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London Earth Topsoil Chemical Results: User Guide

Land use planning and development Programme

Open Report OR/11/035

BRITISH GEOLOGICAL SURVEY

LAND USE PLANNING AND DEVELOPMENT PROGRAMME

OPEN REPORT OR/11/035

London Earth Topsoil Chemical Results: User Guide

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Foreword

This report presents a description of the BGS London Earth Topsoil Chemical survey. The purpose of this user guide is to enable those licensing this dataset to have a better appreciation of how the data set has been created and therefore better understand the potential applications and limitations that the dataset may have.

Acknowledgements

A number of individuals in the Land Use Planning and Development Programmes have contributed to the project and helped compile this report. This assistance has been received at all stages of the study. In addition to the collection and processing of data, many individuals have freely given their advice, and provided local knowledge.

Contents

Summary

This report describes the London Earth Dataset, specifically the file: LondonEarth_Topsoil_XRFS_v1.xlsx. It describes how the sample data were collected, prepared and analysed, describes the format of the results, and details how the data was conditioned before delivery.

1 Introduction

Founded in 1835, the British Geological Survey (BGS) is the world's oldest national geological survey and the United Kingdom's premier centre for earth science information and expertise. The BGS provides expert services and impartial advice in all areas of geoscience. Our client base is drawn from the public and private sectors both in the UK and internationally.

Our innovative digital data products aim to help describe the ground surface and what's beneath across the whole of Great Britain. These digital products are based on the outputs of the BGS survey and research programmes and our substantial national data holdings. This data coupled with our in-house Geoscientific knowledge are combined to provide products relevant to a wide range of users in central and local government, insurance and housing industry, engineering and environmental business, and the British public.

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2 About the London Earth Dataset

Data Described: LondonEarth_Topsoil_XRFS_v1.xlsx created 18th May 2011

This guide describes and explains the London Earth topsoil chemical results. The London Earth project is part of a nationwide project to determine the distribution of chemical elements in the surface environment, namely the Geochemical Baseline Survey of the Environment (G-BASE). London Earth focuses on the soil of the capital city, the limits of the survey being defined by the Greater London Authority (GLA) administrative boundary (Figure 1). Chemical elements have been determined by X-ray fluorescence spectrometry (XRFS) at the laboratories of the British Geological Survey (BGS) in Keyworth, Nottingham. These results are presented as a MS Excel file.

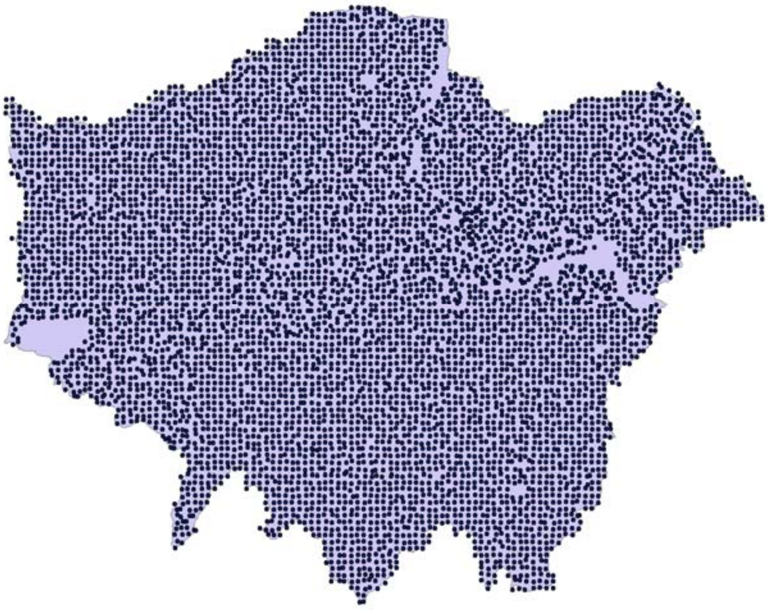

Figure 1: A plot of the London Earth topsoil sites in file LondonEarth_Topsoil_XRFS_v1.xlsx within a polygon of the GLA

2.1 SAMPLE COLLECTION

Soil samples were collected at a density of four samples from every square kilometre. Each sample is a composite of five subsamples collected at the corners and centre of a 20 m square. The soil was collected using a 1-m stainless steel hand-held soil auger and stored in Kraft paper bags. The topsoil was collected from a standard depth in the soil profile, 5 – 20 cm. A surface soil (0 – 2 cm) and deep soil (35 – 50 cm) were also collected but these samples are not routinely analysed. The surface and deep soils are archived at the National Geoscience Data Centre (NGDC) in Keyworth along with the excess topsoil samples.

At each site samplers recorded comprehensive information about the sample and location, including information such as soil texture, land use and observed contamination. This field information is available as the field database and can be made available on request to those who have a licence to use the results. British National Grid coordinates were determined at site using a GPS and recorded to the nearest metre though in reality the spatial error is estimated at ±50 m.

Symbol	Element/Oxide	Units	LLD*
Ag	silver	mg/kg	0.5
Al_2O_3	aluminium	wt%	0.2
As	arsenic	mg/kg	2.4
Ba	barium	mg/kg	1.0
Bi	bismuth	mg/kg	0.3
Br	bromine	mg/kg	0.8
CaO	calcium	wt%	0.05
Cd	cadmium	mg/kg	0.5
Ce	cerium	mg/kg	1.0
Co	cobalt	mg/kg	1.5

Symbol	Element/Oxide	Units	LLD*
Nb	niobium	mg/kg	1.0
Nd	neodymium	mg/kg	4.0
Ni	nickel	mg/kg	1.3
P_2O_5	phosphorous	wt%	0.05
Pb	lead	mg/kg	1.3
Rb	rubidium	mg/kg	1.0
S	sulphur	mg/kg	1000
Sb	antimony	mg/kg	0.5
Sc	scandium	mg/kg	3.0
Se	selenium	mg/kg	0.2

Cr	chromium	mg/kg	3.0	SiO_2	silicon	wt%	0.1
Cs	caesium	mg/kg	1.0	Sm	samarium	mg/kg	3.0
Cu	copper	mg/kg	1.3	Sn	tin	mg/kg	0.5
Fe_2O_3	iron	wt%	0.01	Sr	strontium	mg/kg	1.0
Ga	gallium	mg/kg	1.0	Ta	tantalum	mg/kg	1.0
Ge	germanium	mg/kg	0.5	Th	thorium	mg/kg	0.7
Hf	hafnium	mg/kg	1.0	TiO_2	titanium	wt%	0.01
Hg	mercury	mg/kg	0.5	Tl	thallium	mg/kg	0.5
I	iodine	mg/kg	0.5	U	uranium	mg/kg	0.5
K_2O	potassium	wt%	0.01	V	vanadium	mg/kg	3.0
La	lanthanum	mg/kg	1.0	W	tungsten	mg/kg	0.6
MgO	magnesium	wt%	0.03	Y	yttrium	mg/kg	1.0
MnO	manganese	wt%	0.005	Yb	ytterbium	mg/kg	1.5
Mo	molybdenum	mg/kg	0.2	Zn	zinc	mg/kg	1.3
Na_2O	sodium	wt%	0.3	Zr	zirconium	mg/kg	1.0

***LLD** = lower limit of detection

Table 1: List of elements reported for the London Earth topsoils following determination by XRFS

2.2 SAMPLE PREPARATION AND ANALYSIS

Samples were prepared at the BGS laboratories. After drying (~35°) the samples were sieved through a nylon sieve to give a < 2 mm fraction. A 50 g subsample of this fraction was pulverised in an agate ball mill to create a homogeneous sample used to make a pressed powder pellet prior to XRFS analysis.

Samples were analysed by XRFS which gives total element concentrations in the soil samples. Several different XRFS instruments were used (wave dispersive and energy dispersive) to determine 53 chemical elements. Fifty of these elements are listed in Table 1, three elements, chlorine (Cl), indium (In) and tellurium (Te) are excluded from the released data set as the majority (>95wt%) of the results for these elements are below the lower limit of detection.

Loss on ignition (LOI) (an indicator of the soil’s organic content) and pH has also been determined and this is available as a separate MS Excel spreadsheet - LondonEarth_Topsoil_pHLOI_v1 in which there are 6,467 sample results. The loss on ignition is determined by weighting samples before and after heating the soil sample at 450ºC for 24 hrs. The soil pH is determined using a pH meter on a slurry of the sample made using 0.01 M $CaCl_2$.

2.3 RESULTS

When the results are received from the laboratory they undergo a series of data conditioning processes to check the quality of the data and to level the results so the will fit seamlessly with other UK soil chemical results when plotted as maps. This data conditioning is described below and uses control samples submitted with the analytical batches and are seen as normal samples by the analyst. Once the data has been conditioning it is loaded to the BGS Oracle Geochemical Database, a repository for all the BGS UK landmass surface chemical results.

In the Geochemistry Database every element result is qualified with a qualifier code that identifies any data quality issues relating to that result. Most results have no qualifier code indicating there are no data quality issues. Results with qualifiers are those generally with results that are below the element's detection limit. Qualified data is indicated in the Excel file by colour highlights and fonts as shown in Table 2.

Colour/ format	Signifies	User Action
56.7	No Quality issues	None
25.4	This result is associated with a qualifier	Be aware that the result is qualified
(red)	Data of dubious quality with significant issue(s)	Pay careful attention to what the quality issue is and if necessary don't use results
(yellow)	Results <= 0	Be aware that the result could give problems in some statistical or plotting packages
(grey)	<null> value	Be aware that no result is present though transferring to some software packages could erroneously reset this to 0
25	Result is at the upper limit of detection	Be aware that this result has some quality issue but is unlikely to restrict its use
10	Generally a data issue relating to representation of results below limits of detection	
5.0		
0.6		

Table 2: Explanation of the colour formatting in the Excel spreadsheet "Results" used to indicate data quality issues

2.4 UNITS OF CONCENTRATION

The units of concentration for elements are shown in Table 1. For trace elements these are mg/kg (i.e mg kg^{-1}) and for the major elements these are wt%, i.e. expressed as a percentage weight of the sample. Geochemists also use the old notation of ppm (parts per million which is equivalent to 1 mg/kg) and express the major elements in terms of oxides (e.g. CaO, Na_2O, Fe_2O_3 etc.).

2.5 FIELDS IN THE RESULTS DATABASE

The "Results" spreadsheet contains five columns before the element results for the elements in the next 50 columns. The first row of data gives the column names. Descriptive statistics for all the fields are given in Table 3.

Column A – Project_Code : Two character code to identify the project collecting the samples. For London Earth two codes are used, namely 64 and 65. The 64 code represents samples collected before the start of the main London Earth project in 2008.

Column B – Site_Number : An integer number between 1 and 9999 giving the number assigned to the soil sampling site. A combination of the Project_Code and the Site_Number to give a six character number (e.g. 641304, 650001) provides a unique id for the sample and is a key field.

Column C – Date : Date the site was sampled in standard date format (dd/mm/yyyy).

Column D – Easting : British National Grid Easting (x) co-ordinate in metres.

Column E – Northing : British National Grid Northing (y) co-ordinate in metres.

Columns F – BC : Fifty columns of element results with column header as chemical symbol which for the major elements is expressed as an oxide.

2.6 DATA CONDITIONING

The results received from the laboratory contain control samples (replicates, duplicates and reference materials) which are used to assess the quality of the results. These control samples are removed from the data set and are not included in the results provided in the Excel data file which this user guide describes.

A summary of primary reference materials analysed along with London Earth soil samples is given in Table 4. These are certified reference materials (CRM) for which there is an accepted set of results and can be used to assess the accuracy of the element results. Table 4 shows tabulated certified values versus data values reported by the BGS XRF laboratory for four accredited reference materials (GSD-7, GSS-1, LKSD-1, LKSD-4). Certified data values are indicated in red and represent a mean value derived from approximately 20 analyses of each material.

The precision of the results is demonstrated by repeatedly analysing a secondary reference material and an example is given in Figure 2.

Field	Mean	Median	Std. Dev.	Range	Minimum	Maximum	Number
Project_Code	-	-	-	1	64	65	6487
Site_Number	-	-	-	6798	1	6799	6487
Date	-	-	-		02/08/2005	13/11/2009	6483
Easting	-	-	-	58095	503724	561819	6487
Northing	-	-	-	45095	155662	200757	6487
Ag	1.053	0.5	4.809181	200.8	0.1	200.9	6467
Cd	0.987	0.6	3.218913	165.2	0	165.2	6467
Sn	25.07	13.9	43.43841	1040.6	0.9	1041.5	6467
Sb	5.232	3	12.8729	434.5	0.1	434.6	6467
I	3.686	3	3.008918	64.7	0.1	64.8	6467
Cs	3.047	3	1.311103	10	1	11	6467
Ba	402.6	379.5	147.9445	3331.6	143.5	3475.1	6467
La	25.2	24	8.75202	127	3	130	6467
Ce	50.9	49	12.88859	220	18	238	6467
K2O	1.396	1.31	0.444684	3.21	0.12	3.33	6467
CaO	2.229	1.31	3.432534	52.55	0.22	52.77	6467
TiO2	0.586	0.558	0.150692	1.004	0.175	1.179	6467
MnO	0.063	0.055	0.042119	0.695	0.002	0.697	6467
Fe2O3	3.986	3.83	1.229329	15.22	0.15	15.37	6467
S	1017	960	377.93	9925	75	10000	6467
Sc	8.261	7.9	3.22153	38.1	-4.8	33.3	6467
V	82.9	76.4	28.56777	286.6	15.7	302.3	6467
Cr	77.98	72	48.29469	2079.6	14.7	2094.3	6467
Co	12.24	11.5	5.257148	84.4	0.8	85.2	6467
Ni	27.99	25.4	15.80002	503.3	2.3	505.6	6467
Cu	72.4	46.1	142.6825	5322.3	3.2	5325.5	6467
Zn	221.3	154.5	292.2913	10095	0	10095	6467
Ga	11.06	10.5	2.791615	26.6	1	27.6	6467
Ge	1.93	1.5	1.670454	29.9	-0.5	29.4	6467
As	17.08	15.4	8.637098	159.7	1.2	160.9	6467
Se	0.667	0.6	0.604414	19.7	-0.1	19.6	6467
Br	13.04	12	5.815867	117.5	1.5	119	6467
Rb	59.3	55.7	19.04873	139.7	8.9	148.6	6467
Sr	83.71	75.6	40.54883	588.9	12.3	601.2	6467
Y	21.11	20.4	7.62795	128.1	4.8	132.9	6467
Zr	288.7	276.9	85.11562	1411.1	35.3	1446.4	6467
Nb	12.88	12.5	3.020127	141.4	5.3	146.7	6467
Mo	2.048	1.5	8.874716	561.2	0	561.2	6467
Nd	22.28	21.4	8.727336	123.4	-0.6	122.8	6467
Sm	3.558	3.4	2.044726	28.5	-2.7	25.8	6467
Yb	1.882	1.8	0.896897	10.3	-1.5	8.8	6467
Hf	7.461	7.2	2.30664	36	1.1	37.1	6467
Ta	0.213	0.2	0.595945	11	-1.5	9.5	6467
W	2.39	2	6.203868	317.3	-0.5	316.8	6467
Hg	0.163	0	1.369056	37.8	-4	33.8	5964
Tl	0.306	0.2	0.640149	28.1	-1.9	26.2	6467
Pb	295.6	180.1	430.4443	9989.2	10.8	10000	6467
Bi	0.637	0.2	2.789603	73	-2.5	70.5	6467
Th	6.867	6.6	5.896254	456.6	-0.1	456.5	6467
U	1.679	1.7	0.875289	11.6	-5.2	6.4	6467
Na2O	0.423	0.4	0.127707	1.4	0.2	1.6	6467
MgO	0.856	0.8	0.42341	3.9	0.1	4	6467
Al2O3	7.987	7.5	2.757696	20	0.8	20.8	6467
SiO2	65.52	65.9	10.38328	95.4	4.6	100	6467
P2O5	0.364	0.32	0.226831	4.45	0.04	4.49	6467

Table 3: Summary statistics of London Earth topsoil results

CRM ID	Ag	Cert Ag	Cd	Cert Cd	In	Cert In	Sn	Cert Sn	Sb	Cert Sb
GSD-7	1.4	1.1	0.9	1.1	not detected	no data	4.8	5.4	2.8	2.6

GSS-1	0.4	0.4	4.4	4.3	not detected	no data	5.9	6.1	1.0	0.9
LKSD-1	0.5	0.6	1.1	1.2	0.5	no data	15.2	16.0	0.9	1.2
LKSD-4	0.1	0.2	1.9	1.9	not detected	no data	4.6	5.0	1.3	1.7
CRM ID	**I**	**Cert I**	**Cs**	**Cert Cs**	**Ba**	**Cert Ba**	**La**	**Cert La**	**Ce**	**Cert Ce**
GSD-7	0.9	no data	5	6	740	720	45	45	82	78.0
GSS-1	1.9	1.9	9	9	587	590	34	34	68	70.0
LKSD-1	1.7	no data	1	2	396	430	14	16	25	27.0
LKSD-4	9.5	no data	2	2	262	330	21	26	38	48.0

(Table 4.1 Elements by XRF-ED)

CRM ID	K2O	Cert K2O	CaO	Cert CaO	TiO2	Cert TiO2	MnO	Cert MnO	Fe2O3	Cert Fe2O3
GSD-7	3.64	3.54	1.65	1.67	0.707	0.747	0.093	0.089	6.50	6.51
GSS-1	2.53	2.59	1.75	1.72	0.766	0.805	0.238	0.227	5.18	5.19
LKSD-1	1.06	1.10	12.14	10.80	0.448	0.500	0.093	0.100	4.03	4.10
LKSD-4	0.76	0.80	1.85	1.80	0.299	0.400	0.068	0.100	4.20	4.10
CRM ID	**S**	**Cert S**	**Cl**	**Cert Cl**	**Sc**	**Cert Sc**	**V**	**Cert V**	**Cr**	**Cert Cr**
GSD-7	646	190	83	no data	13.7	14.6	93.4	96.0	119.3	122.0
GSS-1	847	310	114	78	10.4	11.2	80.7	86.0	60.0	62.0
LKSD-1	9306	1570	430	no data	6.5	9.0	47.8	50.0	27.0	31.0
LKSD-4	5952	999	215	no data	7.1	7.0	45.5	49.0	30.1	33.0
CRM ID	**Co**	**Cert Co**	**Ni**	**Cert Ni**	**Cu**	**Cert Cu**	**Zn**	**Cert Zn**	**Ga**	**Cert Ga**
GSD-7	20.6	21.0	55.6	53.0	36.1	38.0	246.2	238.0	16.7	17.7
GSS-1	13.9	14.2	20.7	20.4	19.7	21.0	671.6	680.0	17.6	19.3
LKSD-1	11.0	11.0	16.0	16.0	40.6	44.0	322.4	331.0	9.0	no data
LKSD-4	11.7	11.0	34.1	31.0	30.1	31.0	194.3	194.0	7.9	no data
CRM ID	**Ge**	**Cert Ge**	**As**	**Cert As**	**Se**	**Cert Se**	**Br**	**Cert Br**	**Rb**	**Cert Rb**
GSD-7	0.9	1.4	83.7	84.0	0.2	0.3	0.6	no data	146.4	147.0
GSS-1	0.6	1.3	35.8	33.5	0.1	0.1	2.5	2.9	137.9	140.0
LKSD-1	0.1	no data	34.9	40.0	1.0	no data	10.3	11.0	22.7	24.0
LKSD-4	0.5	no data	16.6	16.0	2.3	no data	50.6	49.0	25.0	28.0
CRM ID	**Sr**	**Cert Sr**	**Y**	**Cert Y**	**Zr**	**Cert Zr**	**Nb**	**Cert Nb**	**Mo**	**Cert Mo**
GSD-7	222.4	220.0	24.9	24.0	156.9	162.0	15.1	17.0	1.3	1.4
GSS-1	156.6	155.0	24.9	25.0	250.1	245.0	14.7	16.6	1.1	1.4
LKSD-1	259.4	250.0	20.9	19.0	132.8	134.0	4.0	7.0	9.4	10.0
LKSD-4	121.0	110.0	22.2	23.0	101.3	105.0	4.3	9.0	1.3	<5
CRM ID	**Nd**	**Cert Nd**	**Sm**	**Cert Sm**	**Yb**	**Cert Yb**	**Hf**	**Cert Hf**	**Ta**	**Cert Ta**
GSD-7	34.1	37.0	4.4	6.1	2.2	2.6	5.0	4.9	0.8	1.4
GSS-1	26.3	28.0	3.9	5.2	2.1	2.7	7.7	6.8	0.5	1.4
LKSD-1	19.4	16.0	2.9	4.0	1.7	2.0	4.1	3.6	-0.2	0.3
LKSD-4	27.1	25.0	4.3	5.0	2.1	2.0	3.1	2.8	-0.1	0.4
CRM ID	**W**	**Cert W**	**Hg**	**Cert Hg**	**Tl**	**Cert Tl**	**Pb**	**Cert Pb**	**Bi**	**Cert Bi**
GSD-7	6.5	5.5	-0.3	0.1	0.7	0.9	361.1	350.0	0.6	0.7
GSS-1	4.6	3.1	-0.8	0.0	0.7	1.0	98.2	98.0	0.7	1.2

LKSD-1	1.7	<4	-0.6	0.0	0.1	no data	83.7	82.0	0.6	no data
LKSD-4	1.8	<4	-0.5	no data	0.8	no data	97.3	91.0	0.0	no data

CRM ID	Th	Cert Th	U	Cert U
GSD-7	12.6	12.6	3.4	3.5
GSS-1	11.4	11.6	3.7	3.3
LKSD-1	2.1	2.2	9.7	9.7
LKSD-4	5.1	5.1	31.4	31

(Table 4.2 Elements by XRF-WDT)

CRM ID	Na2O	Cert Na2O	MgO	Cert MgO	Al2O3	Cert Al2O3	SiO2	Cert SiO2	P2O5	Cert P2O5
GSD-7	1.2	1.2	4.3	3.1	14.6	13.4	67.3	64.7	0.21	0.19
GSS-1	1.4	1.7	2.1	1.8	14.1	14.2	57.4	62.6	0.18	0.17
LKSD-1	1.6	2.0	1.8	1.7	5.6	7.8	31.5	40.1	0.16	0.20
LKSD-4	0.5	0.7	1.0	0.9	5.2	5.9	45.2	41.6	0.36	0.30

CRM ID	SO3	Cert SO3
GSD-7	not detected	no data
GSS-1	0.1	0.08
LKSD-1	2.6	no data
LKSD-4	2.1	no data

(Table4.3 Elements by XRF-WDM)

Table 4: Summary of primary reference material results for London Earth soil samples XRFS analyses.

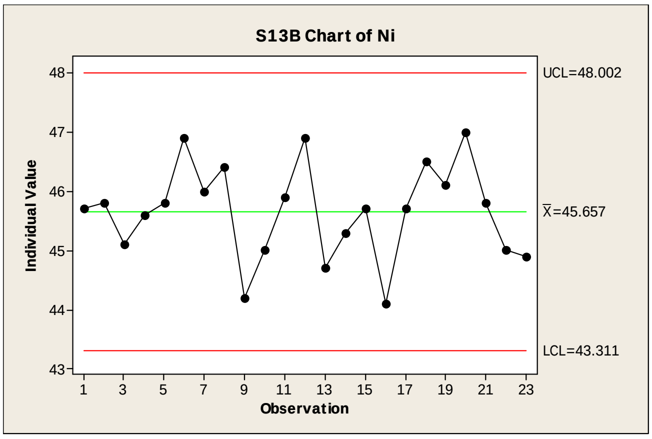

Figure 2: Example of a time-series plot (Shewhart plot) used to indicate the precision and accuracy of elemental analyses between different analytical batches. This chart shows repeated analyses for Ni in reference soil S13B. Green line shows accepted value (x), red lines x ± 2 std. dev.

Duplicate samples (i.e. separate samples that have been collected from the same sampling site) and replicate samples (i.e. a sample split into two samples in the laboratory) can be used to indicate within-site and within-sample variability, respectively. Using a statistical technique called nested ANOVA (Analysis of Variance) the duplicates can be used to give an estimate of the between site variability for each element. A variability that represents > 80wt% of between site total variance shows that the sampling and analytical methodology are satisfactory, though ANOVA analysis is not valid when a large number of samples have element concentrations that are near or below detection. If there is a high percentage of variance within site then the results suggest that the element concerned shows a high variability in the soil over short distances. A high within sample variance indicates a high degree of uncertainty in the analytical determination for the element concerned. Results for the ANOVA analysis of the London Earth soil duplicates and replicates are given in Table 5. This shows the poor "between site" variance for Yb, Hg, Sm, Tl and Ta suggesting that any interpretation of these elements should be done with caution.

Element	Between Site wt%	Between Sample wt%	Within Sample wt%	Number of sites	Element	Between Site wt%	Between Sample wt%	Within Sample wt%	Number of sites
Nb	93.95	5.27	0.78	150	**S**	82.38	14.41	3.21	150
TiO_2	93.76	5.95	0.29	150	**Mo**	81.20	14.81	3.98	150
K_2O	92.59	7.11	0.30	150	**Co**	80.94	12.00	7.06	150
Rb	92.39	7.27	0.34	150	**Cs**	80.86	5.95	13.18	149
La	91.47	6.89	1.64	149	**MnO**	80.74	17.66	1.60	150
Y	91.14	7.31	1.55	150	**Ni**	80.60	18.73	0.67	150
Al_2O_3	90.46	9.08	0.46	149	**Ba**	80.01	19.09	0.90	149
V	89.84	9.51	0.64	150	**Cr**	79.98	18.70	1.32	150
Zr	89.63	9.86	0.51	150	**Cu**	78.42	19.69	1.89	150
Ce	89.41	9.23	1.36	149	**Zn**	76.53	22.74	0.73	150
MgO	89.39	9.66	0.95	146	**Sc**	75.95	9.52	14.53	150
Fe_2O_3	88.97	10.60	0.43	150	**Sb**	74.50	16.73	8.77	148
Th	88.68	7.20	4.12	150	**Sn**	71.96	20.18	7.86	149
Ga	88.20	8.98	2.82	150	**U**	71.41	5.86	22.73	150
CaO	87.78	11.37	0.86	150	**W**	69.38	10.72	19.90	150
Sr	87.47	11.71	0.82	150	**Se**	67.60	13.91	18.48	150
Nd	87.26	6.80	5.94	150	**Cd**	62.19	26.27	11.54	95
Br	86.72	12.10	1.18	150	**Ge**	61.99	20.95	17.07	150
Hf	86.29	7.78	5.93	150	**Ag**	58.23	32.13	9.64	27
Na_2O	86.23	11.84	1.93	102	**Bi**	54.49	25.61	19.90	150
I	85.75	9.78	4.48	149	**Yb**	30.10	-1.83	71.73	150
Pb	84.74	11.64	3.62	150	**Hg**	29.68	55.22	15.09	150
SiO_2	84.37	14.00	1.64	149	**Sm**	24.31	1.42	74.27	150
As	83.51	14.43	2.06	150	**Tl**	14.62	-8.82	94.20	150
P_2O_5	82.77	16.69	0.54	149	**Ta**	9.80	8.99	81.22	150

Table 5: A table showing the nested ANOVA results for the London Earth soil duplicate and replicate sets. The number of sites indicates the number of locations where duplicate and replicate samples were collected. Those sites where element results were below detection are excluded from the ANOVA analysis.

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Further Information

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: http://geolib.bgs.ac.uk.

London Earth Project:

G-BASE web site – www.gs.ac.uk/gbase/londonearth

G-BASE urban soil chemistry data:

APPLETON, J.D. 2011. User Guide for British Geological Survey Urban Soil Chemistry dataset. *British Geological Survey*. 24pp. (IR/11/039). (unpublished).

Field sampling manual:

JOHNSON, C.C. 2005. *2005 G-BASE field procedures manual. British Geological Survey*, 65pp. (IR/05/097) (Unpublished).

Data conditioning procedures:

LISTER, T.R. AND JOHNSON, C.C. 2005. *G-BASE data conditioning procedures for stream sediment and soil chemical analyses. British Geological Survey*, 85pp. (IR/05/150) (Unpublished).

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