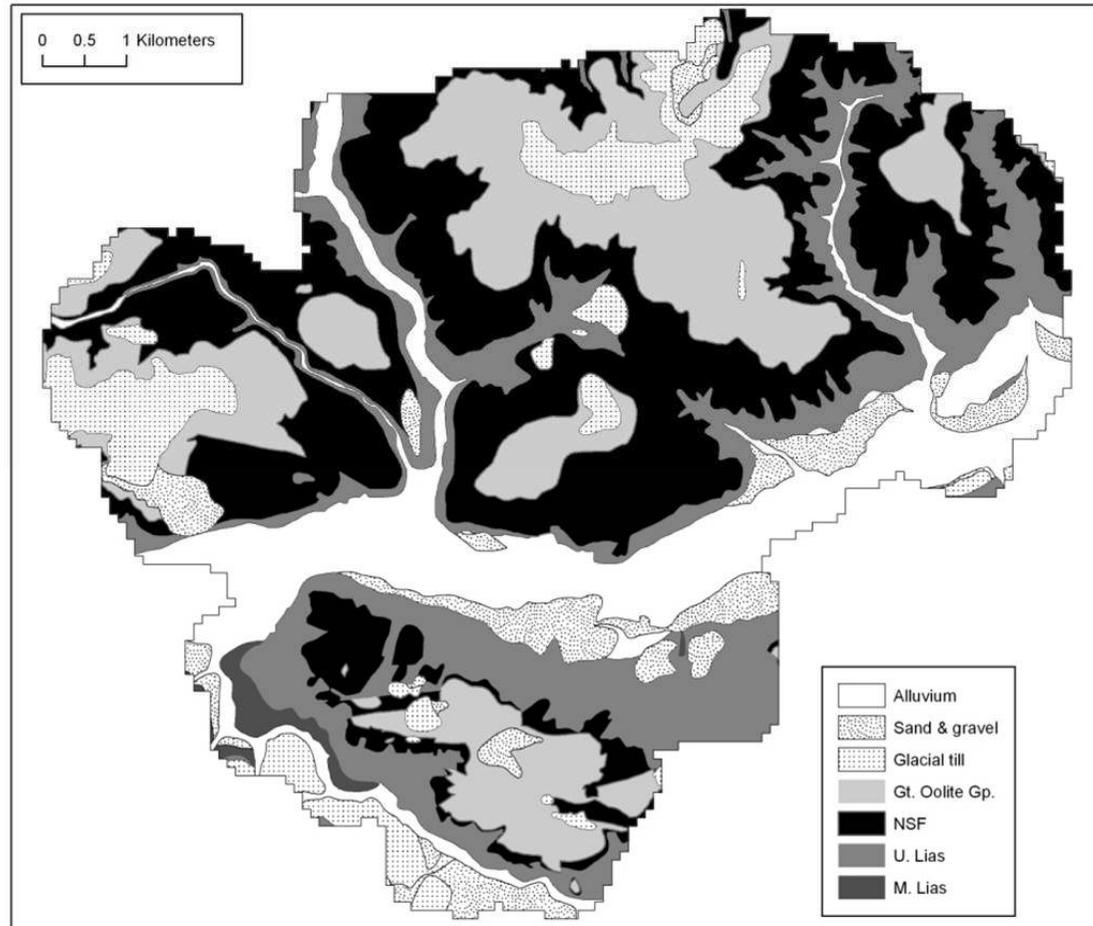


Northampton

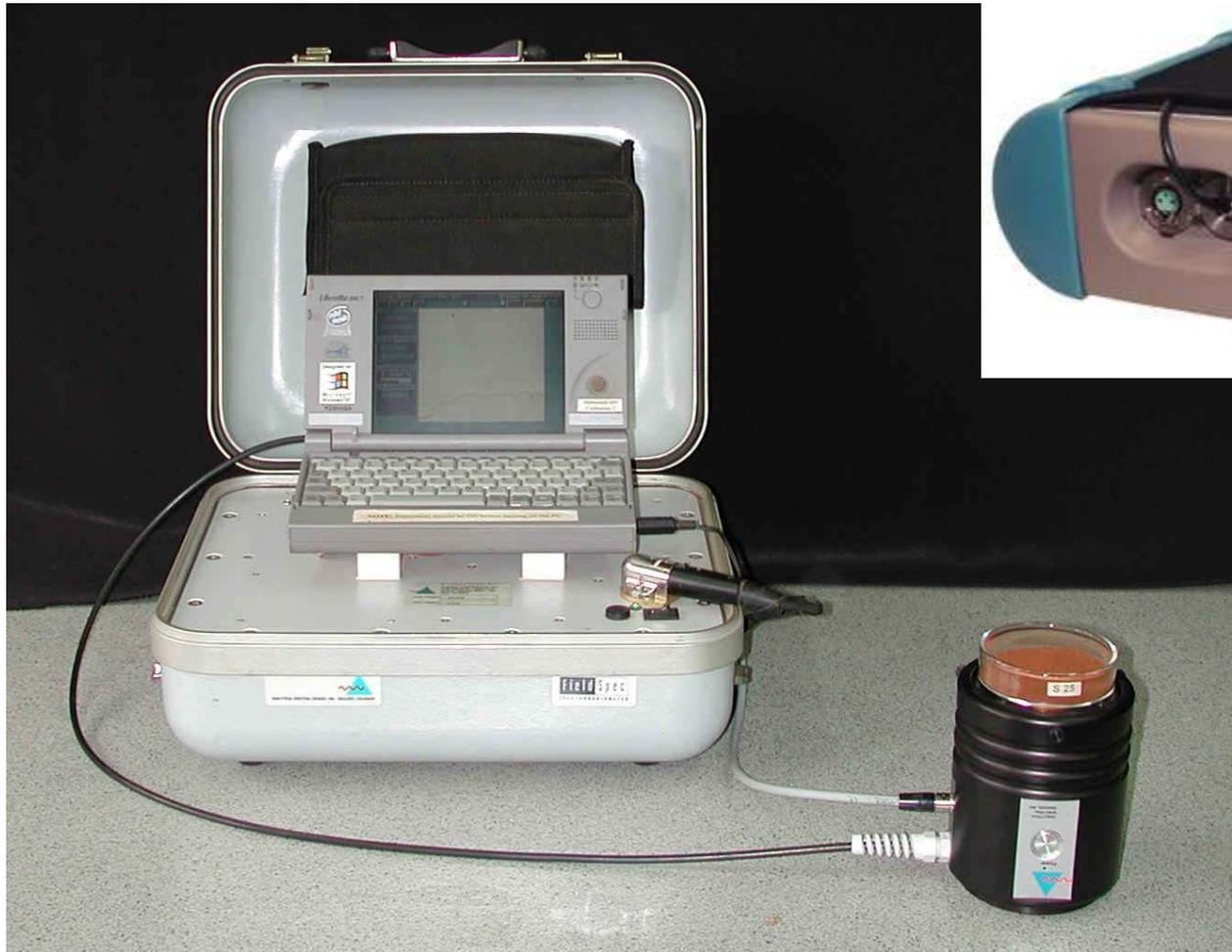
- Large Market town in central England
 - Population of c. 200,000
 - Busy Road and Rail links
- Primary industrial activities were shoe making and other leather industries
 - Now a hub for finance and distribution industries
- BGS surveyed the area as part of the G-BASE programme
- Ironstone soils, naturally elevated in arsenic
- 45% of the soils have As concentrations above the residential SGV of 32 mg mg⁻¹



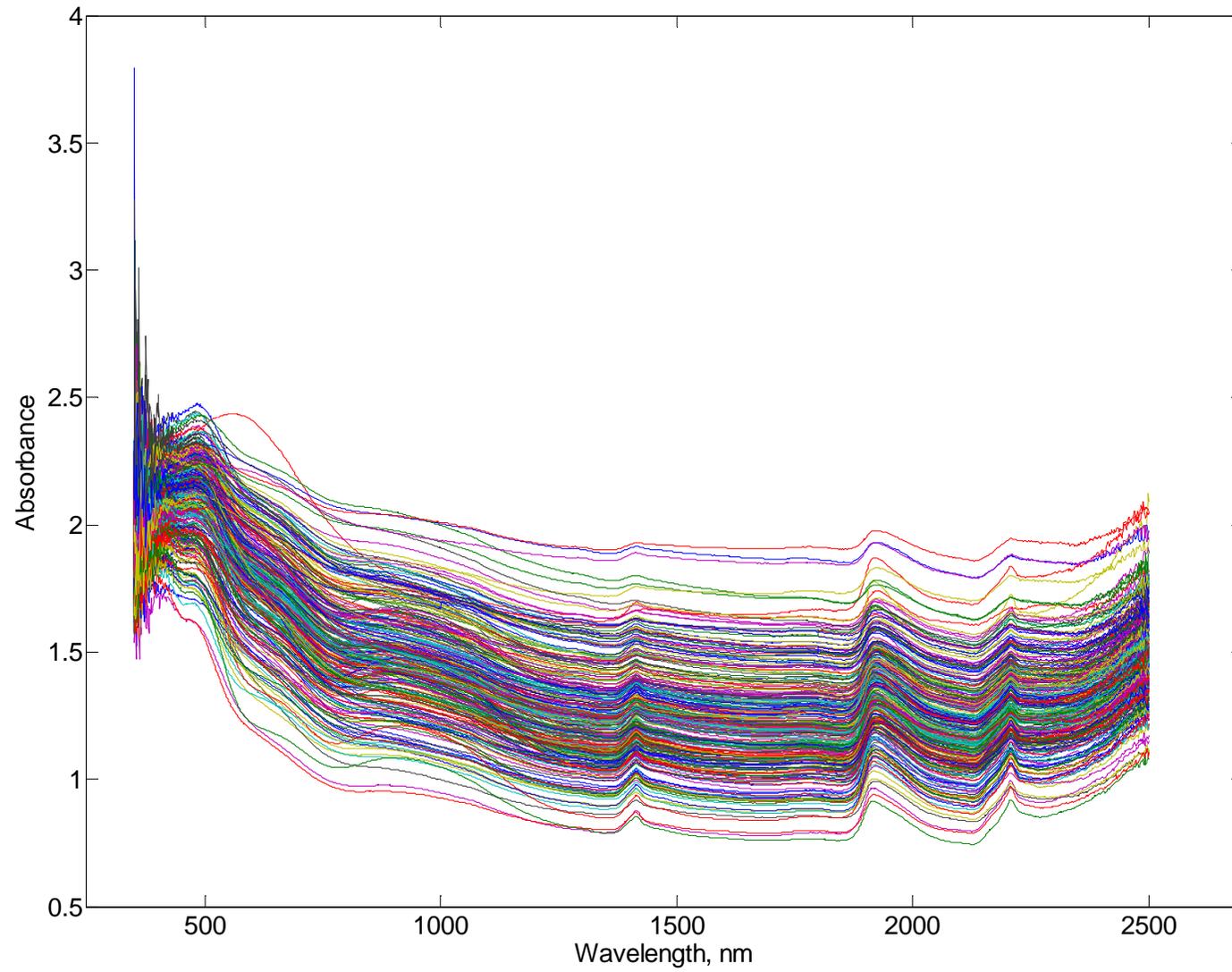




Measurement of the diffuse reflectance spectra of soils using a mug light.



281 spectra Northampton urban soils

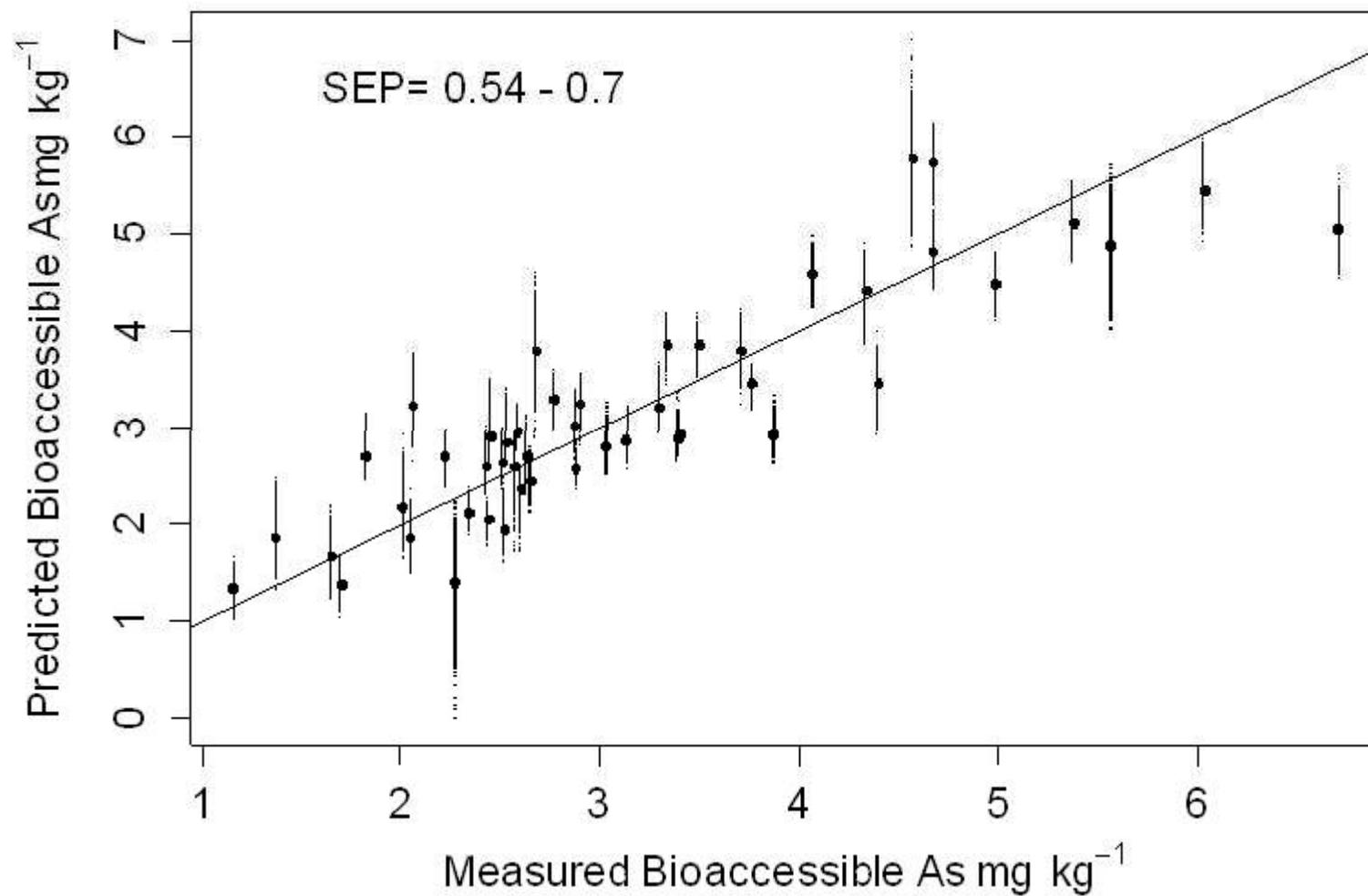


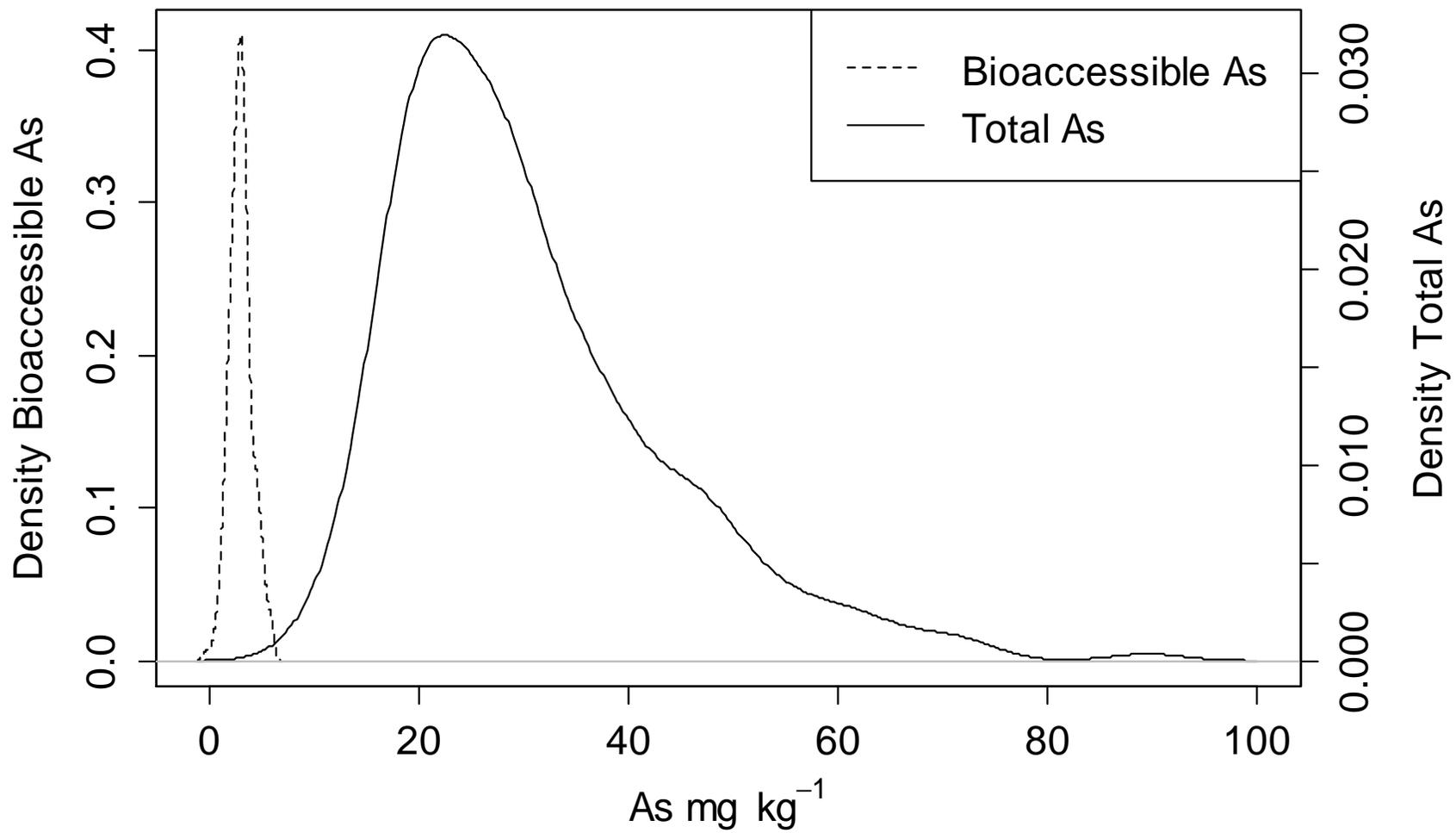
MLR model of bioaccessible As using NIR spectral components and Major element compositions

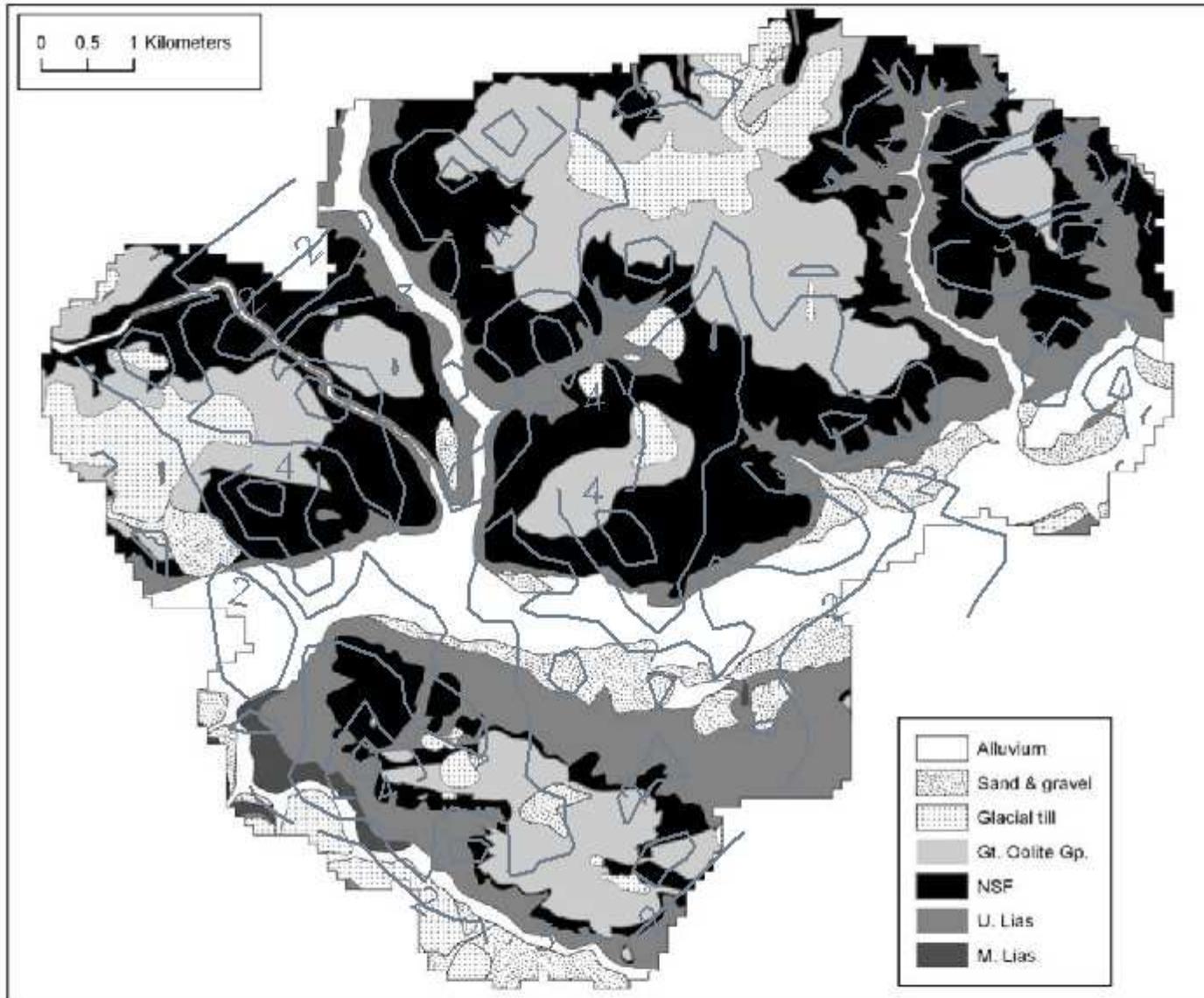
Coefficient	Value	Standard Error	P value	% Variance explained
Intercept	-0.56	1.22	<0.64	-
pH	0.41	0.12	<0.05	22.6
As	0.05	0.01	<0.05	37.6
Mg	0.00	0.00	<0.05	4.9
SC1	-21.1	3.6	<0.05	2.5
SC2	16.2	2.5	<0.05	16.5

R square = 0.84

CV predictions the Total Element and NIR Model







A Structured Approach

