London Earth; presentation and assessment of field observation data

Land Use Planning and Development Programme

Open Report OR/12/005

BRITISH GEOLOGICAL SURVEY

LAND USE PLANNING AND DEVELOPMENT PROGRAMME

INTERNAL REPORT OR/12/005

London Earth; presentation and assessment of field observation data

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Student Voluntary Worker Rowan Peters recording field observations at a soil sample site.

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1 Introduction

The *London Earth* field survey followed a systematic sampling approach to collect a representative suite of soil samples from across London from a variety of land uses, in order to ensure a robust, unbiased dataset which will represent the baseline geochemistry of the city's environment.

Soil geochemical baseline data can be used to investigate soil quality and geochemical processes in the urban environment, as well as determining where the levels of certain chemical elements are potentially hazardous to humans as well as the natural environment (Johnson and Ander, 2008).

In addition to the collection of samples, important accompanying information including observations about the soil colour and composition, and land use details for each sampling site were recorded. This data is an important aspect of the survey as it allows us to assess the site and supports interpretation of the geochemical results.

The combination of the geochemical survey data and related field observations provides a comprehensive data resource which will provide valuable information to land use planning and development applications such as urban regeneration as well as provide opportunity for science in the interest of national good.

The aim of this report is to present and assess the observational data in order to:

i. show the spatial distribution of certain properties of the data set, such as the land use types that were recorded for each sample;
ii. to discuss their relative proportions; and,
iii. to explain, where possible, any trends or patterns that can be seen in the data.

This will be done primarily by presenting maps and graphs of the data and by some discussion of the information they contain. This is intended to provide a useful resource to support the ongoing interpretation of the geochemical data.

2 Methods

2.1 OVERVIEW OF SAMPLE COLLECTION AND FIELD CAMPAIGN PROGRESS

The *London Earth* field survey consisted of a total of 6635 sampling sites (including duplicate samples taken to assist with error control and data validation). The sample coverage represents the entire area within administrative boundary of the Greater London Authority (GLA) at a sampling density of 4 samples for every square kilometre. Each sampling site was situated as near as possible to the centre of each quadrant of every 1 x 1 km grid square of the British National Grid, in order to achieve a grid of sample coverage for the entire GLA where samples are spaced approximately 500 m apart.

The survey was not targeted to particular sites or land uses, and did not aim for or avoid any anticipated sources of contamination. This unbiased approach is important to ensure results which are a representative snapshot of the urban environment as a whole.

Soil samples were taken by using a 1m hand auger, and were collected at 3 different depths at each sampling site in order to represent different parts of the soil profile:

i. surface soil (0-2cm depth);
ii. topsoil (5-20cm depth); and
iii. deeper soil (35-50cm depth).

At each site, a composite sample was collected which comprised material collected from 5 auger holes at each site (from the centre and corners of a 20 x 20 m square) to ensure a sample which is representative of the site is collected. For a detailed explanation and justification of the sampling methodology, please refer to the G-BASE (Geochemical Baseline Survey of the Environment) field procedures manual (Johnson, 2005).

The sampling was undertaken by teams of student volunteers led by BGS staff in a series of field campaigns over the course of five years. Preliminary surveys were undertaken in 2005 and 2006, focusing on an area in the east end of the city. The majority of North London was surveyed in 2008, and sampling was completed for South London in 2009 (Figure 1).

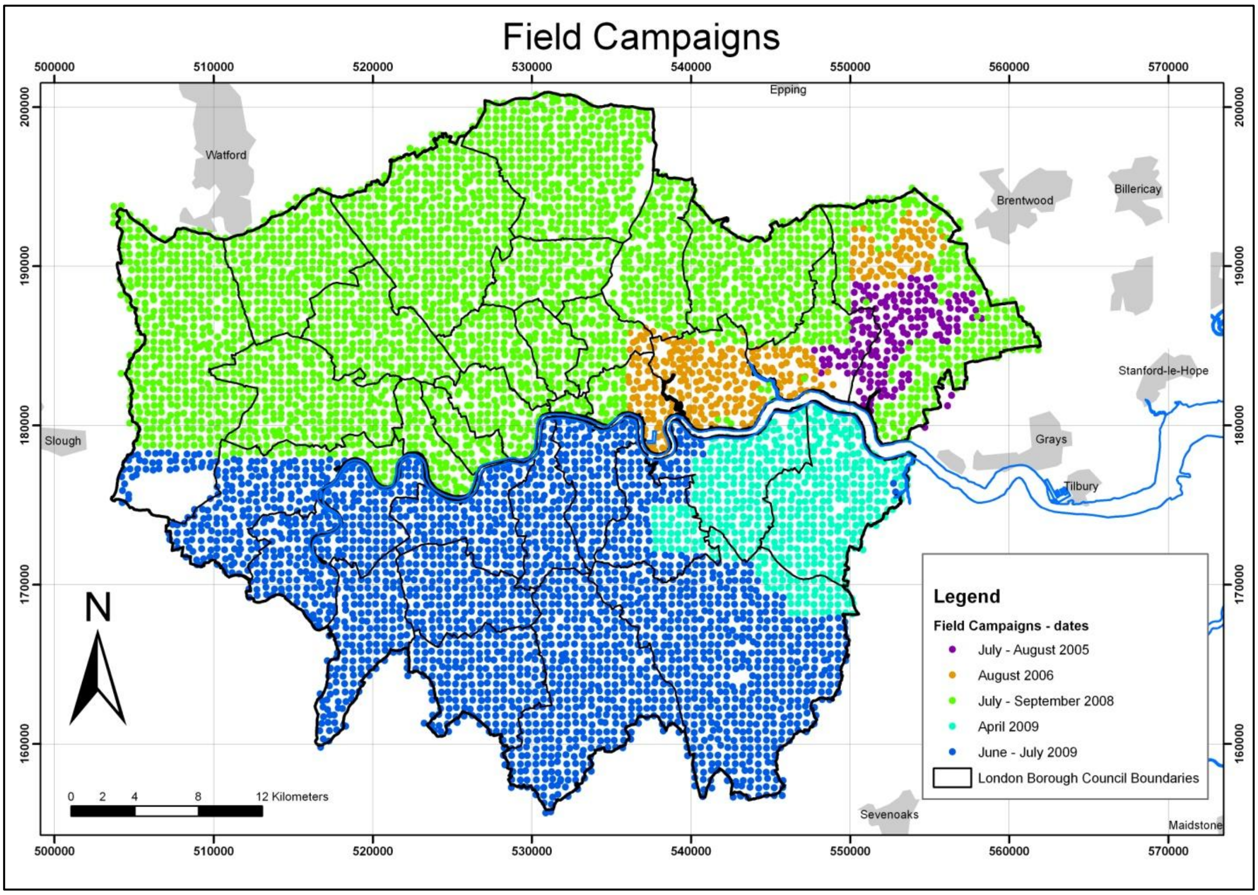

Figure 1. Map showing the progress and sample coverage of the field campaigns which ran from 2005-2009.

The samples were subsequently analysed at the British Geological Surveys (BGS) labs in Keyworth, Nottingham, using the analytical technique X-Ray Fluorescence Spectrometry (XRFS) in order to report major and trace element concentration values for a total of 53 chemical elements. Thus far, geochemical analysis has been completed for all 6635 topsoil samples. This data has been validated, added to the BGS's national geochemistry data set and has been available to licence since May13th, 2011.

During the preliminary surveys only topsoil (5-20 cm depth) and deeper soil (35-50 cm depth) were routinely collected. The surface soil sample was only introduced to the field procedures in 2008 for the remainder of the *London Earth* field survey.

2.2 FIELD DATA COLLECTION

At each site, field cards were completed which contain information to accompany the sample. All of this information is then compiled and held in a field database. The details recorded include pertinent spatial and temporal information associated with the sample collection (such as samplers, date, weather conditions etc.) and also a set of field observations for many different factors which can influence the geochemical properties of the soil sample, such as:

- the land use at site;
- soil colour and texture;
- any sources of contamination that were observed at site;
- clasts within the soil;
- approximate water content in soil;
- approximate organic matter content;
- drift (superficial geology) observed at site; and
- bedrock geology (and where applicable, mineralisation) observed at site.

The field card (Figure 2) has several boxes and fields into which this information is entered either as text or as a code which represents a description from a dictionary of relevant categories which are defined on an accompanying reference sheet (e.g. the dictionary of land use codes; Figure 3).

These details are mostly obtained from observation, but additional drift and geology details are also recorded on the card after locating the site on a solid and superficial geology map and recording additional codes to describe the underlying drift and geology which could not be observed.

The data is then compiled into a Microsoft Access database. The occurrence, abundance and distribution of any of the observation types above can be easily shown by interrogating this field database using GIS, Microsoft Excel or statistics packages. The database can also be integrated with geochemical data, and is loaded to data tables within the BGS Oracle Geochemistry Database.

At each site, more than one code for land use, drift, and soil clast lithology observations, can be recorded and so it is important that the codes on the field card are listed in order of abundance/dominance. The first code entered is referred to as the "primary" observation in this report, and the following codes as "secondary" and so on. It is important that codes are recorded in this way as when the database is held in a GIS table only properties of one field can be displayed at a time, so this allows the most important data to be displayed and queried.

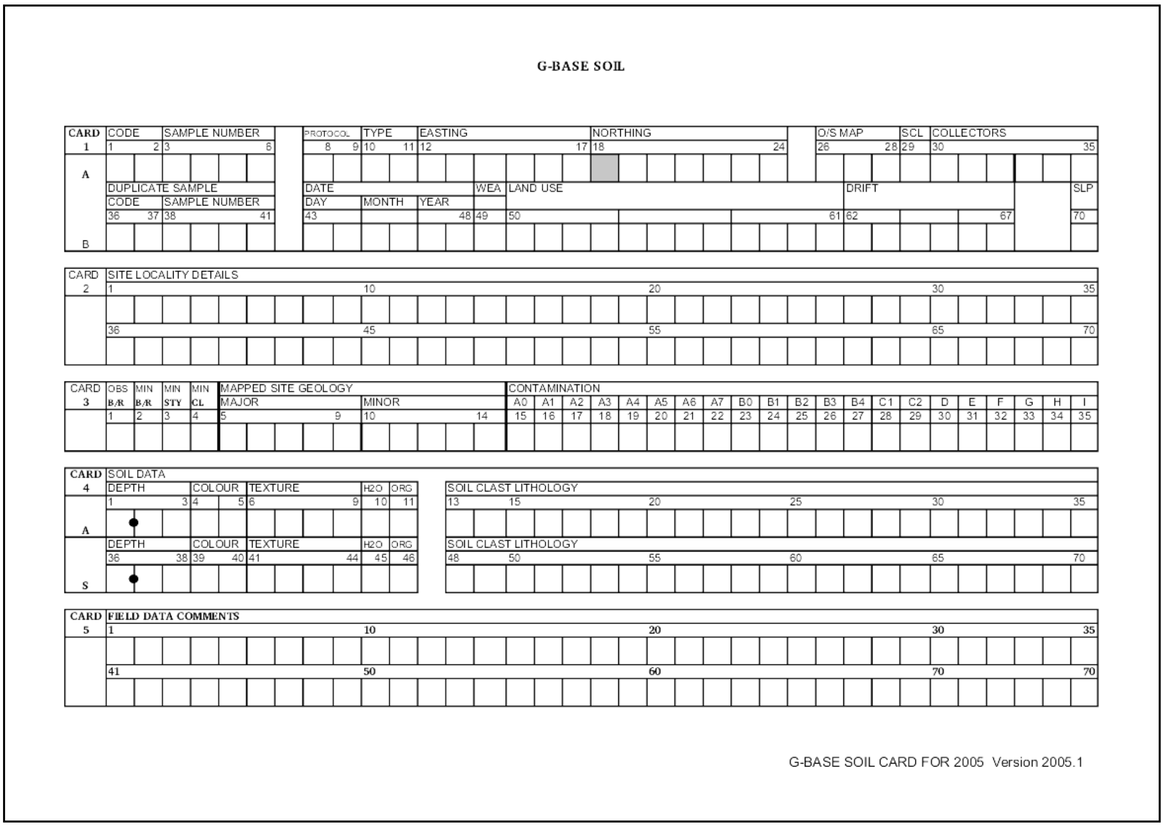

Figure 2. Example of the G-BASE soil field card (version 2005.1)

LAND USE (150 - 161)

AAC0	Saltwater Marsh	EA00	Manufacturing
AEBB	Mature Coniferous Forest	EAA0	Treatment of non metalliferous mining products other than coal
AEBA	Recent Coniferous Forest	EAB0	Chemical and allied trades
AEAB	Mature Deciduous Forest	EAC0	Metal Manufacture
AEAA	Recent Deciduous Forest	EAD0	Engineering, manufacturing, shipbuilding
AC00	Rough Grazing	EAE0	Vehicle manufacture
ABB0	Heather Moor	EAF0	Metal goods manufacture (not specified elsewhere)
BD00	Arable	EAG0	Precision instruments manufacture, jewellery
BAB0	Pasture	EAH0	Textile manufacture
BCD0	Allotment Gardens	EAI0	Leather manufacture, leather goods, fur
CA00	Port areas and airfields	EAJ0	Clothing manufacture
CB00	Major Roads/verge	EAK0	Food manufacture, drinks, tobacco
CC00	Minor Road/verge	EAL0	Wood manufacture and cork
CD00	Railway	EAM0	Paper manufacturing industries
CE00	Tramway	EAN0	Other manufacturing industries
DD00	Recreational	EB00	Extractive
DAC0	Urban open space	EBA0	Quarry, mine (non metalliferous, non coal)
DACA	Urban open space, tended but unproductive	EBB0	Quarry, mine, coal, lignite
DACB	Urban open space, cleared, derelict	EBC0	Quarry, mine, metalliferous
DAA0	Commercial and residential	EC00	Tips
DAAA	School	ECA0	Domestic urban wastes
DAAB	Hospital Grounds	ECB0	Industrial waste tip
DAD0	Domestic Garden (urban)	ED00	Utilities
DBD0	Domestic Garden (rural)	EDA0	Water treatment works
DC00	Caravan/Camp site	EDB0	Gas works
DDA0	Playground	EDC0	Electrical generation plant
DDB0	Playing Field	GR00	Graveyard
DDC0	Park	GRA0	Crematorium
DDD0	Golf Course		
E000	Industrial		

Figure 3. Dictionary of codes used to describe land use at sampling sites. This set of codes was developed for urban areas and was implemented in 2008.

2.3 DATA MANIPULATION AND MAP PREPERATION

Data was extracted from the Microsoft Access database into a Microsoft Excel spreadsheet, in which it could be manipulated and organised into a format which was then added to a GIS as an attribute table (dbf file).

The data was manipulated in the following ways:

2.3.1 Re-categorisation of land use codes

Each site was assigned a new land use code in order to group categories that were recorded into a simpler format. This was required in order to generate a land use map that shows the spatial distribution of the main land use types, as the codes that were assigned in the field are very specific and too variable to easily view their distribution by colouring up each category on a map or when displaying the data on a graph. The original codes were re-assigned new codes as shown in the table below (Table 1).

Land use types	**Original land use codes** (refer to Figure 3).	**Reassigned land use code**	**Number of occurrences**
Rough Grazing	AC00	A	392
Woodland and Forests	AEBB, AEBA, AEAB, AEAA.	B	307
Arable	BD00	C	323
Pasture	BAB0	D	169
Urban open space	DAC0, DACA, DACB	E	1180
Commercial and Residential	DAA0	F	142
Golf	DDD0	G	178
Allotments	BCD0	H	30
Playing Fields and sports grounds	DDA0, DDB0	I	255
Road verge	CB00, CC00	J	606
Cemetery/Crematorium	GR00, GRA0	K	104
Parks and Recreational	DD00, DDC0	L	1125
Domestic Garden	DAD0, DBD0	M	1611
School/ hospital grounds	DAAA, DAAB	N	68
Industrial site	E000, EA00, EAA0, EAB0, EAC0, EAD0, EAE0, EAF0, EAG0, EAH0, EAI0, EAJ0, EAK0, EAL0, EAM0, EAN0, EB00, EAB0, EB00, EBA0, EB00, EBA0, EBB0, EBC0, EC00, ECA0, ECB0, EC00, ECA0, ECB0, EC00, ECA0, ECB0, ED00, EDA0, ECB0, ED00, EDA0, EDB0, EDC0 (all industrial land use codes).	O	93
Other land uses	CD00, AAC0, ABB0, CA00, CD00, CE00, DC00,	P	52

Table 1. Table detailing how land use codes recorded in the field were re-classified into their main types and re-assigned a new land use code.

2.3.2 Re-organisation of contamination data for use in a GIS attribute table

Contamination data have been are recorded in a one-to-many relationship in the Microsoft Access database as several contaminants could be present at any one sample site. This is exported from the Access database into an excel file that lists a row of contamination fields for each sample site as Contam1, Contam2, etc, which were populated with the relevant contamination codes recorded on the field card, in the order they were committed to the database.

In a GIS, symbols representing the occurrences of the contaminant codes can only be displayed for one column of data (i.e. Contam1 or Contam2 etc.) at any one time.

Therefore, in order to provide a table which can be attached to a GIS and used to generate maps which show the spatial distribution of one contaminant across all of the sample sites, new columns for each contaminant were added to the excel spreadsheet and then populated with a value of 1 if that contamination code was recorded at site, or left blank if not. This way it was possible to generate GIS maps showing every site where a particular type of contamination was observed based on the value of 1 being present in the column corresponding to the selected contaminant.

2.4 CHANGES MADE TO LAND USE CLASSIFICATION AFTER THE PRELIMINARY SURVEYS

Subsequently to the preliminary surveys, the land use code dictionary which has been used previously to 2008 for G-BASE regional and urban surveys was expanded to include several codes which allow a better description of the range of land uses in urban areas. The following land use codes were added;

AAC0: Saltwater Marsh	CC00: Minor Road/verge	DAAA: School
DAAB: Hospital Grounds	DAD0: Domestic Garden (urban)	DBD0: Domestic Garden (rural)
DDA0: Playground	DDB0: Playing field	DDC0: Park
DDD0: Golf course	GR00: Graveyard	GRA0: Crematorium

The addition of these codes has been beneficial but it has caused some issues within the field database; when a map of the field data was generated with symbols based on re-classified land use types some unusual patterns developed.

The "Commercial and Residential" (code DAA0) land use code was used to describe a large proportion of sites collected between 2005-2007 in East London, compared to the sites collected subsequently. This resulted in a biased land use map demonstrated in Figure 4.

The field data comments for each entry in the database corresponding to a sample site collected in 2005-2007 where "Commercial and Residential" was recorded as the primary land use were reviewed and aerial photographs of sites were examined. On closer inspection it seem that primary land use for many of these sites would have been more appropriately recorded as either minor road verge (CC00), urban open space (DAC0), domestic garden (DAD0) or parks (DDC0) had these codes been available for use by samplers at the time of collection.

The database was updated as appropriate by replacing "Commercial and Residential" codes and this allowed a land use map to be generated that does not display this bias (see Section. 3.1).

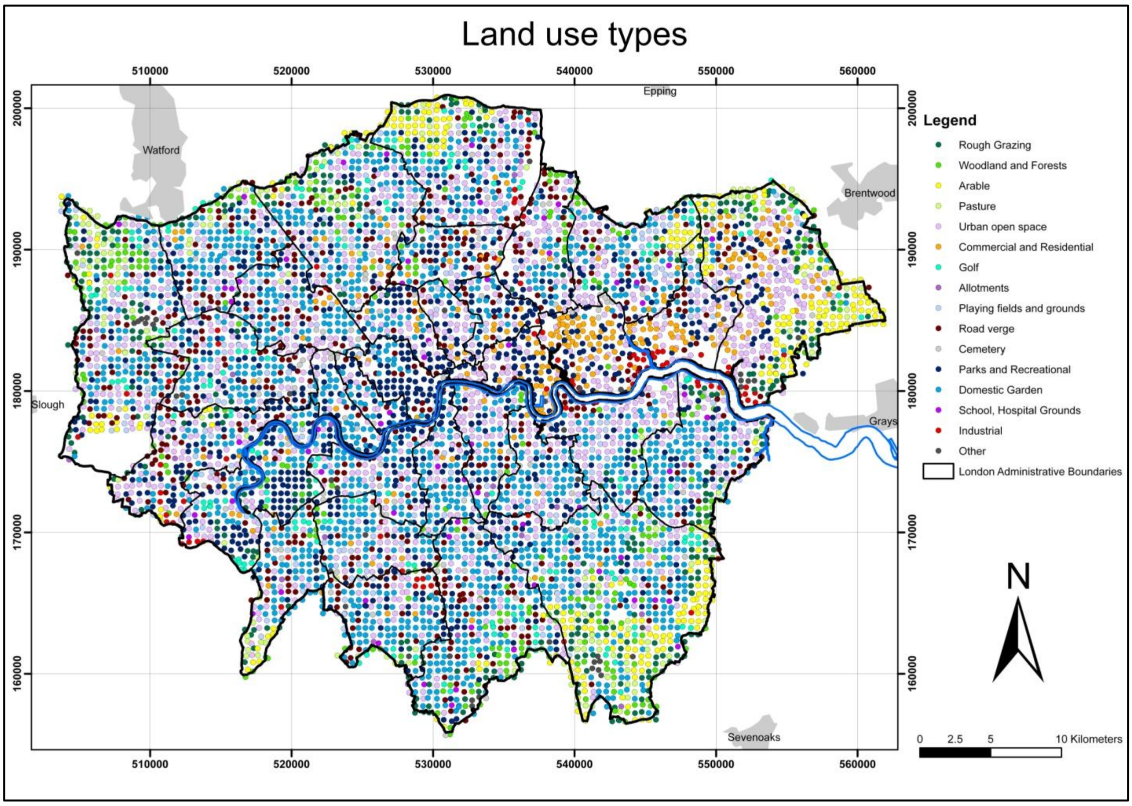

Figure 4. Map showing primary land use types as recorded in the field, prior to re-classification of some of the sites classified as "Commercial and Residential" in 2005-2007. Note the concentration of these in the east end of the city, within the areas covered in the 2005/2007 preliminary surveys.

3 Results - presentation of the field data

This section discusses and presents maps and graphs generated from the field data to summarise the relative proportions and spatial distribution of the main land use types, contamination, soil texture, and soil colour that were observed. These maps are intended to serve as a reference for geochemical interpretation and focus on factors which can influence the geochemistry of the site.

For easy reference, Figure 5 and 6 show a topographic map and superficial and solid geology map, in order to help put the maps of the field data in context.

Maps of clast types, and water and organic content were made but not found to yield any meaningful patterns so are not included in this report. Maps were generated using the drift and geology codes that were recorded in the database but these show less detail than the geology map included in Figure 6, from which they were inferred in the first place.

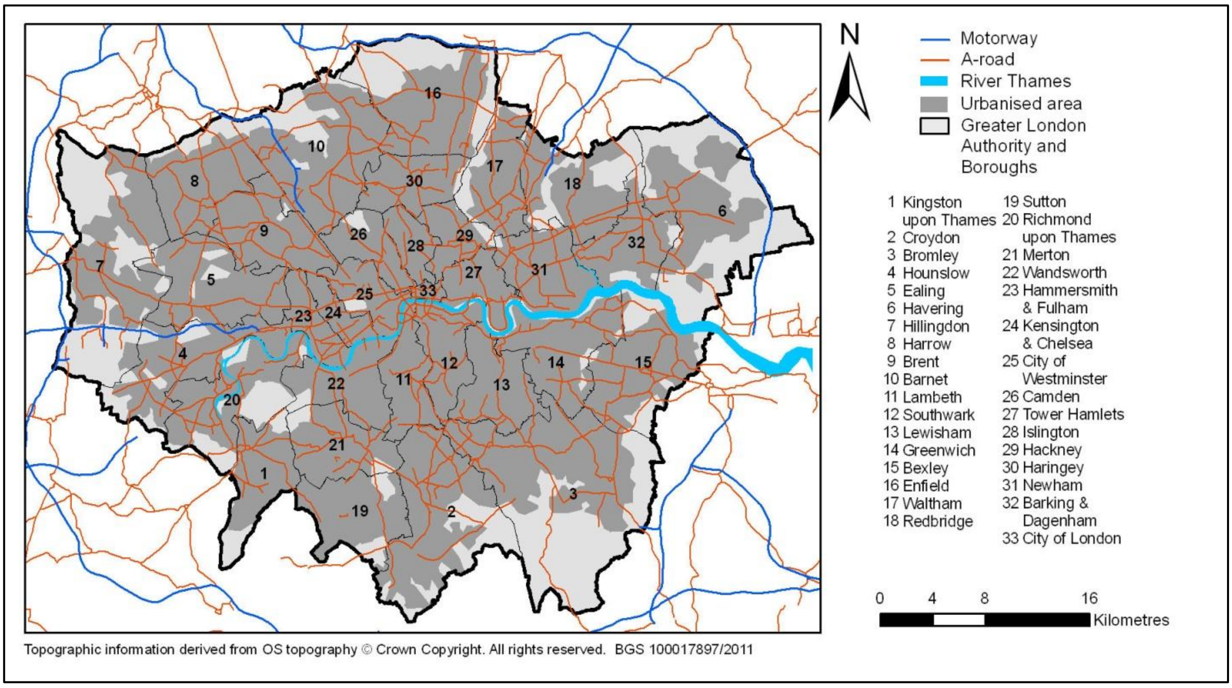

Figure 5. Simplified topographic map of the Greater London Authority area showing the extent of the City of London and the 32 London Borough Councils.

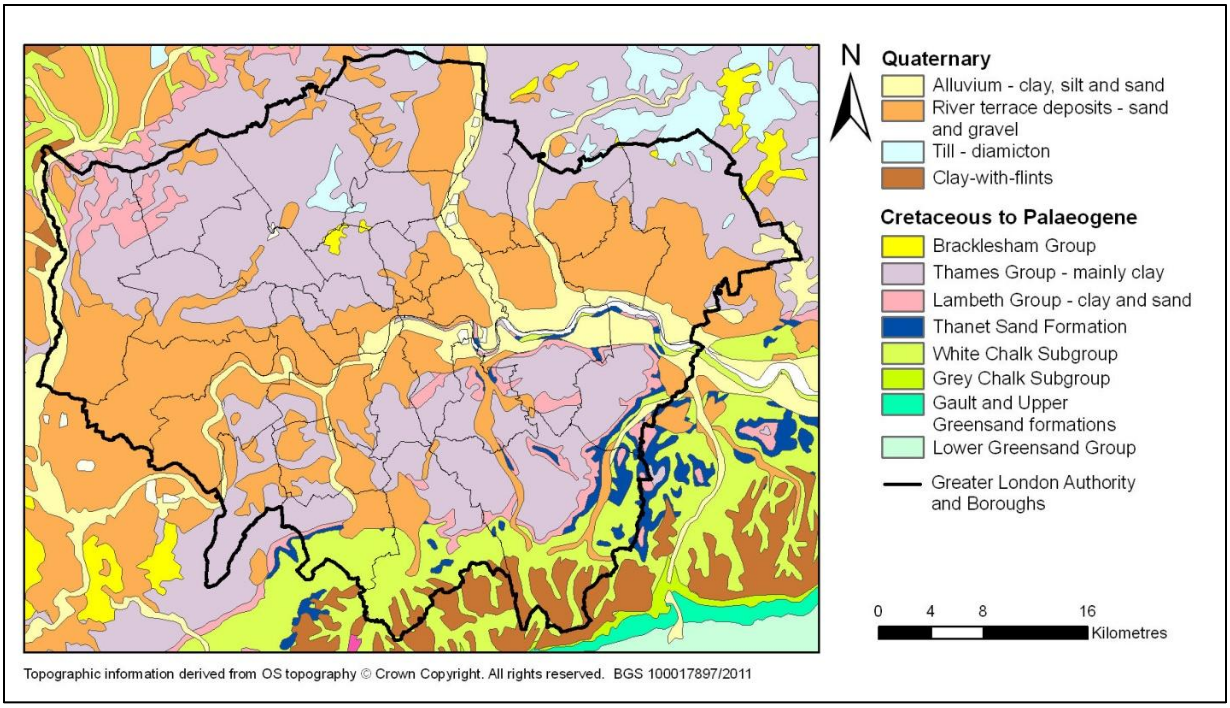

Figure 6. Superficial and bedrock geology of Greater London and surroundings, 1:625 000 (DiGMapGB-625)

3.1 LAND USE

The field database records how many sites were collected from each land use type, and their relative proportions (Figure 7). It can be seen that samples were most often taken from domestic gardens, followed by urban open spaces, and then parks and recreational grounds.

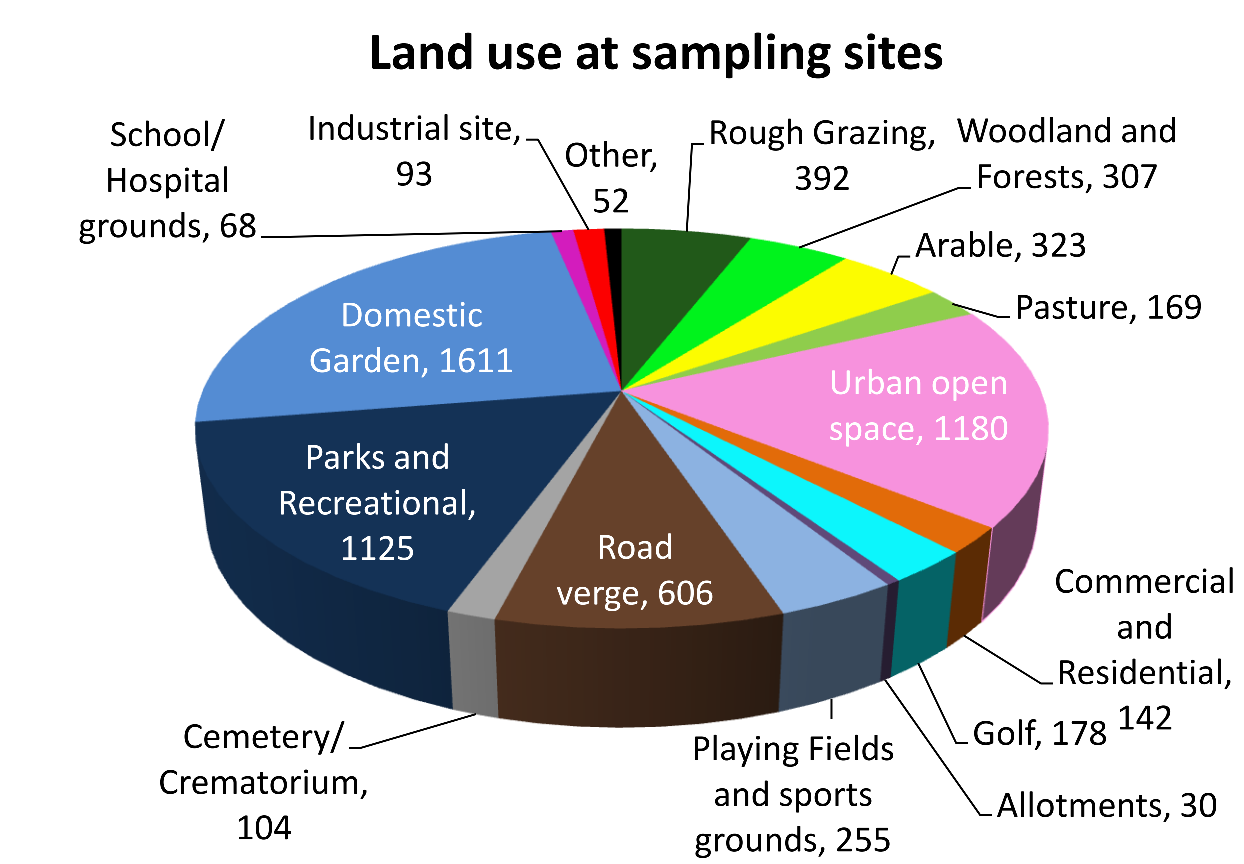

Figure 7. Graph showing the relative proportions of each main land use type.

The land use map (Figure 8) shows the spatial distribution of the land use types which were recorded at sites. Some zones of a particular land use types can be clearly seen: industrial sites around the Lea Valley, Creekmouth and Purfleet; arable land towards the edges of the GLA; parks and recreational spaces across Richmond park and Hyde park, etc. This map and the field data associated could be used to help identify if geochemical signatures can be assigned particular land use types or zones. For example, soil geochemistry in parks, in particular, is visibly different from adjacent developed land on the same bedrock/superficial geology (Knights and Scheib, 2011; Scheib *et al.*, 2011).

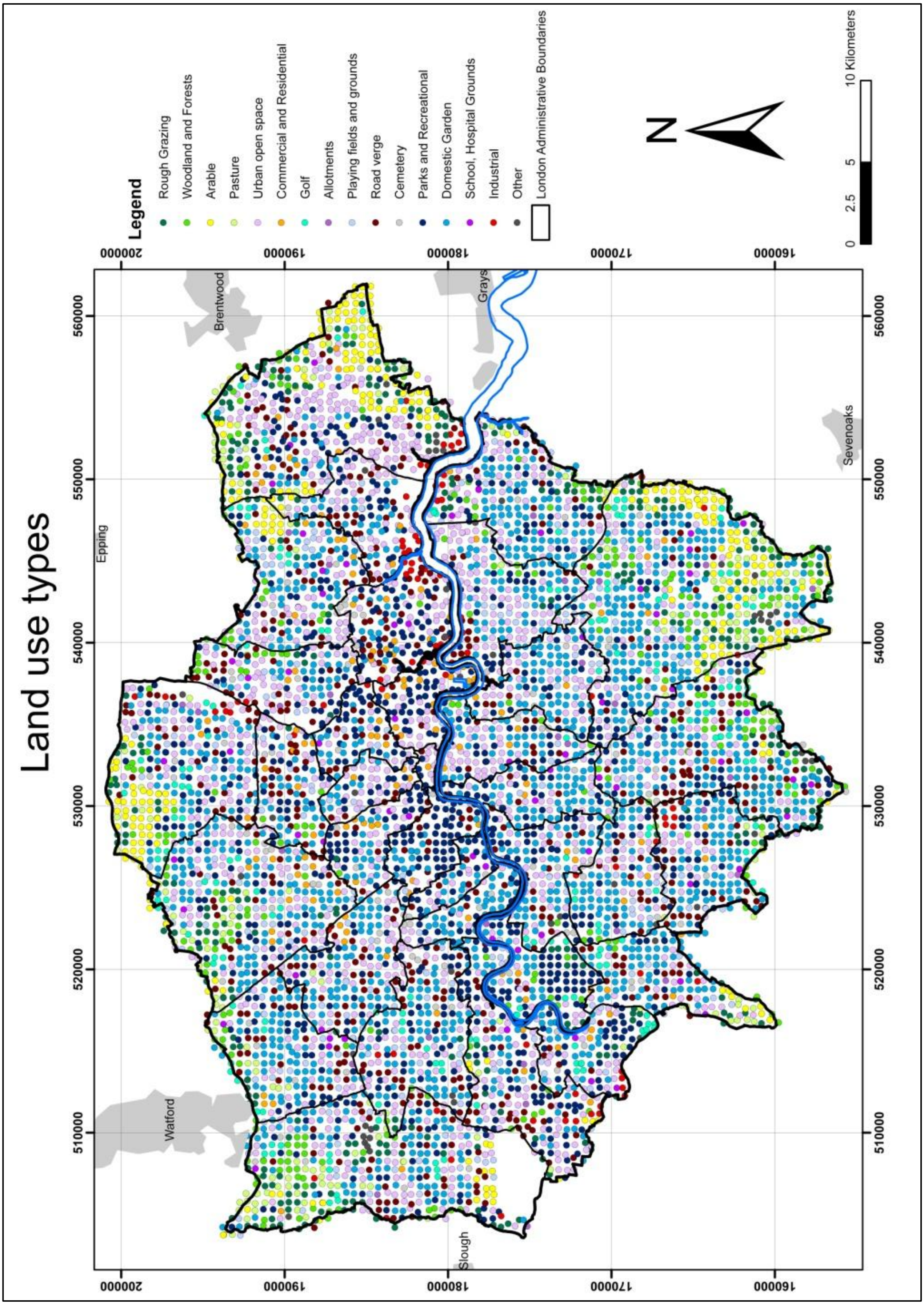

Figure 8. Map showing the distribution of the land use types that were sampled.

3.2 CONTAMINATION

3.2.1 Summary of main contamination types

The number of sites at which each contaminant was observed is shown in Figure 9.

Maps of a selection of these contamination types are presented in Appendix 1. Only maps of a selection of the most significant contaminants are included as many seldom occurred, as shown by the graph in Figure 9. These are intended to be used to identify where contamination occurs and for visual comparison to geochemical maps which may help to highlight and constrain the cause of any anomalies in soil geochemistry that may be influenced by the presence of contaminants.

Brick and Slag (furnace waste) are the most common type of contamination found in soil in the GLA, and are found throughout the survey area, across all types of land use but tending to be more prevalent within built-up areas.

Bricks have been used as a building material throughout the London area for centuries and broken pieces of brick in soil could be present due to demolition and re-building across the region. A significant proportion of this contamination may have originated from buildings that were destroyed during the World War 2 bombings. Observations of metals, while fewer, are particularly important since these can particularly effect the geochemical results.

It is noticeable that observations of manufactured metal and ceramic contamination were recorded more often in South London. Observations of iron and steel wire, and plastic contamination were recorded more often in the east end of London but this may, in part, be due to sampler bias (see Section 4.3).

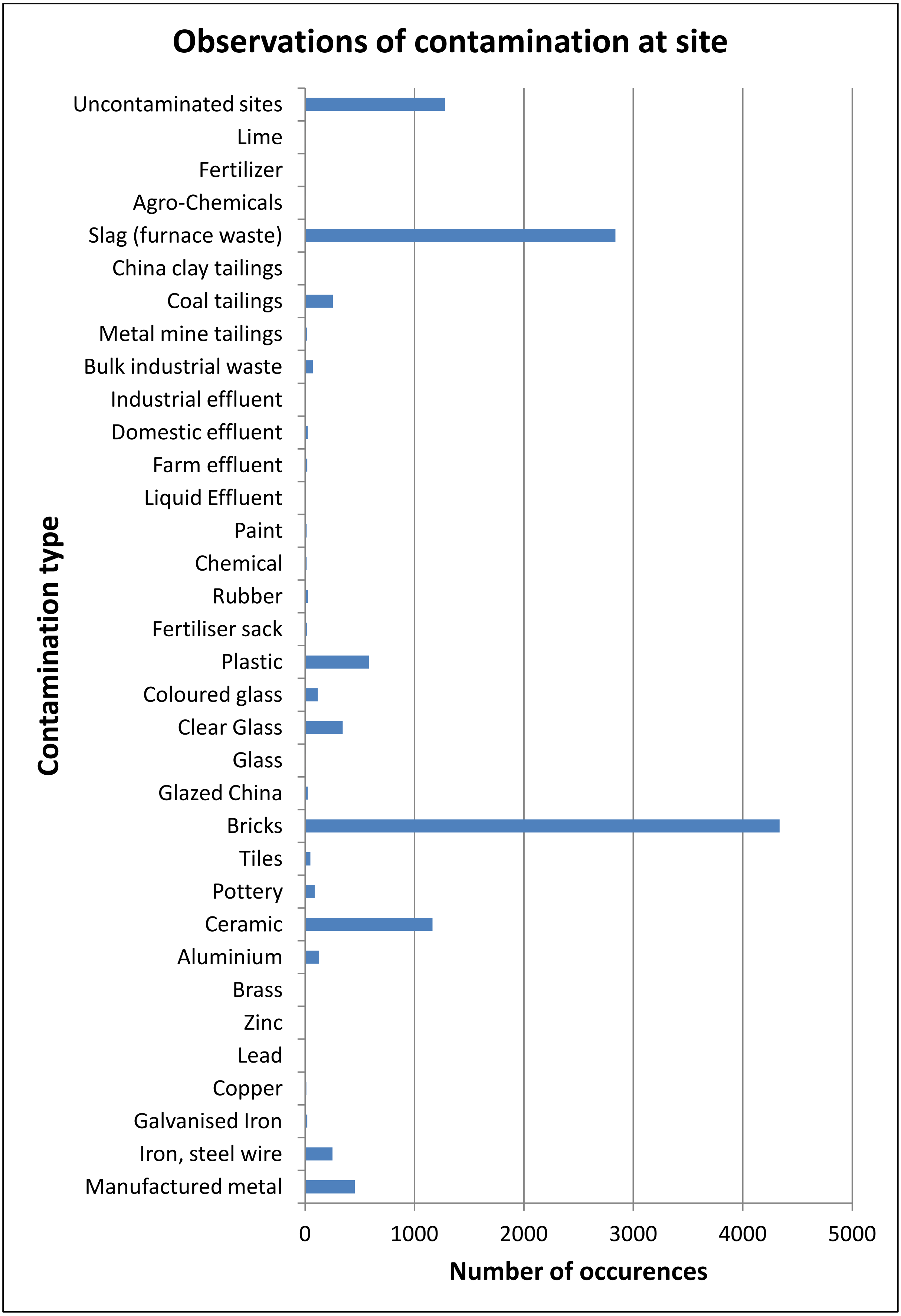

Figure 9. Graph showing the number of occurrences of each contamination type.

The graph in Figure 10 demonstrates which land use types were found to be the most contaminated. Developed land, such as Industrial sites (the most contaminated), urban and residential areas have a higher percentage of contaminated sites than urban open spaces such as parkland and recreational areas, with rural/peri-urban land uses such as woodland and farmland having the lowest percentage of sites where contamination was observed.

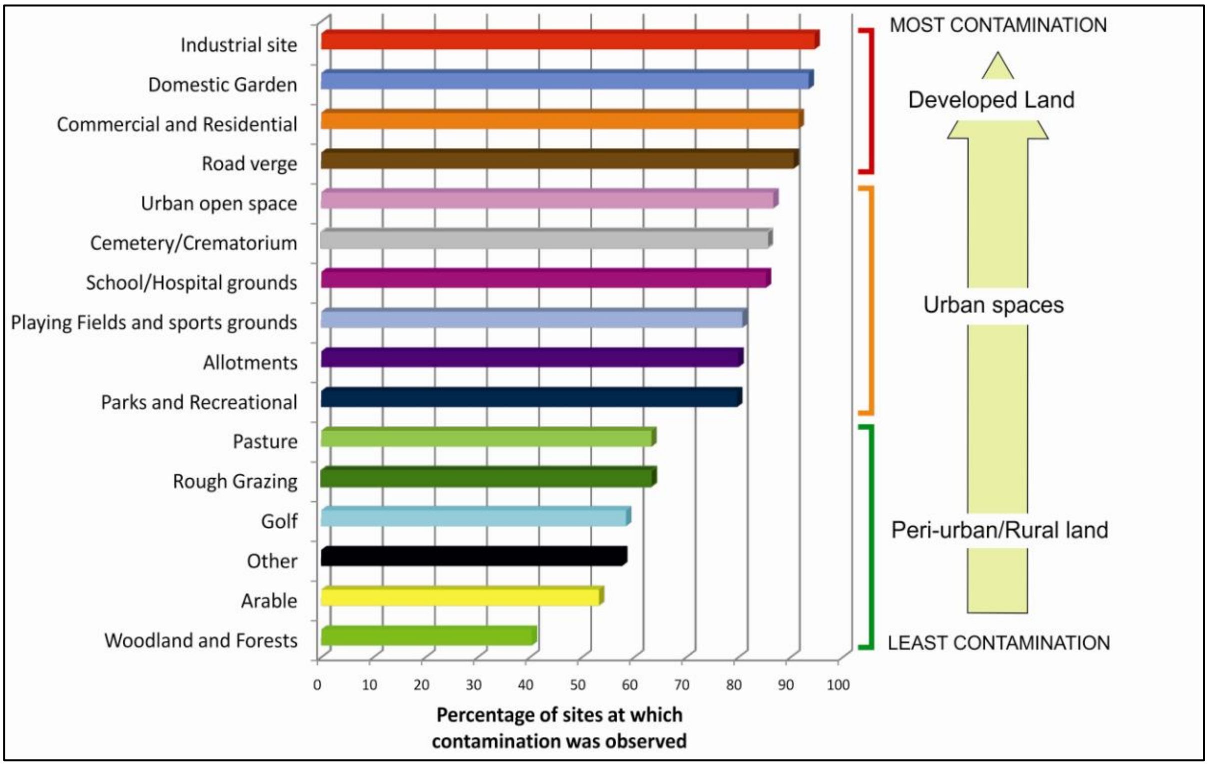

Figure 10. Graph showing the proportions of contaminated sites found within each main land use type.

In order to explore how the abundance of particular contaminants varies across land use types, "contamination profile" graphs can be made for comparison. Figure 11 shows the relative abundance of some significant contaminants across selected land use types. For each land use type, the percentage of sites collected from that land use at which a particular contaminant was observed is plotted on the Y axis, e.g. the graph shows that manufactured metal was observed at 19.4% of industrial sites.

These percentages were calculated in a Microsoft Excel spreadsheet for each land use type and a selection of significant contaminants. These are summarised in the table in Appendix 2.

This graph shows that although contamination was observed at a high percentage of domestic gardens, this was mostly in the form of bricks, with some ceramic and slag contamination, but other contaminants were relatively scarce. Industrial sites, on the other hand contain much higher values of manufactured metal, iron and steel wire, aluminium, plastic and chemical contaminants compared to other land use types.

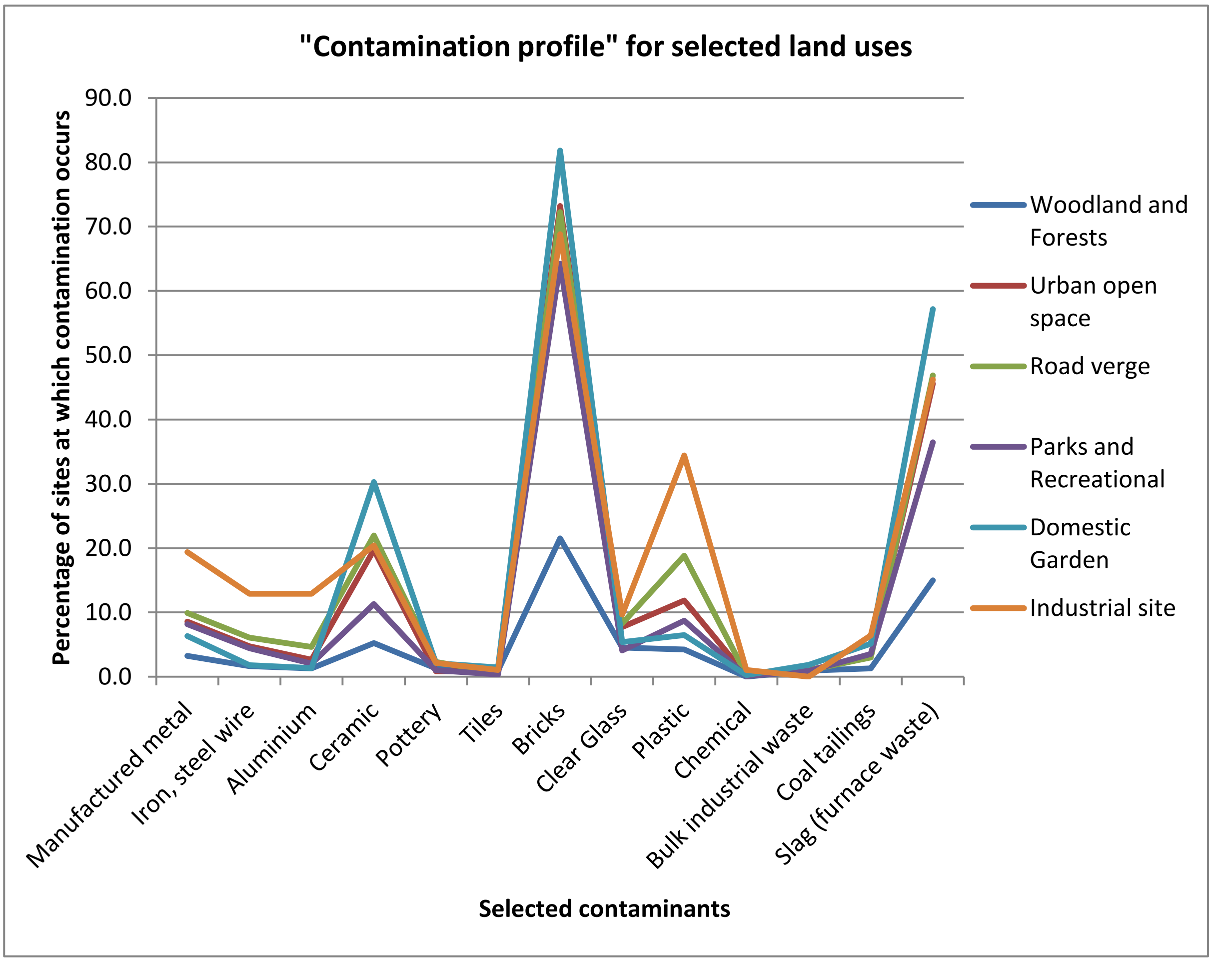

Figure 11. "Contamination profile" graph. This graph shows how selected contamination types vary in abundance for each land use type.

3.3 SOIL TEXTURE

Soil texture was recorded for surface soil, topsoil and deeper soil at each sampling site. Soil could be described either as; clay, clayey sand, sandy clay, sand, sandy silt, silty clay, silt or silty sand, as specified by a soil texture dictionary on the field card overlay.

Soil texture maps were made using this information held within the field database to show the spatial distribution of these soil textures across the survey area. These are included in this section for topsoil (Figure 12), deeper soil (Figure 13) and surface soil (Figure 14). Note that since surface soil samples were not collected during the preliminary surveys, there is no surface soil texture data available for the area of East London where the preliminary survey was conducted.

These maps are of interest as soil texture is influenced by the underlying superficial geology (drift), a parent material from which the soil is partly derived, as well as the bedrock geology present. Soil texture can have an effect on water runoff in certain areas so this field data may be useful for hydrological/drainage studies.

From a comparison with the combined drift and solid geology map in Figure 6, it can be seen that soil texture seems to be more clay-rich where drift is absent and sites directly overlie the Thames group, a geological unit mainly comprised of clay. Soil texture tends to be more sandy where it overlies drift in the form of the alluvium and river terrace deposits of the Thames and Lea valleys.

3.3.1 Soil texture maps and description

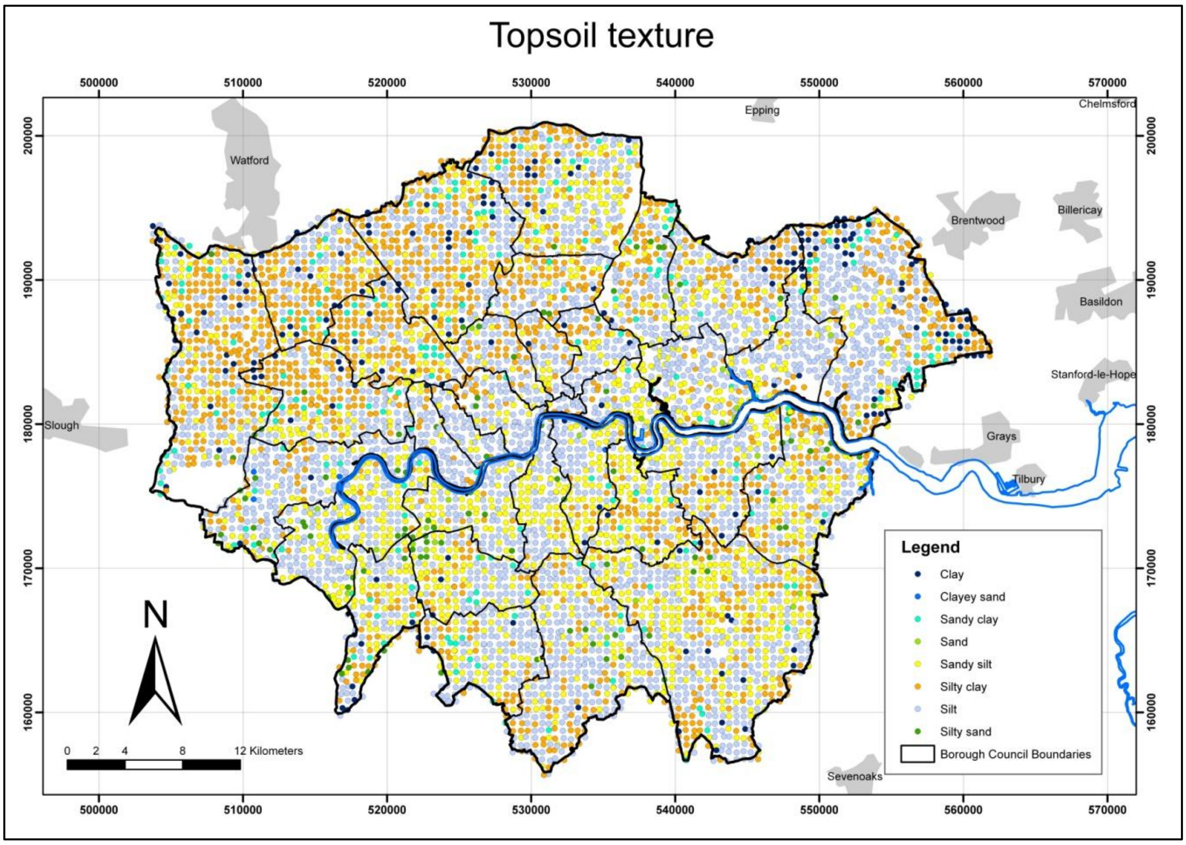

Figure 12. Topsoil texture map showing the distribution of soil textures recorded for topsoil samples (5-20 cm depth).

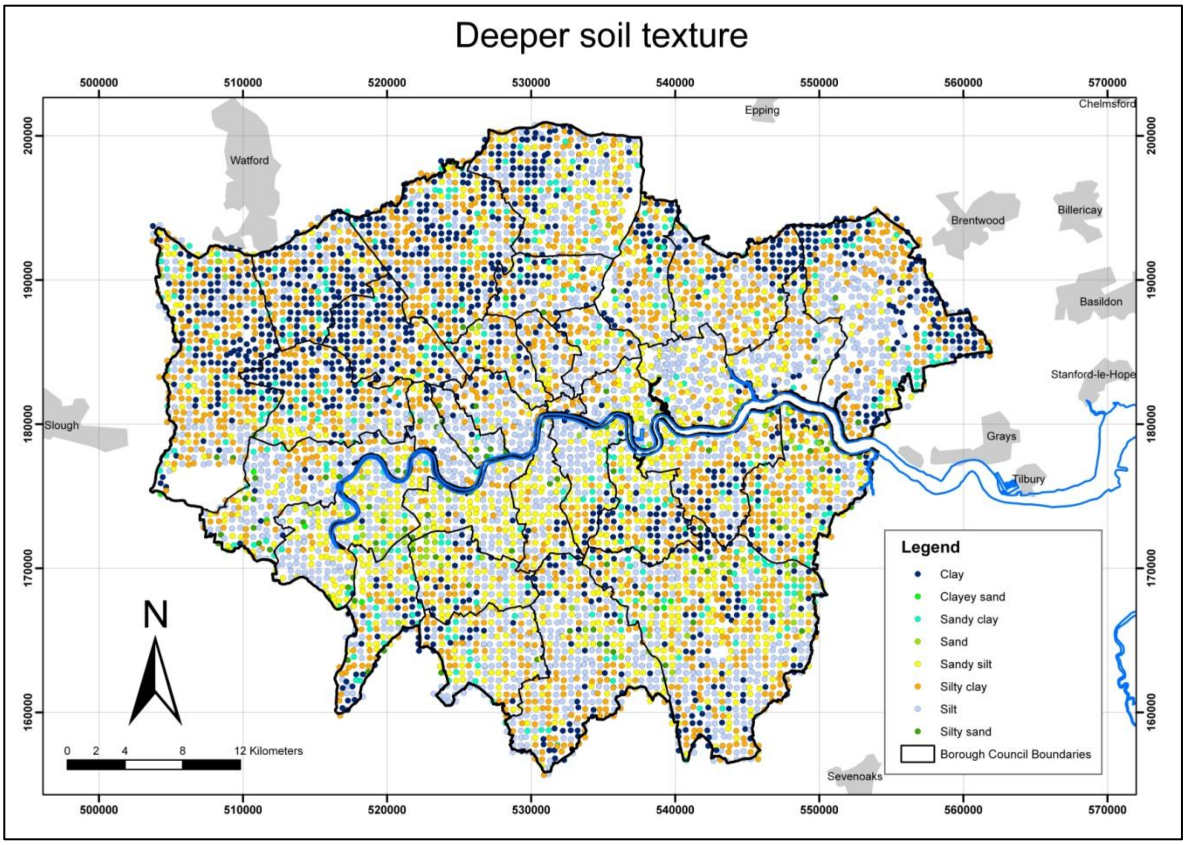

Figure 13. Deeper soil texture map showing the distribution of soil textures recorded for deeper soil samples (35-50 cm depth).

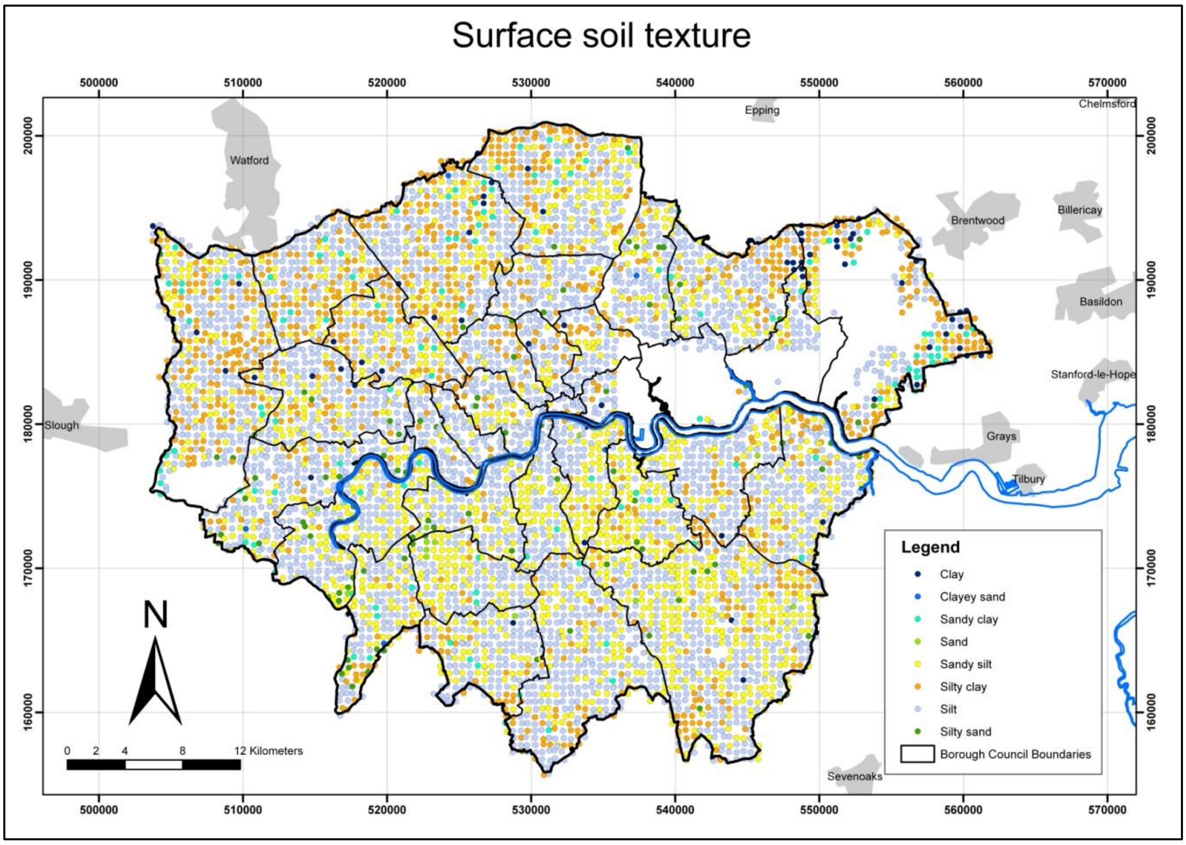

Figure 14. Surface soil texture map showing the distribution of soil textures recorded for surface soil samples (0-2 cm depth).

3.4 SOIL COLOUR

Soil colour was also recorded for surface soil, topsoil and deeper soil at each sampling site; i.e. undried sample. Soil colour could be described either as; black, dark brown, green, grey, light brown, orange, or yellow, as specified by a soil colour dictionary on the field card overlay.

It is difficult to establish any factor as controlling soil colour in the survey area. Most of the soils that were sampled were recorded as being either dark or light brown and in general, these observations were evenly distributed throughout the survey area, although in the case of deeper soil colour it is noticeable that dark brown soils tend to occur nearer the centre of London, generally overlying alluvium and river terrace deposits which may have an influence on the soil colour.

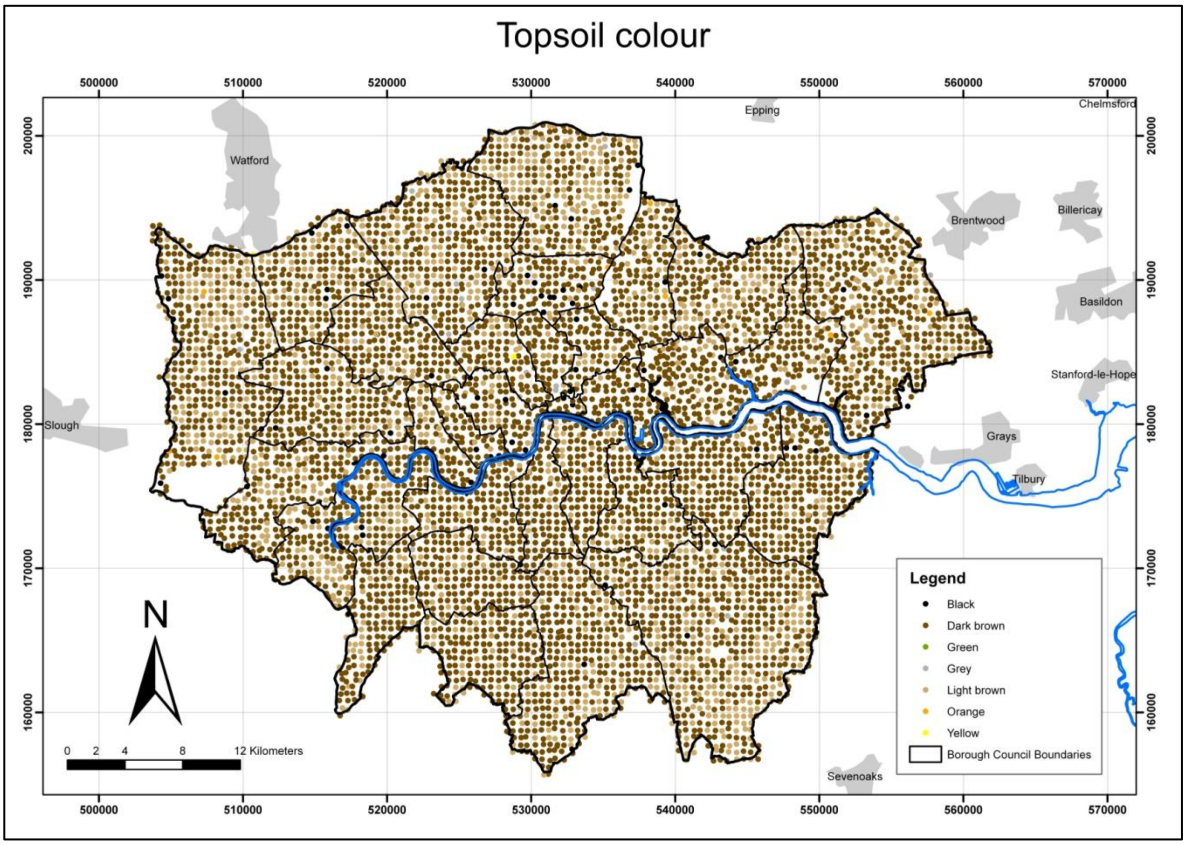

Figure 15. Topsoil colour map showing the distribution of soil colour recorded in topsoil samples (5-20 cm depth).

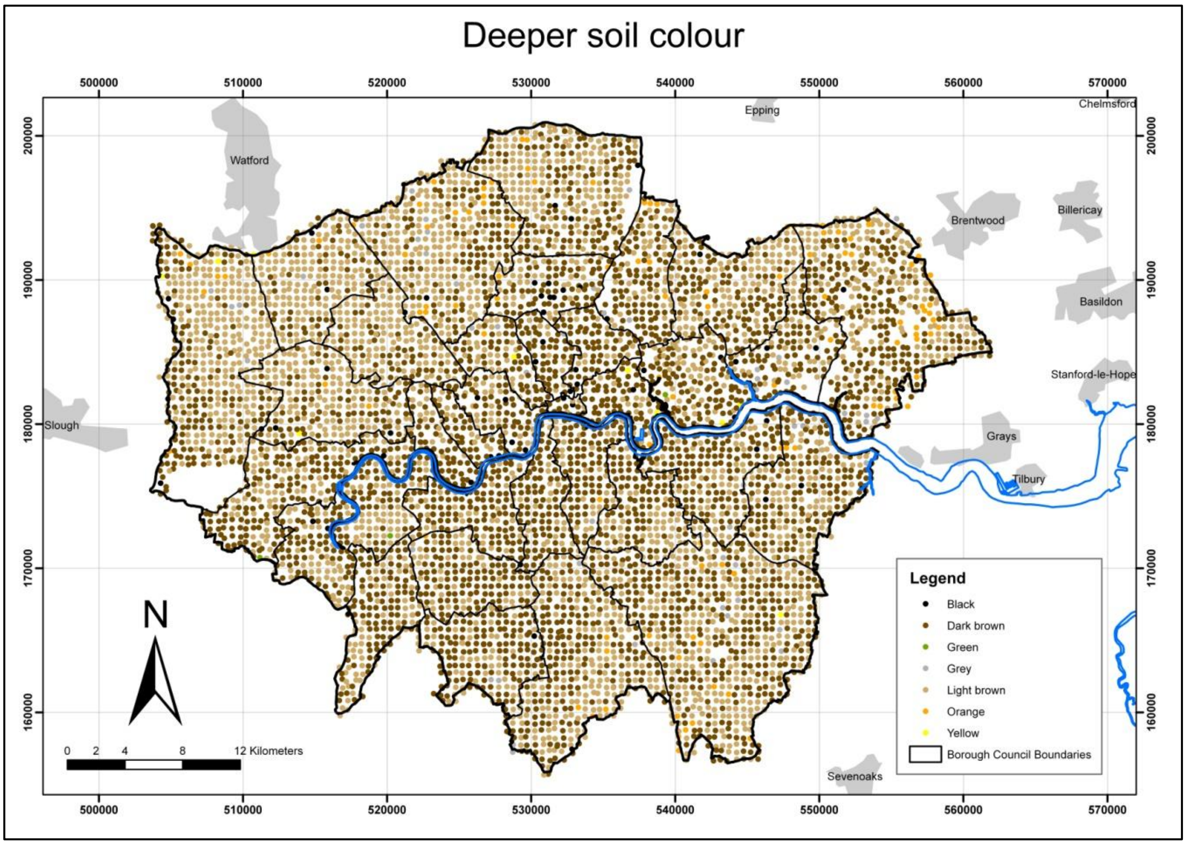

Figure 16. Deeper soil colour map showing the distribution of soil colour recorded for deeper soil samples (35-50 cm depth).

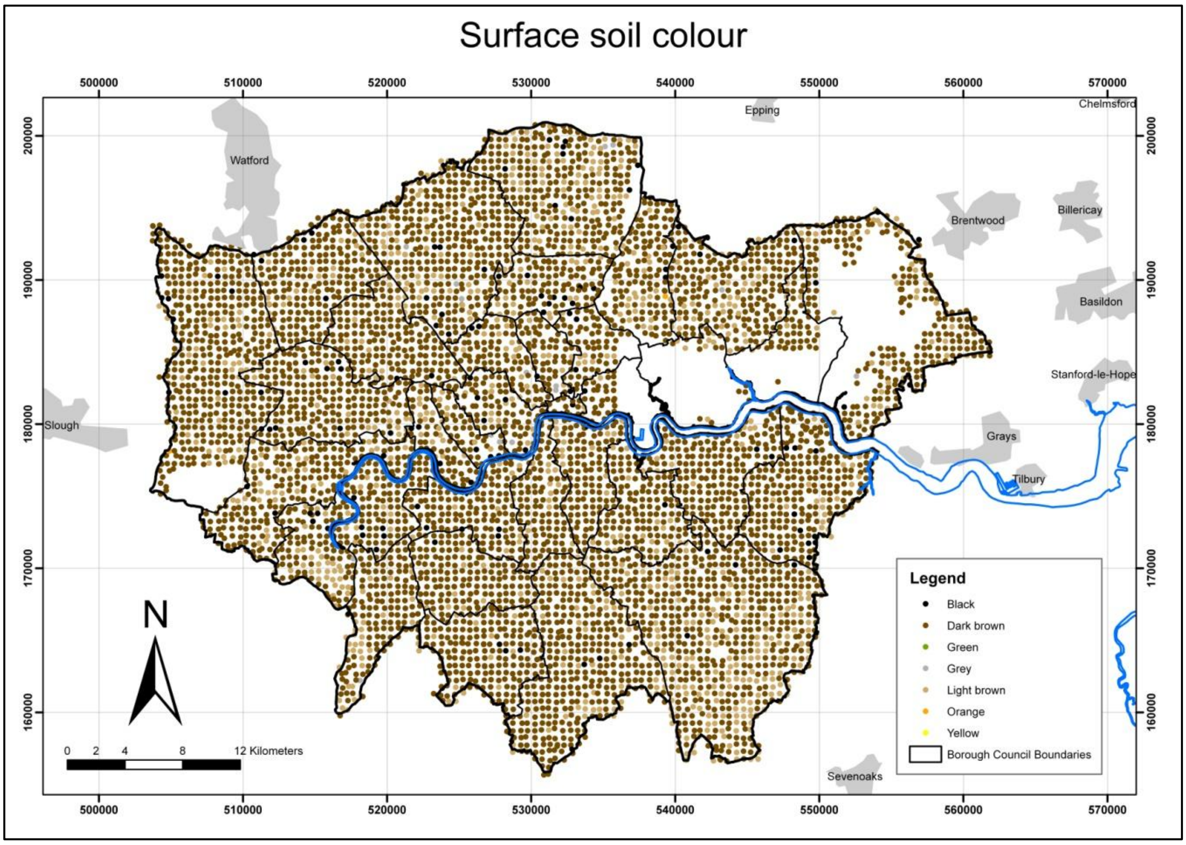

Figure 17. Surface soil colour map showing the distribution of soil colour recorded for surface soil samples (0-2 cm depth).

4 Assessment of the field data

4.1 CONTAMINATION

Contamination codes are entered in no particular order on the field card but have to be entered into the field database input form in an order, which puts the observed contaminants in a sequence.

This sequence is of no relevance unless the relative abundance of each contaminant is noted within the field data comments on the card, which allows the contamination types to be committed to the Microsoft access database in a meaningful order, which would identify the primary contamination type and then the secondary type etc. in order of abundance.

Many samplers followed best practice and indicated the relative abundance where more than one contaminant was observed at a site, and when this was done the contaminant codes could be entered into the access database in order of abundance.

However, this has not occurred throughout the data collection and databasing stages, and the database tends to have contamination codes arranged in alphabetical order, since that is the order in which they are listed on the field card.

If it is deemed important that contaminants be represented in order of abundance within the database, a more rigorous procedure could be employed in future whereby samplers routinely record the relative abundance of contaminants clearly.

This could be done in several relatively simple ways;

- Training samplers to indicate either the *relative* abundance of contamination on the back of the field card, i.e. (Bricks>Plastic>Glass)
- Indicating the order of abundance by adding superscript numbers, 1, 2, 3 etc, in order above the relevant contamination boxes on the field card.
- Contamination is recorded currently by putting a number in a specific box on the field card, and these boxes are arranged alphabetically. Future editions of the field card could do away with this system and simply record codes (using the current code scheme) for contaminants in order of abundance from left to right on a row of boxes. This could be employed using the current field card if samplers treat the restriction of using specific boxes for particular contaminants as irrelevant and instead record the whole codes in order of abundance as they do for clast type.

If any of these steps were taken, the functionality of the database could be improved as the primary (i.e. most abundant) contaminants at each site could be displayed easily within a GIS and additionally each data point would then hold more information on which types of contamination are the most relevant for each individual site.

4.2 DRIFT

Drift is always entered in order of dominant type but as it stands the primary drift field in the field card and database tended to be recorded as soil (code: C1) since soil was present where a soil sample was collected. Although in theory procedure allows a peat sample to be collected, and peat be recorded as primary drift, this may be unlikely to occur in an urban area.

While this code is useful to record drift types over regional areas particularly in mixed media surveys such as G-BASE, for urban surveys there may be little need for C1 to be automatically recorded as primary drift as it is implicit that soil is present at every sample site, since a soil sample was collected.

The secondary drift fields usually contain codes referring to the superficial geology at site as inferred from a geological map of the area and this information would be more useful for statistical comparison and displaying the data, therefore it could instead be entered in the primary field.

Alternatively, future editions of the field card could record drift in two separate fields as "observed drift" (drift seen at site) and "mapped superficial deposits" (as inferred from geology map), or a convention could be adopted to record these different observations on the field card in the primary and secondary drift field respectively.

4.3 LAND USE

The primary land use code is intended to provide the best description of the land use at the sampling site. Upon close inspection of the database, however, it appears that in many cases the primary land use code has not been consistently used in this way by student samplers.

Samplers have in fact tended to use the primary land use code on the field card to provide the best description of the land use within the grid square quadrant from which the sample has been collected (dominant land use). This works well in some ways, as a land use map displaying primary land use types gives a good representative picture of the dominant land uses across the whole survey area, which may have been the rationale for this practice.

At most sites, several land uses were recorded, to describe the various land uses present at the location. As such, the secondary land use tended to describe the site itself; e.g. a sample taken from a road verge within a residential area could have "Commercial and Residential" as the primary land use and "Road Verge" as the secondary land use. In many cases, i.e. if a sample was taken from a park and the park covered the entire grid square quadrant, then only one code was entered which describes both the dominant land use and the land use at site.

This makes it difficult to extract data and create a GIS map of the land uses which represent the land use at site rather than the dominant land use, since in general, the primary land use will describe the land use in the grid square quadrant, whereas information that describes the site itself can be split across both the primary and secondary fields. Since values from only one field can be represented at a time, the land use at site cannot be easily determined from the database.

This non-standard method may have arisen if a clearly defined protocol for the recording of these codes was not understood clearly by samplers, and/or through the development of non-standard practices within the field teams during the field season. The use of the primary field to record land use at site is not directly specified in the latest edition of the G-Base field procedures manual for instance (Johnson, 2005); it may be worth considering that this specification be included in future editions.

In the future, a convention could be adopted where the primary field is used to describe the land use at site, while the secondary field represents the dominant land use, or vice versa. This would then cover both types of observation and would present dominant land use in one field of the database and land use at site in another, allowing both to be represented in a GIS and the data easily extracted.

For this scheme to work, if the same code is selected as the best description of the site and dominant land use, it should be entered in *both* the primary *and* secondary field. This will ensure that codes which represent either the land uses at site or the dominant land use are held within and can be extracted easily from one field in the database, and therefore will allow us to easily create both a map showing the land use at site and another showing dominant land use. A future edition of the field card could solve this problem more elegantly if it had boxes labelled specifically for site and dominant land use, then this distinction could be clearly made in the database.

As it stands, the database appears to predominantly contain land use codes reflecting dominant land use in the primary field. This means that a GIS map of the primary land use codes in the database is good at showing land use distribution that is representative of the whole survey area and would be good for comparison with geochemical anomaly maps to identify where broad zones of land use can have an effect on soil geochemistry. However, the database will not as easily allow an assessment of how the land use at specific sites can be related to soil geochemistry, or allow samples to be assessed based on the type of site from which they have been extracted, which is unfortunate since this is an important aspect of interpretation for which the collection of land use codes is intended to support. If land use at site is deemed more important then it should be recorded in the primary field, however, the conventions proposed above could allow for both to be achieved.

This issue would not be expected to be a problem for regional surveys as areas of a specific land uses are typically more spatially extensive and one land use will typically be a good description of both the site and the grid square from which it is collected. However, it is still important that standard conventions for the recording of primary and secondary land uses are followed in regional surveys.

In the future, if land use codes are to be recorded in a more consistent way, it should be ensured that the proper method of recording land use should be established and explained to samplers during training at the beginning of each field season.

The Commercial and Residential land use code is useful as a generic “catch all code” within urban areas but it there have been some problems with its use since it was used extensively in the preliminary surveys before new more specific codes relevant to urban areas were introduced in 2008. The problems with this land use code can be attributed to the fact that the dictionary has been updated part way through the sample collection programme, therefore we would not anticipate any problems with using the dictionary in its current form for future urban surveys.

However, “Commercial and Residential” is not necessarily the most useful classification as it refers to two possible land uses, commercial areas or residential areas. It could therefore be split into a code for commercial districts and a code for residential areas in order to make it more useful.

It is noticeable that observations of manufactured metal and ceramic contamination were recorded more often in South London. Observations of iron and steel wire, and plastic contamination were recorded more often in the east end of London. This seems unusual and may be due to a sampler bias as the areas where higher concentrations of these contaminants were observed correspond to separate field campaigns.

5 Summary

The *London Earth* field database is a valuable set of data, gathered at the time of sample collection for the main geochemical survey. It has been possible use this data to generate high-quality soil texture and colour maps for the survey area, as well as examine which contamination types are the most prevalent, over which land use types.

The soil texture map shows a good spatial correlation to the underlying superficial geology (drift) deposits.

Section 4 of this report proposed some small changes which could be made to the way field data is recorded which could improve the functionality of the database. These changes are primarily concerned with arranging the input of data codes which can have one-to-many relationships to the sample site, such as land use, drift, and contamination. Some simple steps could be taken either by adopting some simple conventions and training samplers to follow, and/or by making some minor changes to future editions of the field card.

These proposals made in the assessment of field data section may help to refine the present method of data collection and address some problems that have occurred. Most of these issues are likely to arise specifically in urban surveys as land use is more diverse and spatially variable, and more contamination types are observed. Therefore these issues would previously have been unlikely to have been a major problem for regional surveys.

Appendix 1 Contamination maps

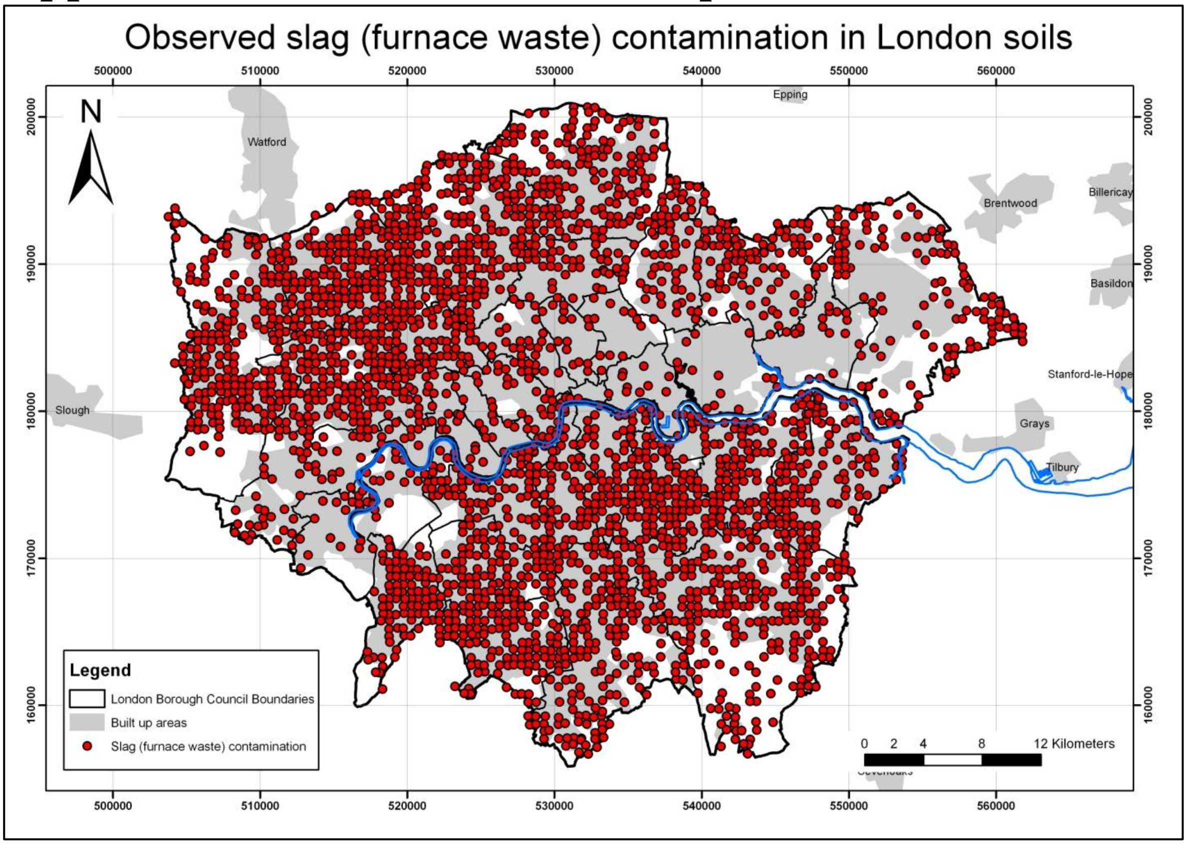

Figure 18. Map showing the locations and distribution of sampling sites where slag (furnace waste) contamination was observed.

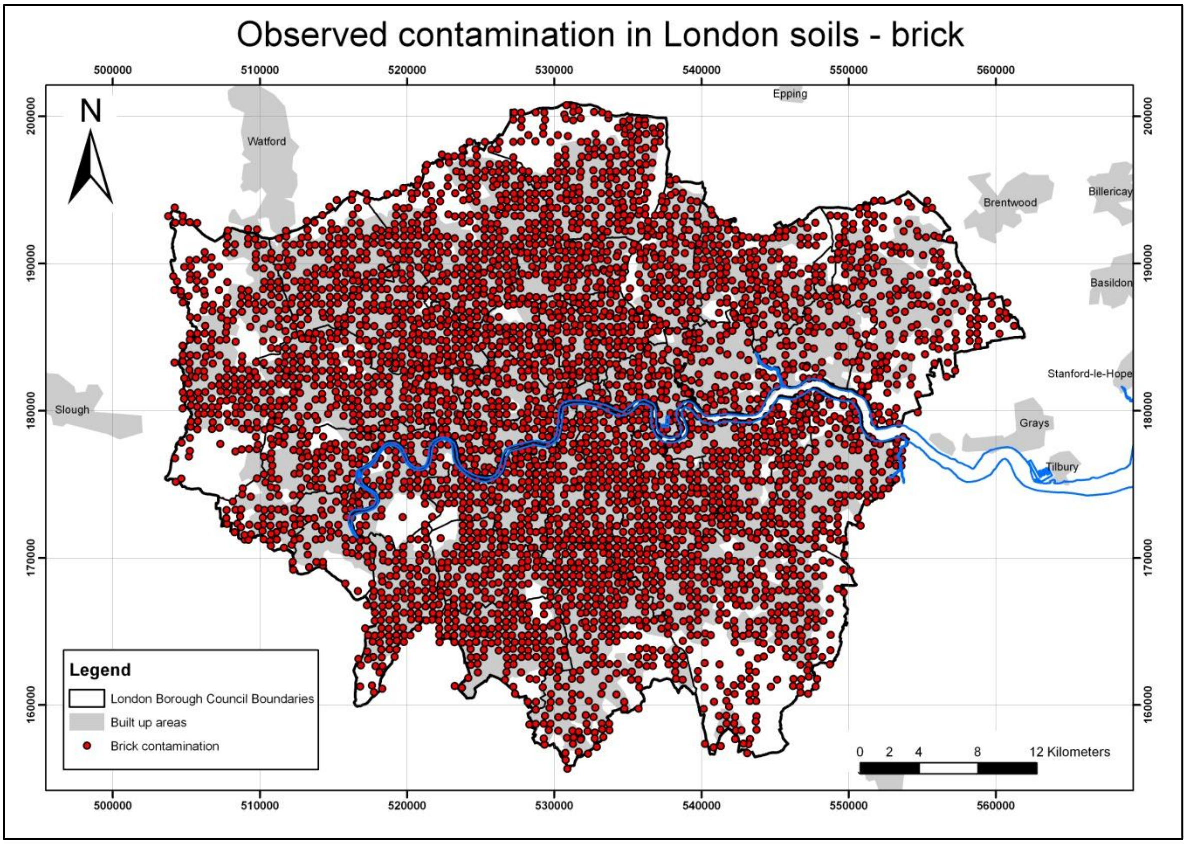

Figure 19. Map showing the locations and distribution of sampling sites where brick contamination was observed.

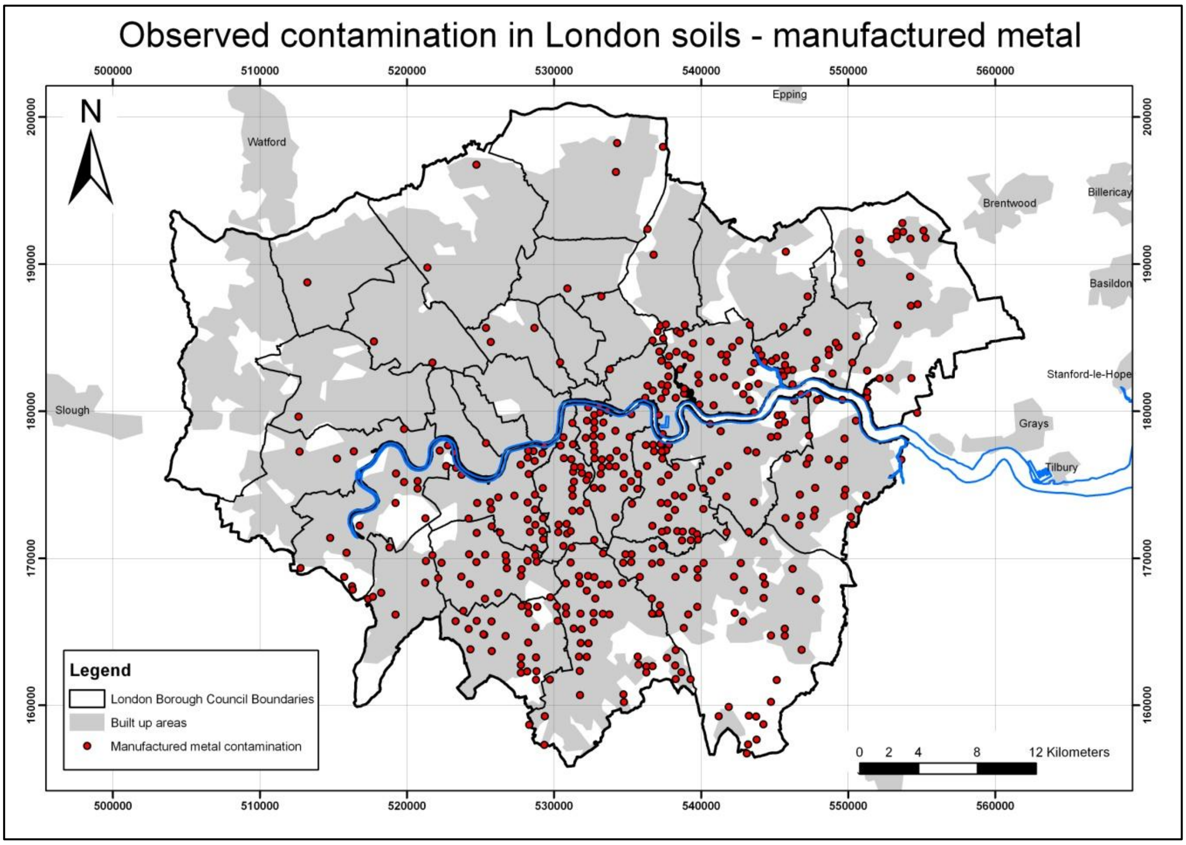

Figure 20. Map showing the locations and distribution of sampling sites where manufactured metal contamination was observed.

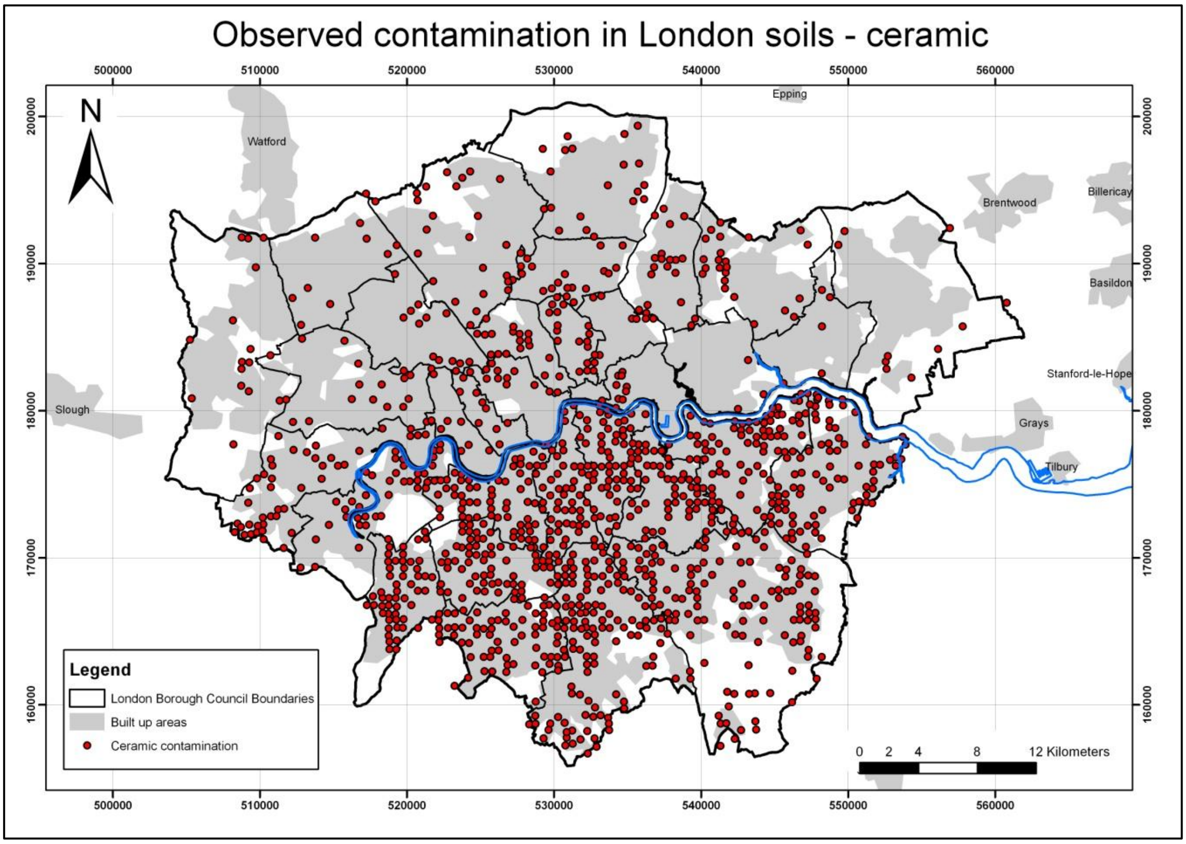

Figure 21. Map showing the locations and distribution of sampling sites where ceramic contamination was observed.

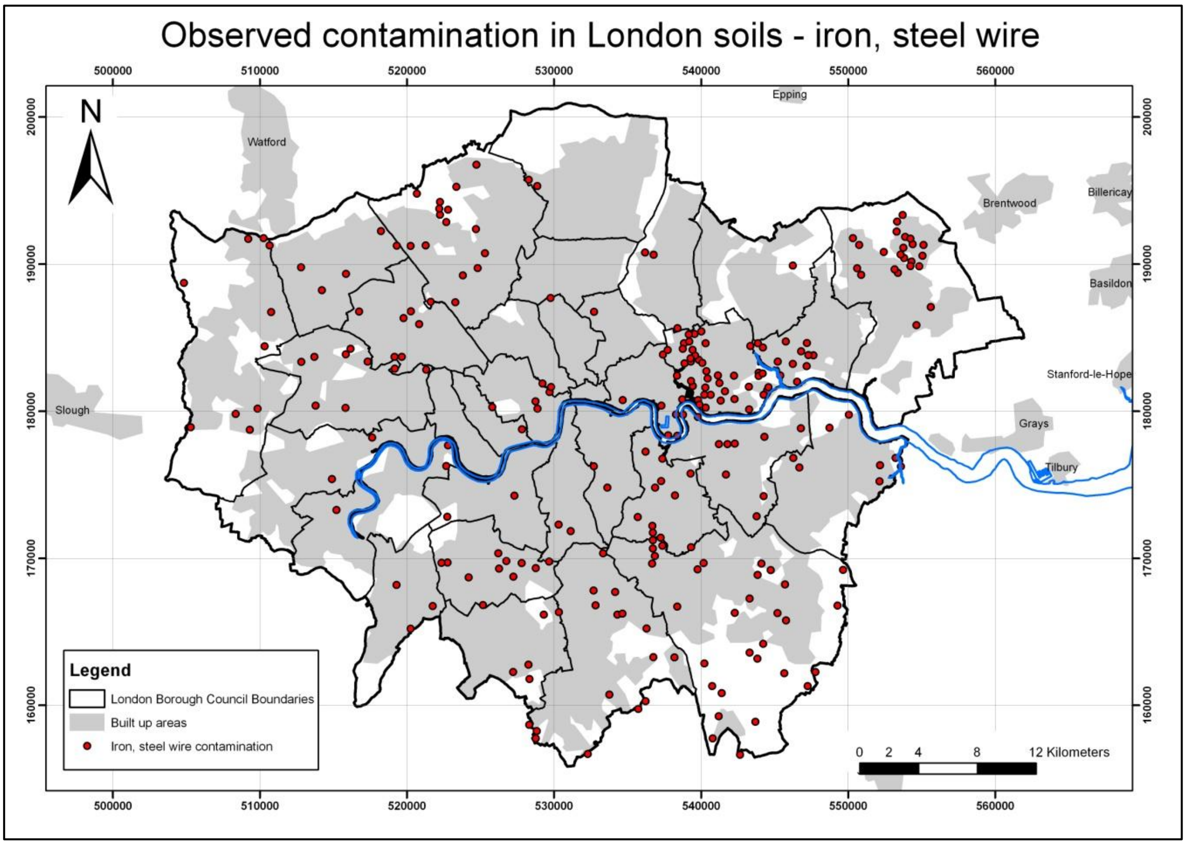

Figure 22. Map showing the locations and distribution of sampling sites where iron or steel wire contamination was observed.

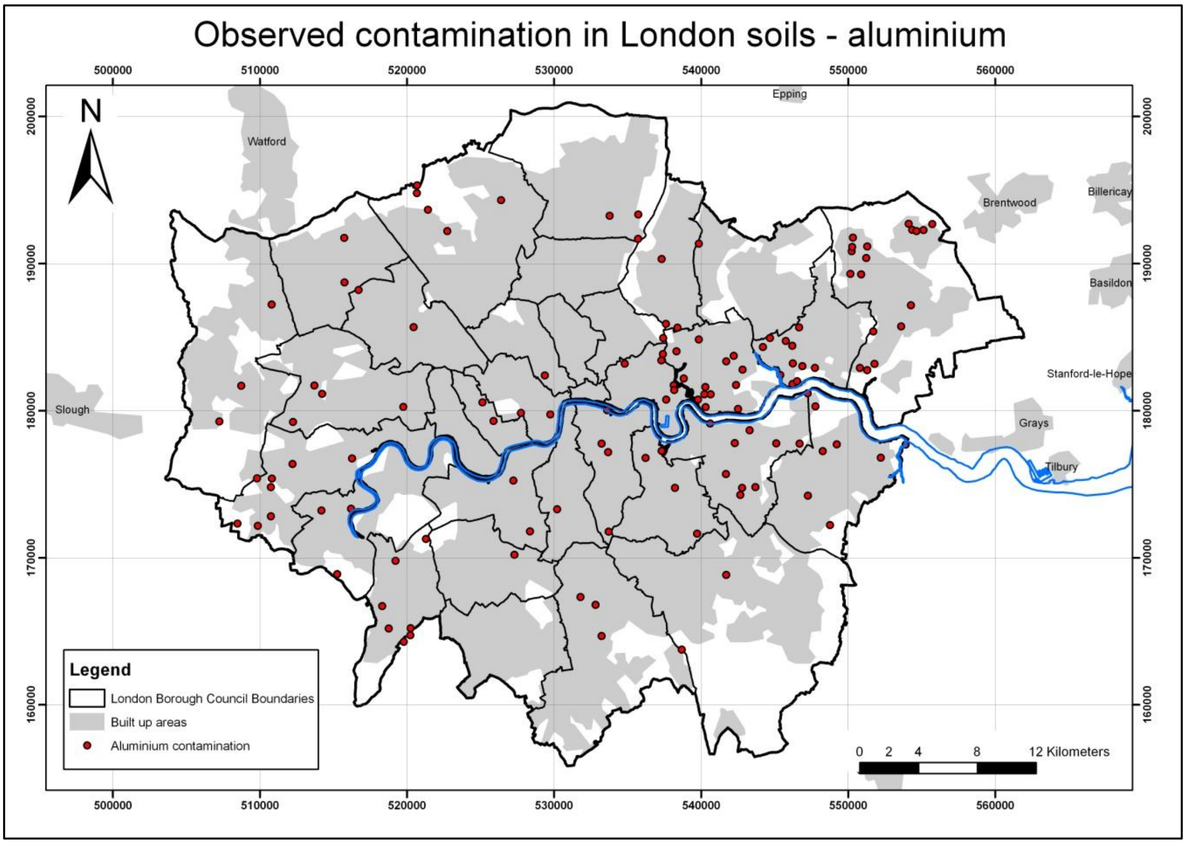

Figure 23. Map showing the locations and distribution of sampling sites where aluminium contamination was observed.

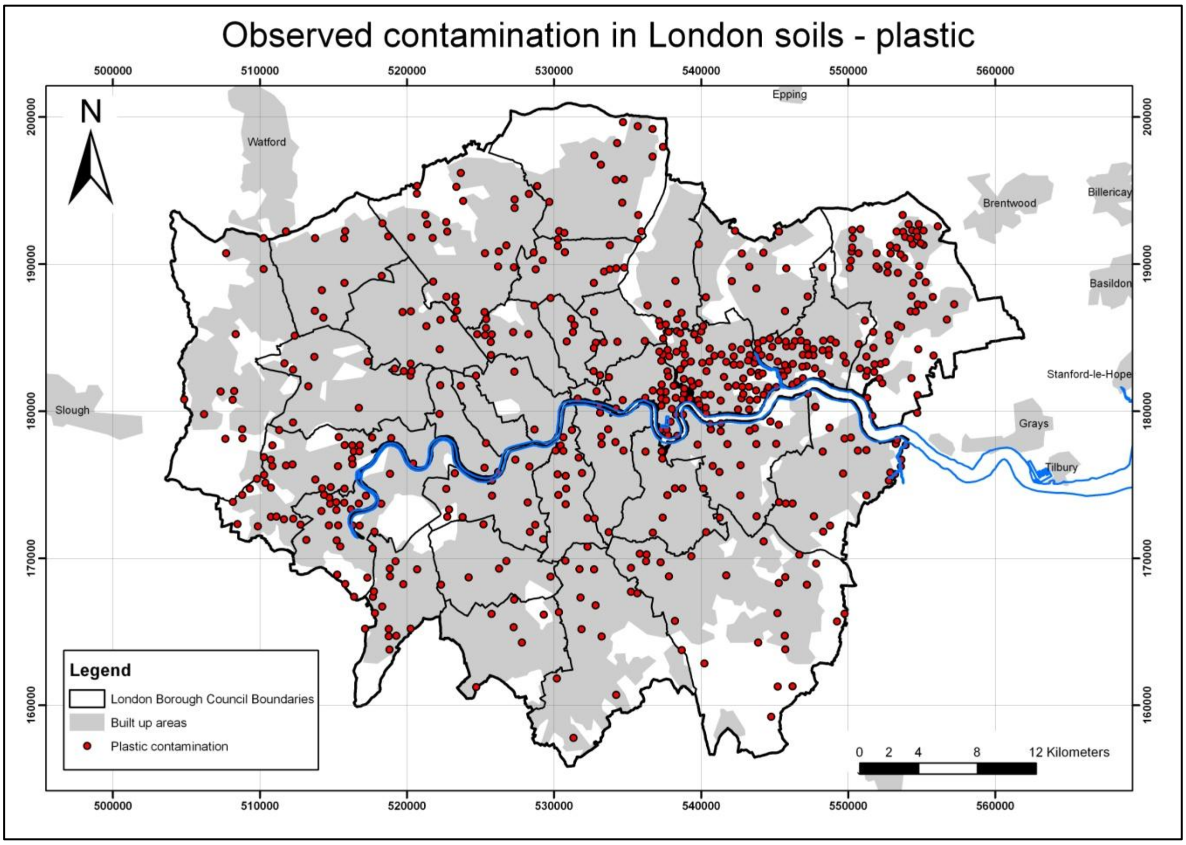

Figure 24. Map showing the locations and distribution of sampling sites where plastic contamination was observed.

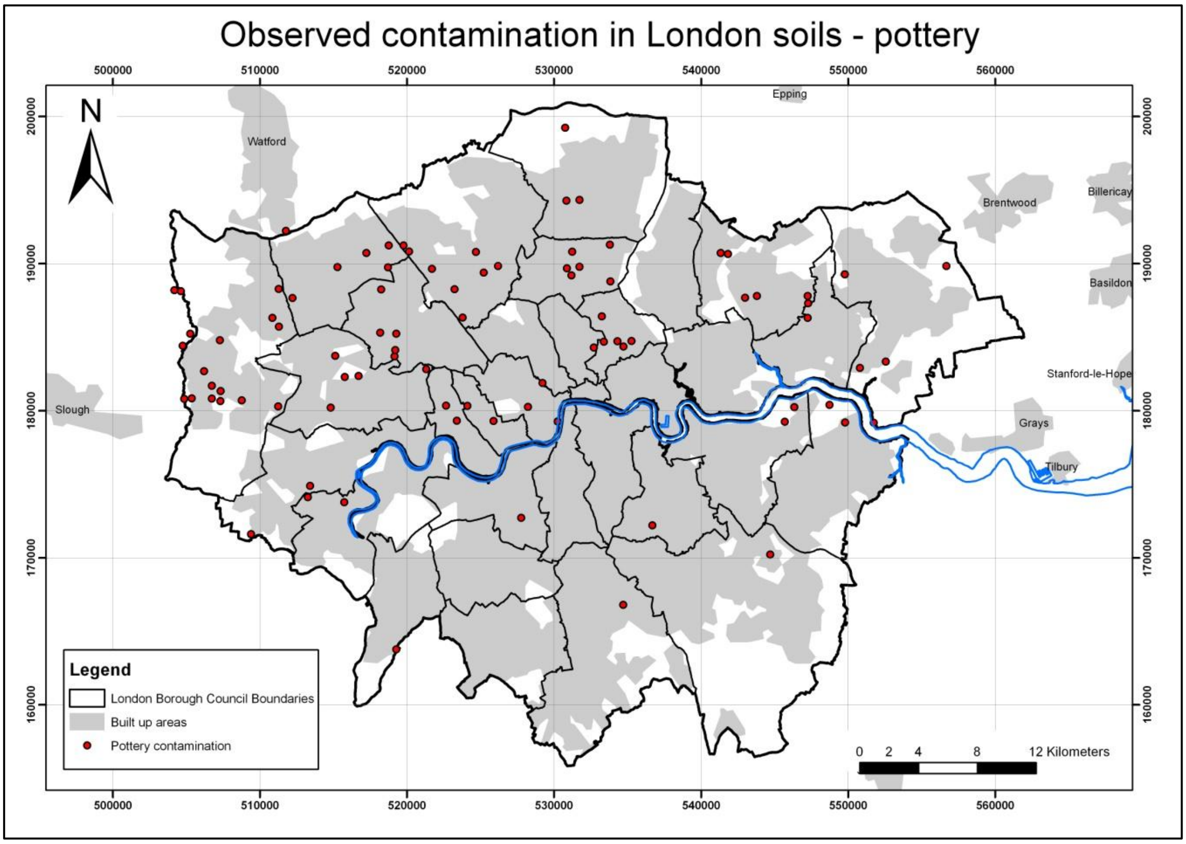

Figure 25. Map showing the locations and distribution of sampling sites where pottery contamination was observed.

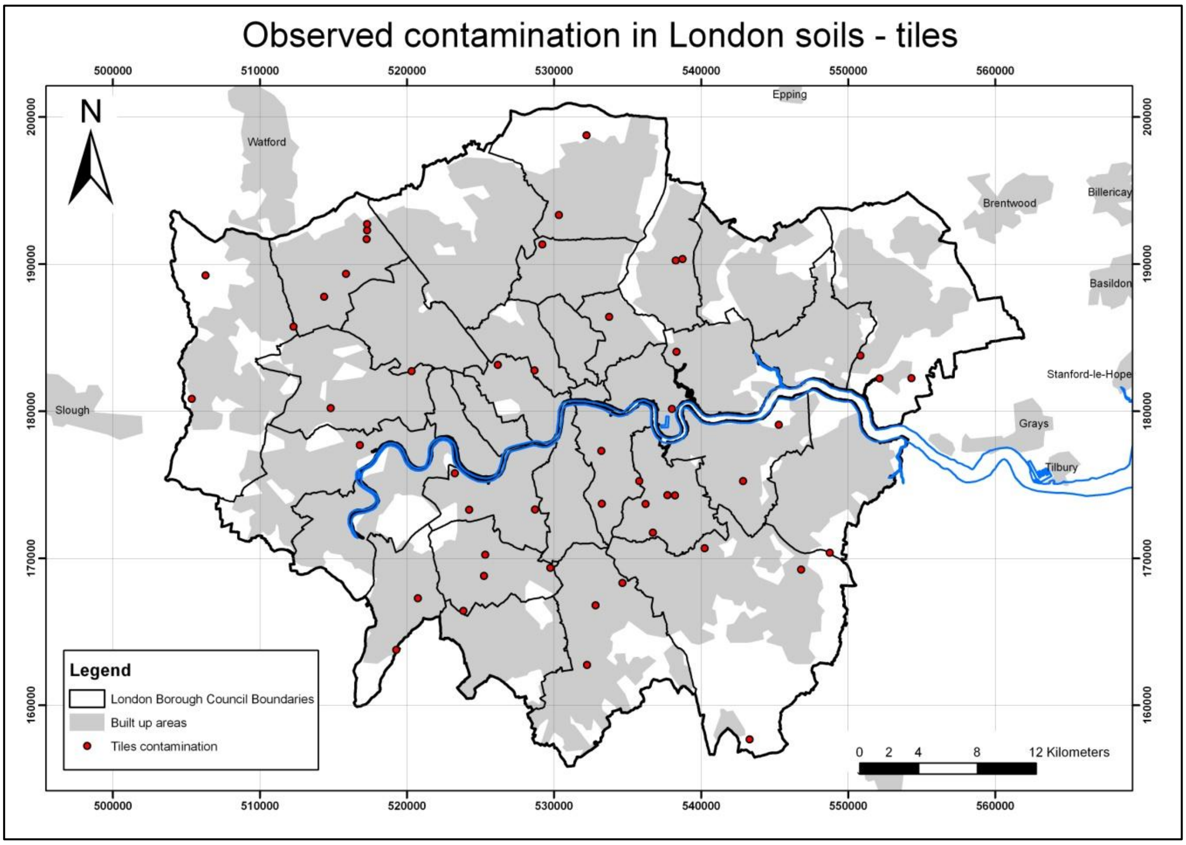

Figure 26. Map showing the locations and distribution of sampling sites where tiles were observed.

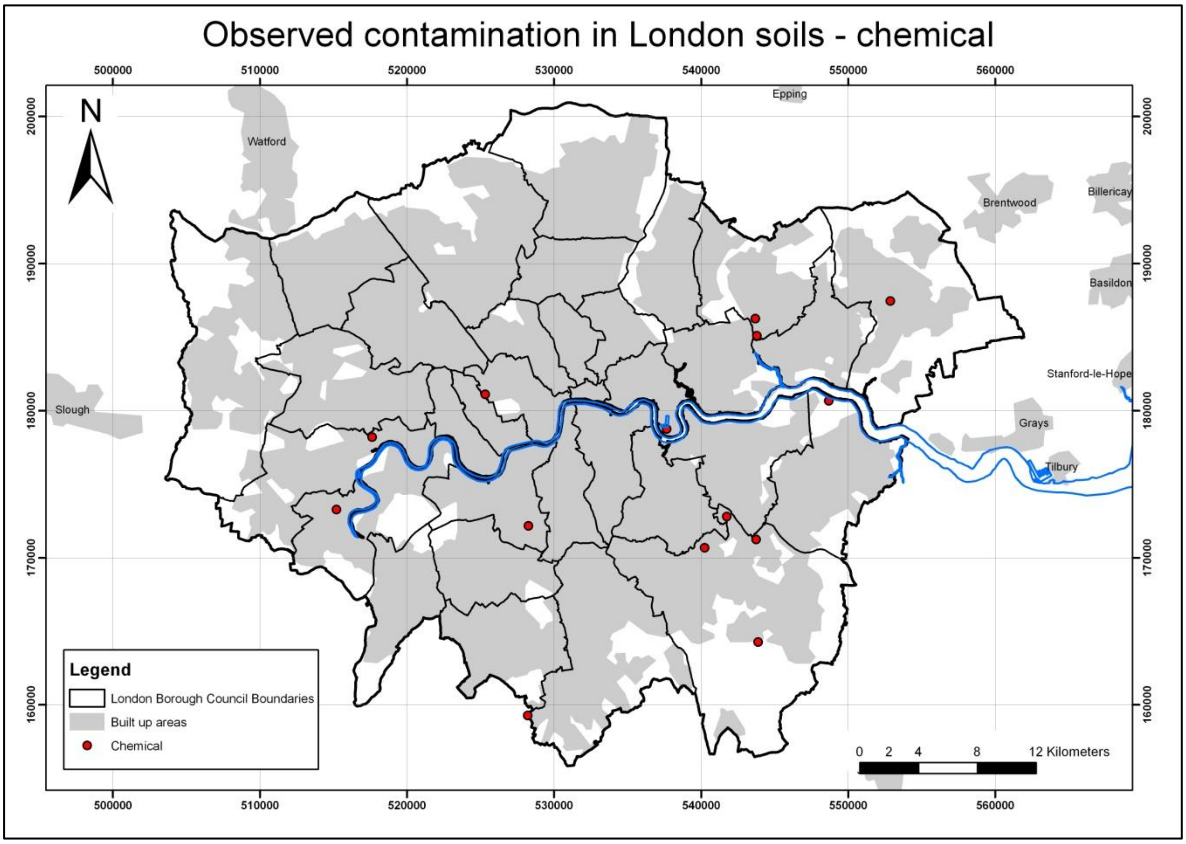

Figure 27. Map showing the locations and distribution of sampling sites where chemical contamination was observed.

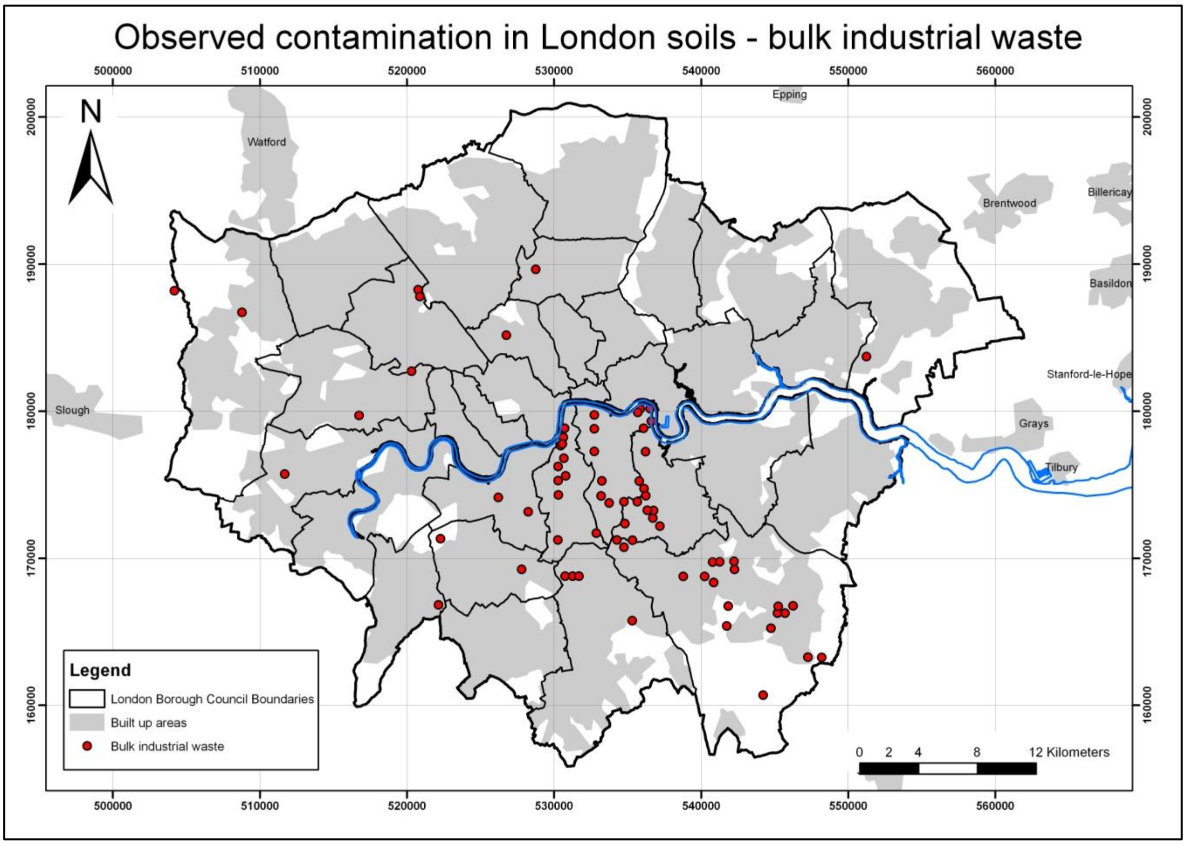

Figure 28. Map showing the locations and distribution of sampling sites where bulk industrial waste contamination was observed.

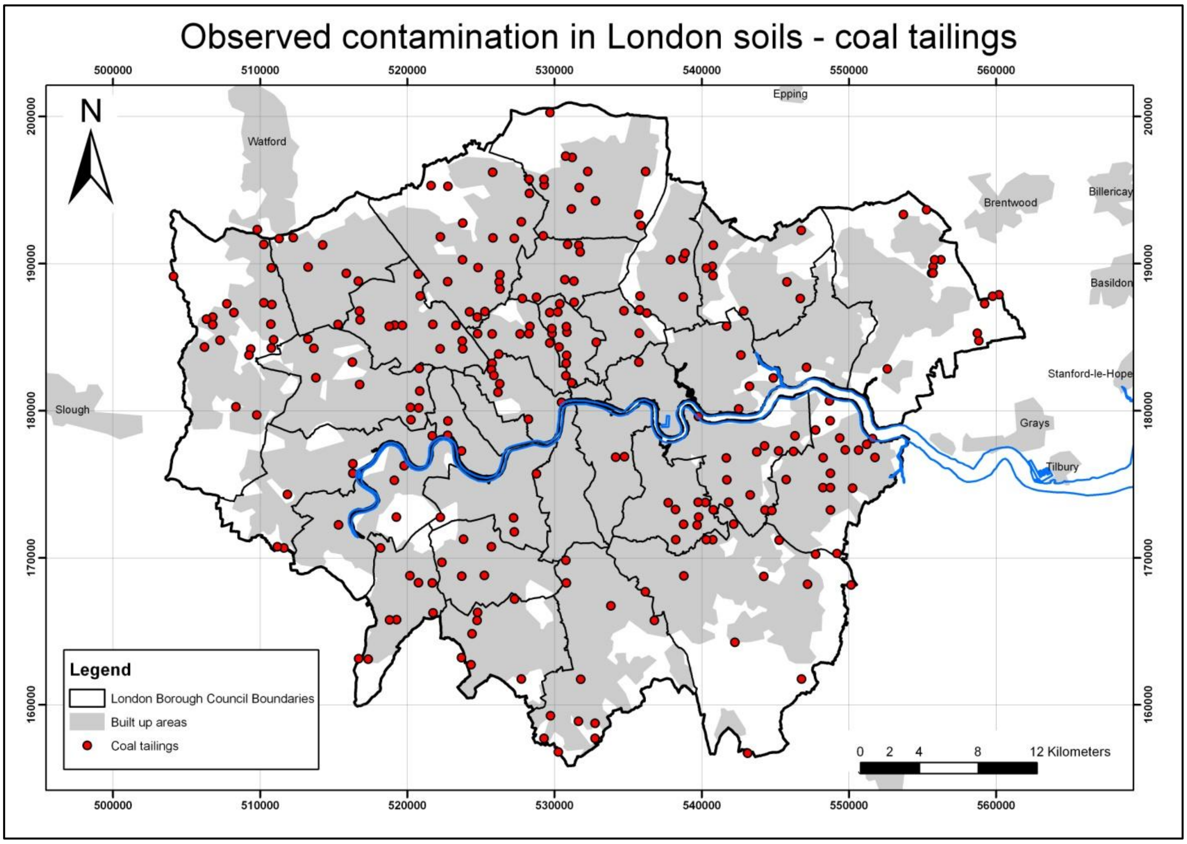

Figure 29. Map showing the locations and distribution of sampling sites where coal tailings were observed.

Appendix 2 Contamination prevalence by land use code

Land use	Land use Code	Total number of sites	Manufactured metal	Iron, steel wire	Aluminium	Bricks	Clear Glass	Plastic	Chemical	Bulk industrial waste	Coal tailings	Slag (furnace waste)	% contaminated sites
Rough Grazing	A	392	2.6	5.6	0.0	44.9	1.5	3.8	0.0	0.3	4.1	29.8	63.3
Woodland and Forests	B	307	3.3	1.6	1.3	21.5	4.6	4.2	0.0	1.0	1.3	15.0	40.4
Arable	C	323	0.6	0.6	0.0	30.3	0.9	1.5	0.0	0.0	2.5	28.8	53.3
Pasture	D	169	4.1	4.7	0.0	43.8	1.8	1.8	0.0	0.0	1.8	34.3	63.3
Urban open space	E	1180	8.6	4.7	2.6	73.2	7.7	11.9	0.2	1.0	3.3	45.6	86.7
Commercial and Residential	F	142	9.2	8.5	3.5	80.3	9.9	16.9	1.4	0.7	4.2	38.0	91.5
Golf	G	178	2.8	0.6	0.6	39.3	0.6	2.2	0.0	0.6	3.9	32.0	58.4
Allotments	H	30	13.3	10.0	0.0	60.0	6.7	6.7	3.3	0.0	10.0	33.3	80.0
Playing Fields and sports grounds	I	255	7.1	2.7	0.4	64.3	3.5	5.5	0.4	2.4	3.5	47.5	80.8
Road verge	J	606	9.9	6.1	4.6	72.3	8.3	18.8	0.3	1.0	3.0	46.9	90.6
Cemetery/ Crematorium	K	104	1.9	2.9	1.0	74.0	5.8	4.8	0.0	1.9	6.7	39.4	85.6
Parks and Recreational	L	1125	8.2	4.4	2.0	64.3	4.1	8.7	0.1	0.9	3.6	36.4	79.7
Domestic Garden	M	1611	6.3	1.8	1.4	81.8	5.4	6.5	0.2	1.9	5.2	57.2	93.5
School/ hospital grounds	N	68	8.8	2.9	1.5	72.1	1.5	10.3	0.0	0.0	7.4	44.1	85.3
Industrial site	O	93	19.4	12.9	12.9	68.8	9.7	34.4	1.1	0.0	6.5	46.2	94.6
Other	P	52	7.7	3.8	0.0	44.2	1.9	7.7	0.0	0.0	3.8	26.9	57.7

Table 2. Table showing the percentage of sites from each land use at which a particular contaminant was observed, e.g. manufactured metal was observed at 19.4% of industrial sites.

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