

## Part 2A, Environmental Protection Act 1990

### Technical Guidance Sheet (TGS) on normal levels of contaminants in English soils

Normal levels of contaminant concentrations in soils are referred to in the contaminated land Statutory Guidance for the Part 2A regime Defra 2012. This Technical Guidance Sheet (TGS) gives an indication as to what cadmium concentrations can be expected in soils based on results from samples systematically collected across England. Normal Background Concentrations (NBCs) can be used along with other criteria (e.g. site investigation data and risk assessments) to help decide whether land is contaminated land as defined by Part 2A, on a site-by-site basis.

**The NBCs are not intended to be a tool to be utilised when undertaking works via the planning regime.** They are contaminant concentrations that are seen as typical and widespread in topsoils (depth 0 – 15 cm) and include contributions from both natural and diffuse anthropogenic sources.

When using this Guidance Sheet, please refer to the section on 'Using Normal Background Concentrations' at the end, the Supplementary Information, and the revised Part 2A Statutory Guidance.

## CADMIUM (Cd)

Technical Guidance Sheet TGS06, July 2012.

Cadmium (Cd) is a metallic element naturally occurring in trace amounts at the Earth's surface. It is toxic to humans, animals and plants, and known to be a human carcinogen. The metal associates with sulphide ores, mainly the mineral sphalerite (ZnS), and its cycling can be highly influenced by accumulation in plants and organic debris. Its abundance in igneous and sedimentary rocks is generally low, not exceeding 0.3 mg/kg, although Cd can concentrate in metalliferous ore deposits, in argillaceous (fine grained) rocks and in coal. In England there is also an enrichment of Cd in the Chalk soils of the North and South Downs, but not further north. The reason for this is unknown.

The main factor determining the Cd content of soil is the chemical composition of the parent material. Areas in which soils are enriched in Cd are those with high naturally occurring Cd concentrations in the underlying rocks. Cadmium is an element associated with some mineralised areas and the accompanying mining and processing activities such as ore smelting (e.g. the Peak District and Avonmouth).

Zn smelters may cause large emissions of fumes enriched in CdO. Historically, in England the mineralised areas associated with Cd include: the Mendips (Shipham), the Derbyshire Peak District, the Lake District and parts of the northern Pennines, areas known for a mining legacy of Pb contamination. Phosphate fertilisers and sewage sludges are also sources of Cd in soil. The presence of Cd in car tyres and motor oil often accounts for the relative accumulation of Cd in roadside soils. Other important anthropogenic sources are Ni-Cd batteries and coal burning.

Cadmium has adverse effects on soil biological activity and plant metabolism. The occurrence of Cd in cultivated soils is of major concern since human health might be indirectly affected through vegetable or grain consumption. Cadmium can accumulate in relatively large amounts in plants without affecting them, leading to concentrations in crops that may possibly be harmful for human health.

The most important factors controlling soil Cd mobility and plant uptake are pH, oxidation potential and soil solution composition. Generally, Cd is most mobile in acidic soils and less mobile in alkaline soils. Cadmium goes readily into solution, as divalent free ion (Cd<sup>2+</sup>) or forming aqueous complexes with chloride, carbonate and hydroxide and organic chelates. Soil microbial activity is known also to influence Cd behaviour in soils.

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

Table 1: NBCs for the cadmium domains (cited to 2 significant figures, n is number of samples used in the calculation). Cadmium is determined by laboratory-based X-ray fluorescence spectrometry (XRFS), i.e. total Cd in soils sampled from a depth 0 – 15 cm. The NBC is the upper 95% confidence limit of the 95<sup>th</sup> percentile of the domain data (see supplementary information).

## NORMAL BACKGROUND CONCENTRATIONS (NBCs)

### Methods

NBCs are calculated using contaminant data, with demonstrably high levels of quality assurance, for English topsoils systematically collected from a variety of land uses and analysed using certified methods. For this purpose the primary data sets used are the British Geological Survey's G-BASE results and samples collected for the National Soil Inventory (NSI) by the Soil Survey of England and Wales (now the National Soil Resources Institute (NSRI), Cranfield University, UK) (see Figure 1). The G-BASE samples cover both urban and rural locations and all data used are total concentrations, measured by X-ray fluorescence spectrometry (XRFS). Soils used to calculate NBCs are from a consistent depth (0 – 15 cm) and are based on aggregating subsamples collected from within a 20 m square. England's soils have developed on a diverse range of parent materials (including those hosting Cd-bearing mineralisation), which are inherently variable in their chemical composition. These soils have also been subjected to a long history of diffuse pollution from urbanisation. This causes a significant variability in the Cd distribution across the country (Figure 2).

Results for Cd in topsoils range from 0.5 - 165 mg/kg with a mean of 0.85 mg/kg and a median of 0.5 mg/kg. In order to establish meaningful NBCs, soils are grouped in domains, defined by the most significant controls on a contaminant's high concentration and distribution.

NBCs are determined for each domain using robust statistical analysis that investigates the distribution of results and, by a process of iteration, takes into account the results that may be associated with point source contamination. "Normal" levels of contaminants are referred to in the Statutory Guidance (Sections 3.21-3.26 and 4.21(b)). They are represented here by the 95<sup>th</sup> percentile upper confidence interval, i.e. the NBC value is the upper limit at or below which contaminant levels can be

considered to be normal for the defined domain. Levels at or below the NBC may not be naturally occurring.

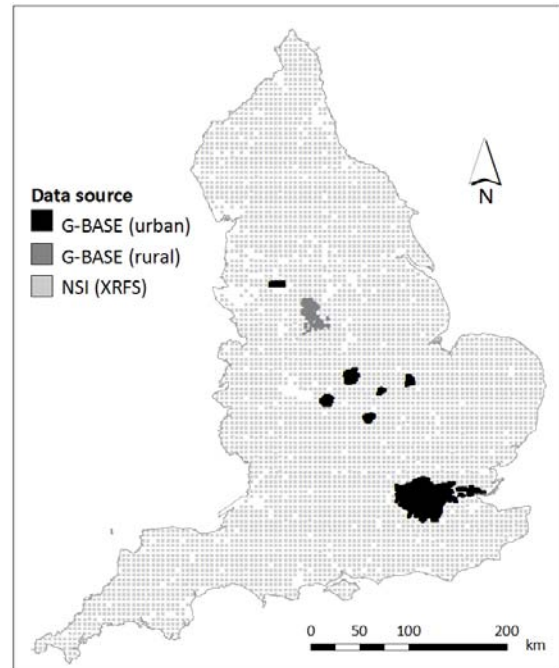


Figure 1: Map showing the distribution of samples used in the Cd NBC determination. NSI (XRFS) covers the whole of England at a sample density of 1:25 km<sup>2</sup>. G-BASE sampling densities for rural and urban are 1:2 km<sup>2</sup> and 4:1 km<sup>2</sup>, respectively.

### Results

Exploration of the soil data shows several significant controls on the distribution of higher Cd concentrations in England. These are in areas where: (i) soil in areas of sulphide mineralisation with associated Cd - Peak District, Northern Pennines and the Mendips. The latter two areas have lower levels of Cd in the topsoil than the Peak District so two mineralised domains are defined, Min. Gp1 and Min. Gp2, respectively; (ii) soils developed over the Chalk of southern England; and (iii) soils in built areas affected by anthropogenic diffuse pollution. Five domains are therefore distinguished (Figure 3). South of London an area of Chalk falls within the Urban Domain. As this Chalk is associated with the higher NBC, this area has been assigned to the Chalk South Domain rather than the Urban Domain. Hence the

area of the Urban Domain given in Table I is less than that determined for other contaminants.

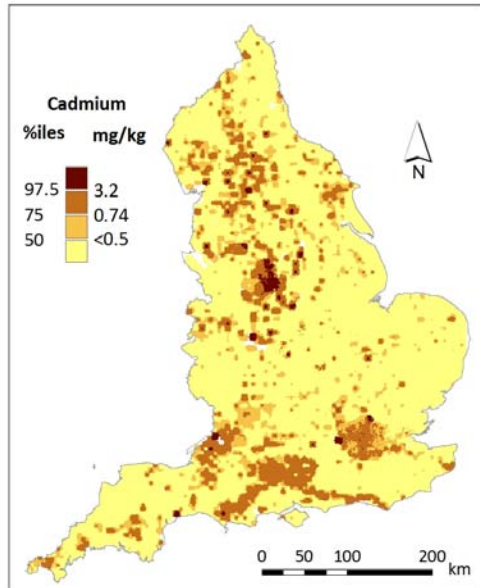


Figure 2: Map showing Cd in topsoil as a percentile classified interpolated image (all data are total concentrations by XRFs).

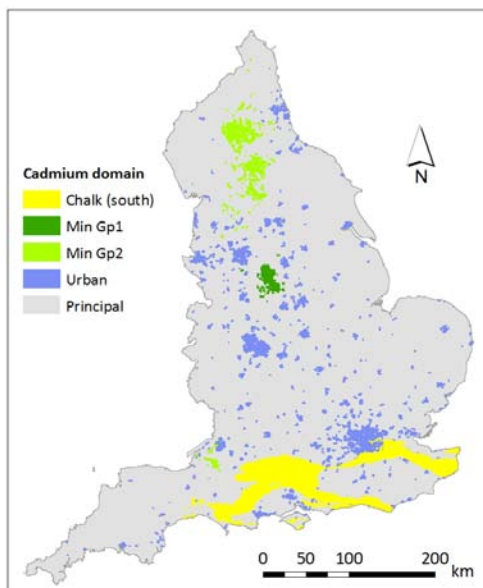


Figure 3: Cadmium domain map.

### USING NORMAL BACKGROUND CONCENTRATIONS

The NBCs are produced to support the Part 2A contaminated land Statutory Guidance (SG) and help inform as to what are normal levels of contaminants. Using this TGS, along with the further information and resources provided, a NBC test can be carried out:

1. A soil sample under investigation for Cd concentration should be spatially located in one of the five domains described. This should be part of a preliminary step in which the scenario and conceptual site model are considered.
2. If the Cd concentration is at or below the NBC for the specified domain then “the result should not be considered to cause the land to qualify as contaminated land, **unless** there is a particular reason to consider otherwise” (SG, Section 3.22). If the latter applies, then proceed to the use of other screening tools or further site investigation as necessary and appropriate.
3. If there is no reason “to consider otherwise” then the decision can be made that there is no evidence that the land is contaminated under Part 2A with respect to Cd (SG, Sections 5.2 – 5.4), that is, the land lies outside Categories 1 or 2.
4. If the Cd concentration is above the domain NBC then using the additional resources, including those provided with this technical guidance, a more detailed investigation at a local scale should be carried out or the use of other screening tools considered as appropriate. This is to determine whether the concentrations reflect “levels of contaminants in the soil that are commonplace and widespread....and for which....there is no reason to consider that there is an unacceptable risk” (SG, Section 3.21). If this is so, then step 3 applies. In the case of Cd, for example, this may be an area within the Principal Domain where a particular land use has caused widespread low level diffuse pollution.
5. If the concentration of Cd in the soil is not considered to be commonplace and widespread

then further testing is required (apply quantitative risk assessment (QRA)).

**THIS TGS SHOULD BE READ IN CONJUNCTION WITH THE FOLLOWING:**

**Part 2 A documents:**

Available from the Defra Contaminated land web site at: <http://www.defra.gov.uk/environment/quality/land/>

Part 2A of the Environmental Protection Act 1990, as amended. The Contaminated Land (England) (Amendment) Regulations 2012 (Statutory Instrument 2012 No 263) (Amends Contaminated Land (England) Regulations 2006 ("the 2006 Regulations") (S.I. 2006/1380).)

Defra. 2012. Environmental Protection Act 1990: Part 2A. Contaminated Land Statutory Guidance. Department for Environment, Food and Rural Affairs. April 2012

**Project Reports:**

Available from the Defra Project SPI008 [web page](#) and the British Geological Survey at: <http://www.bgs.ac.uk/gbase/NBCDefraProject.html>

Ander, E.L., Cave, M.R., Johnson, C.C. and Palumbo-Roe, B. 2011. Normal background concentrations of contaminants in the soils of England. Available data and data exploration. *British Geological Survey Commissioned Report*, CR/11/145. 124pp.

Ander, E.L., Cave, M.R., Johnson, C.C. and Palumbo-Roe, B. 2012. Normal background concentrations of contaminants in the soils of England. Results of the data exploration for Cu, Ni, Cd and Hg. *British Geological Survey Commissioned Report*, CR/12/041. 88pp.

Cave, M.R., Johnson, C.C., Ander, E.L. and Palumbo-Roe, B. 2012. Methodology for the determination of normal background contaminant concentrations in English soils. *British Geological Survey Commissioned Report*, CR/12/003. 56pp.

Johnson, C.C., Ander, E.L., Cave, M.R. and Palumbo-Roe, B. 2012. Normal Background Concentrations of contaminants in English soil: Final project report. *British Geological Survey Commissioned Report*, CR/12/035. 40pp.

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sampled and analysed to consistent and high standards of quality that have enabled the NBCs for many inorganic contaminants to be calculated with a high level of confidence.

**BIBLIOGRAPHIC REFERENCE**

When referring to this document the following bibliographic reference should be made:

Defra, 2012. Technical Guidance Sheet on normal levels of contaminants in English soils: Cadmium. Technical Guidance Sheet No. TGS06, July 2012. Department for Environment Food and Rural Affairs (Defra), Soils R&D Project SPI008. Available on-line from Defra project SPI008 [web page](#).

The accompanying supplementary information for the Cadmium Technical Guidance Sheet:

Defra, 2012. Technical Guidance Sheet on normal levels of contaminants in English soils: Cadmium – supplementary information. Technical Guidance Sheet No. TGS06s, July 2012. Department for Environment Food and Rural Affairs (Defra), Soils R&D Project SPI008. Available on-line from Defra project SPI008 [web page](#).



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