Part 2A, Environmental Protection Act 1990

Technical Guidance on normal levels of contaminants in Welsh soil

Normal levels of contaminant concentrations in soils are referred to in the contaminated land Statutory Guidance for the Part 2A regime (Wales), published by Welsh Government, 2012. This technical guidance gives an indication as to what lead concentrations can be expected in soils based on results from samples systematically collected across Wales. 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, please refer to the section on 'Using Normal Background Concentrations' on page 4, the supplementary information provided by Ander* et al. *(2013), and the revised Part 2A Statutory Guidance (Wales).*

LEAD (Pb)

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Lead (Pb) is a metallic element naturally occurring in trace amounts in the Earth's surface environment with concentrations in rocks averaging 15 mg/kg. Generally, acid igneous rocks (*e.g.* granites) are higher in Pb than basic ones (*e.g.* basalts) and concentrations in sedimentary rocks are variable with up to 70 mg/kg in some limestones. With a low melting point, Pb ore minerals are readily smelted and the metal is easily worked. Lead therefore has a long history of use in human activities. In Wales there are a number of historical lead mining areas (*e.g.* the Mid Wales lead-zinc orefield) where there is a legacy of Pb contamination caused by mining and associated activities. Biologically it is considered as a non-essential element and toxic to man and animals through the food chain and soil dust inhalation or ingestion.

Due to the strong affinity to bond with sulphur, Pb associates with sulphur minerals. Therefore, some rocks and soils containing sulphide minerals can be enriched in Pb. The principal Pb mineral is lead sulphide (galena, PbS). Other common minerals are cerussite (lead carbonate, $PbCO_3$) and anglesite (lead sulphate, $PbSO_4$). The solubility of Pb in soil is very low and decreases with increasing soil pH. During the chemical weathering of rocks, Pb sulphides oxidise and Pb becomes bound to soil components such as clay minerals, iron and manganese oxides, organic matter, or may form carbonate and phosphate minerals.

Soil is a major sink for Pb associated with human activity, and, although many original uses of Pb have stopped because of the recognition of its toxic nature to the environment and humans, Pb contamination persists. Historically, Pb was used for plumbing, in paints and, most significantly in terms of diffuse pollution, tetraethyl lead was used in petrol. Reduction of Pb in petrol commenced in the UK from 1986 and was completely eliminated by 2000. Other notable sources of Pb contamination in the environment are from the application of sewage sludge, coal burning, vehicle parts (*e.g.* Pb wheel weights), batteries, some plastics and metallic Pb used as flashing on buildings.

NORMAL BACKGROUND CONCENTRATIONS (NBCs)

Domain	Area (km^2)	Area (%)	NBC (mg/kg)	n
Principal	18,200	86	**230**	966
Mineralisation 1	200	1	**nd**	15
Mineralisation 2	1,100	5	**280**	61
Urban 1	1,200	6	**1,300**	342
Urban 2	500	2	**890**	291

Table 1: NBCs for the lead domains (cited to 2 significant figures, n is number of samples used in the calculation). Lead is determined by laboratory-based X-ray fluorescence spectrometry (XRFS), *i.e.* total Pb in soils sampled from a depth 0 – 15 cm. The NBC is the upper 95% confidence limit of the 95th percentile of the domain data. nd = not determined (because n<30).

Methods

NBCs are calculated using Pb data from soils systematically collected from a variety of land uses, analysed using certified methods, and with demonstrably high levels of quality assurance. For this purpose the primary data sets used are the National Soil Inventory (NSI) from the Soil Survey of England and Wales (now the National Soil Resources Institute (NSRI), Cranfield University, UK) and the British Geological Survey's G-BASE samples collected from the Cardiff and Swansea urban areas (see Figure 1). All data used are for 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 sub-samples collected from within a 20-m square. Wales has far fewer, and significantly less densely sampled, soil sites compared to England, so the contaminant NBCs for Wales are associated with a much greater level of uncertainty than the NBCs previously calculated for England.

Welsh soils have developed on a diverse range of parent materials, including those hosting metalliferous mineralisation, and therefore are inherently variable in their chemical composition (Figure 2). These soils have also been subjected to a long history of diffuse pollution, particularly around the South Wales Coalfield.

Results for Pb in topsoils range from 15 – 14,328 mg/kg with a mean of 192 mg/kg and a median of 74 mg/kg. In order to establish meaningful NBCs, soils are grouped in domains, defined by the most significant controls on a contaminant's high concentrations 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 concentrations that may be associated with point source contamination. "Normal" levels of contaminants are referred to in the Statutory Guidance (Wales) (Sections 3.21-3.26 and 4.21(b)). They are represented here by the upper 95% confidence limit of the 95th percentile, *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.

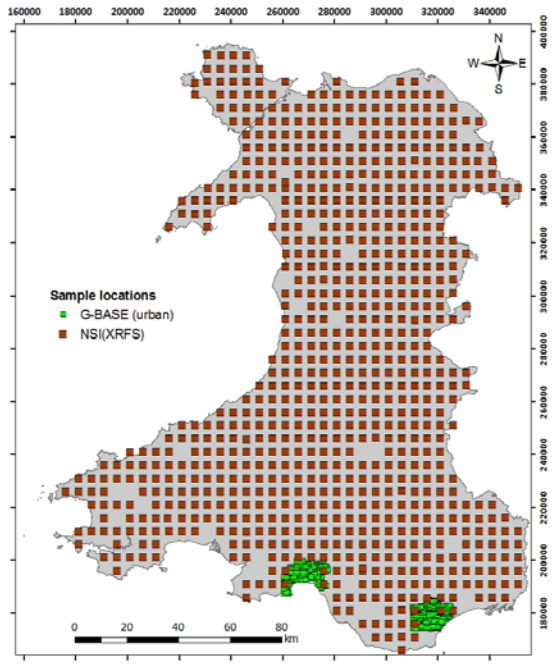

Figure 1: Map showing the distribution of samples used in the Pb NBC determination for Wales. NSI (XRFS) covers the whole country at a sample density of 1:25 km^2. G-BASE sampling densities for the urban areas of Swansea and Cardiff are 4:1 km^2. Total data set consists of 798 NSI and 877 G-BASE urban samples.

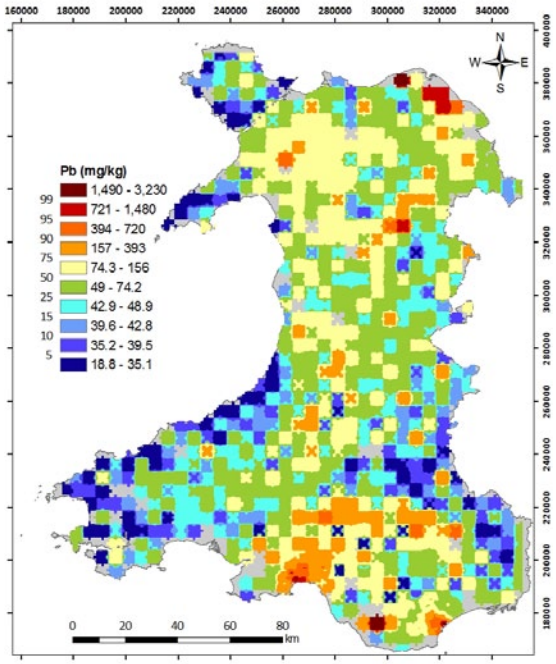

Figure 2: Map showing Pb in topsoil as a percentile classified interpolated image (all data are total concentrations by XRFS and colour thresholds designed for highly skewed data).

Results

Exploration of the available topsoil data, supplemented with information from the high density G-BASE stream sediment survey of Wales, shows two significant controls on the distribution of higher Pb concentrations in Wales. These are: soils where the parent material is in areas of metalliferous mineralisation and historical mining activity and have resulted in elevated levels of Pb in the soil environment; and those areas associated with urbanisation and industrialisation. Two distinctly different areas of metalliferous mineralisation are identified – Mineralisation 1 (Halkyn) and Mineralisation 2 (Anglesey, north, central and south Wales). Both mineralisation domains are poorly represented by the low density NSI sampling though it is seen that the soils from the Halkyn area are generally much higher in Pb. For urban areas two different domains are also defined. The first encompasses the high Pb areas of Swansea and the catchments of the Loughor (Afon Llwchwr), Tawe (Afon Tawe and more commonly referred to as the Swansea Valley), and Neath (Afon Nedd), collectively referred here as the Urban 1 Domain. Other urban areas lying outside the Urban 1 domain as defined by the 'Large Urban' class of the Ordnance Survey Strategi™ data are referred to as the Urban 2 Domain. The area not covered by the two mineralisation and two urban domains is referred to as the Principal Domain (Figure 3 and Table 1).

A higher density and more systematic sampling of topsoils in the areas of Pb mineralisation would be expected to result in higher concentrations of Pb than those currently recorded for the two Mineralisation Domains. The NBC for the Mineralisation1Domain is not calculated as there are only 15 results available from this area using the NSI data. The NBC for the Mineralisation 2 Domain is not significantly higher than that of the Principal Domain, though

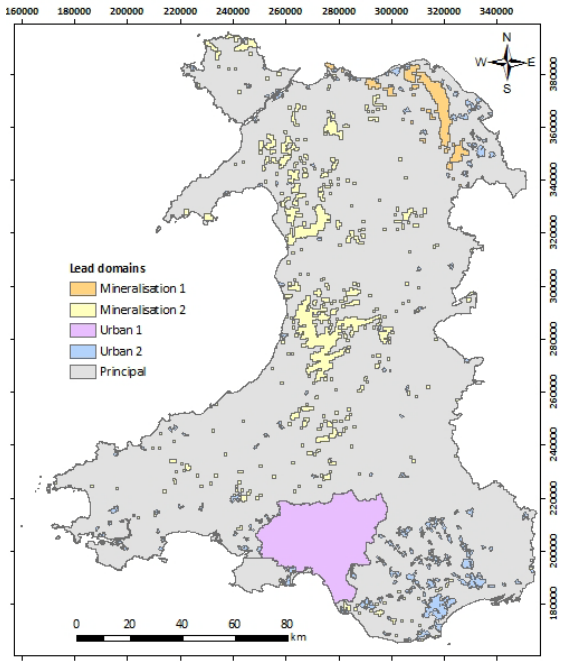

Figure 3: Lead domain map.

the high density G-BASE stream sediment clearly identifies the Mineralisation 2 Domain as an area with significantly elevated levels of Pb.

In the NBC attribution, only the most significant areas at the national scale with the highest concentration range are classified as domains. Although five domains have been distinguished, further spatial variability will occur within these domains. Coal mining areas and peaty areas inside the Principal Domain, for example, will also have slightly elevated levels of Pb which tends to be associated with organic-rich materials.

USING NORMAL BACKGROUND CONCENTRATIONS

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

1. A soil sample under investigation for Pb 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 Pb 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 Pb (SG, Sections 5.2 – 5.4), that is, the land lies outside Categories 1 or 2.
4. If the Pb 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 Pb, for example, this may be an area of peat within the Principal Domain where, combined with widespread low level diffuse contamination, levels in the soil have become elevated.
5. If the concentration of Pb in the soil is not considered to be commonplace and widespread then further testing is required (apply quantitative risk assessment (QRA)).

FURTHER RESOURCES

Additional resources on NBCs are available from the BGS project website. These resources include: project reports; a database of essential information about relevant soil data sets; technical guidance sheets for other contaminants; polygons defining domain boundaries in various GIS formats; and a project bibliography.

Because there are substantial information gaps relating to systematically collected soils across Wales, information on elevated contaminant levels in the surface environment are usefully informed by the high density BGS stream sediment survey (British Geological Survey. 2000. *Regional geochemistry of Wales and part of west-central England: stream sediment and soil*. Keyworth, Nottingham: British Geological Survey).

THIS GUIDANCE SHOULD BE READ IN CONJUNCTION WITH THE FOLLOWING:

Part 2 A documents:

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

Welsh Government. 2012. Contaminated Land Statutory Guidance -2012. Welsh Government, Document Number WG15450.

Project Reports:

Available from the Defra Project SP1008 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. and Johnson, C.C. 2013. Normal background concentrations of contaminants in the soils of Wales. Exploratory data analysis and statistical methods. *British Geological Survey Commissioned Report*, CR/12/107.

Ander, E.L., Cave, M.R., Johnson, C.C. and Palumbo-Roe, B. 2012b. 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.

Defra, 2012. Technical Guidance Sheet on normal levels of contaminants in English soils: Lead. Technical Guidance Sheet No. TGS02, July 2012. Department for Environment Food and Rural Affairs (Defra), Soils R&D Project SP1008. Available on-line from Defra project SP1008 web page.

ACKNOWLEDGEMENTS

The British Geological Survey has produced a series of Technical Guidance Sheets on NBCs for England as part of a project funded by Department for Environment Food and Rural Affairs (Defra) (Soils R&D Project SP1008, October 2011 – March 2012). The work was extended to apply the same methodology for determining NBCs in Wales. This guidance sheet was compiled by Chris Johnson, Louise Ander and Mark Cave. The project thanks the many people and projects that have assisted in the provision of data, in particular, the BGS G-BASE project and the NSRI NSI soil samples (reanalysed by BGS). These systematic national surveys have created unbiased data sets 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.

Version 1.0

BIBLIOGRAPHIC REFERENCE

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

Defra, 2013. Technical Guidance on normal levels of contaminants in Welsh soil: Lead. British Geological Survey (Keyworth, Nottingham) and Defra (London). R & D Project SP1008, January 2013. Available on-line from Defra project SP1008 web page.