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 copper 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 3, the supplementary information provided by Ander et al. *(2013), and the revised Part 2A Statutory Guidance (Wales).*

COPPER (Cu)

January 2013.

Copper (Cu) is an essential micronutrient for the growth of plants and animals, with a reported Earth's crust abundance of 55 mg/kg and impacts on health are related to deficiency as well as excess. The effects of high Cu concentrations in soil decreasing the uptake of other essential micronutrients by plants are well known.

Much of the soil chemistry of Cu is related to sulphur and organic matter. Sulphide minerals (*e.g.* chalcopyrite $CuFeS_2$) are the main detrital Cu phases in soil in mineralised areas and may result in high Cu concentrations. Copper released during the weathering of these minerals is readily adsorbed and complexed by organic matter, clay minerals and oxides, and co-precipitated with carbonates. Mobility and displacement of Cu in soils is therefore low. High concentrations of Cu in soil can also be associated with coalfields due to enrichment with organic matter during coal formation (resulting from the strong affinity of Cu for organic ligands) and the presence of sulphides in Coal Measure sediments.

Copper is often found enriched in the top horizons of a soil profile. Its accumulation in topsoils is seen in urban areas resulting from human activity. Anthropogenic sources of Cu include mining and smelting, coal burning, the electrical and metallurgical industries, agriculture, sewage sludge and steel works.

NORMAL BACKGROUND CONCENTRATIONS (NBCs)

Domain	Area (km^2)	Area (%)	NBC (mg/kg)	n
Principal	18,400	87	**43**	966
Mineralisation	1,100	5	**96**	76
Urban 1	1,200	6	**550**	342
Urban 2	500	2	**170**	291

Table 1: NBCs for the copper domains (cited to 2 significant figures, n is number of samples used in the calculation). Copper is determined by laboratory-based X-ray fluorescence spectrometry (XRFS), *i.e.* total Cu 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.

Methods

NBCs are calculated using Cu 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 calculations of contaminant NBCs for Wales are associated with a much greater level of uncertainty that those determined for England.

Welsh soils have developed on a diverse range of parent materials, including those hosting non-ferrous 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.

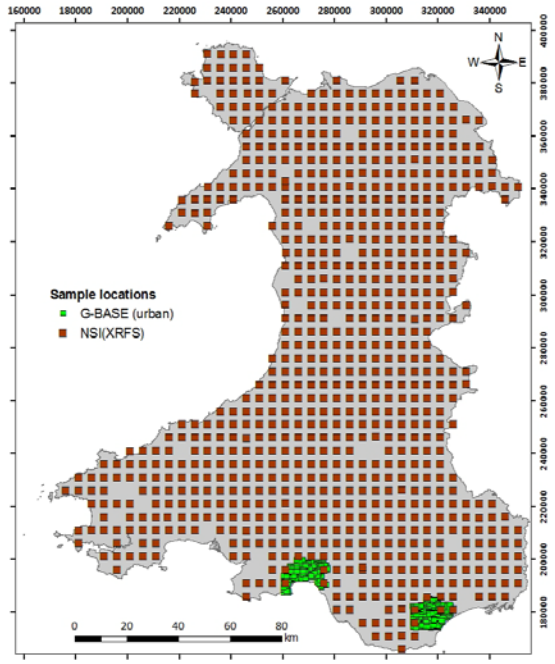

Figure 1: Map showing the distribution of samples used in the Cu NBC determination for Wales. NSI (XRFS) covers the whole country at a sample density of 1:25 km^2. G-BASE sampling densities for the urban areas of Swansea and Cardiff are 4:1 km^2. Total data set consists of 798 NSI and 877 G-BASE urban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

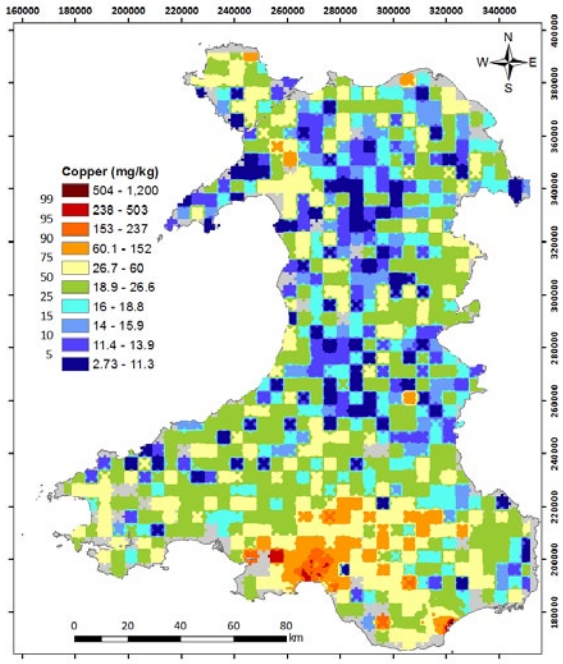

Figure 2: Map showing Cu in topsoil as a percentile classified interpolated image (all data are total concentrations by XRFS and colour thresholds designed for highly skewed data).

Results for Cu in topsoils range from 2.7 – 2,131 mg/kg with a mean of 65.5 mg/kg and a median of 26.7 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.

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 Cu concentrations in Wales. These are: soils where the parent material is in areas where metalliferous mineralisation and historical mining activity have resulted in elevated levels of Cu in the soil environment and those areas associated with urbanisation and industrialisation. In the latter case, significantly high levels of Cu are seen in the valleys draining the South Wales Coalfield, in particular, the catchments of the rivers 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 defined by the 'Large Urban' class of the Ordnance Survey Strategi™ data, and lying outside the Urban 1 Domain, are designated as the Urban 2 Domain. Therefore, a total of four domains for Cu are identified, including the Mineralisation and Principal Domains (Figure 3 and Table 1). The low sampling density of the NSI samples poorly captures the levels of copper seen in the higher density G-BASE stream sediment survey and the NBC results for the Mineralisation Domain are considered to be lower than what might be expected, particularly those areas which were exploited for copper ores.

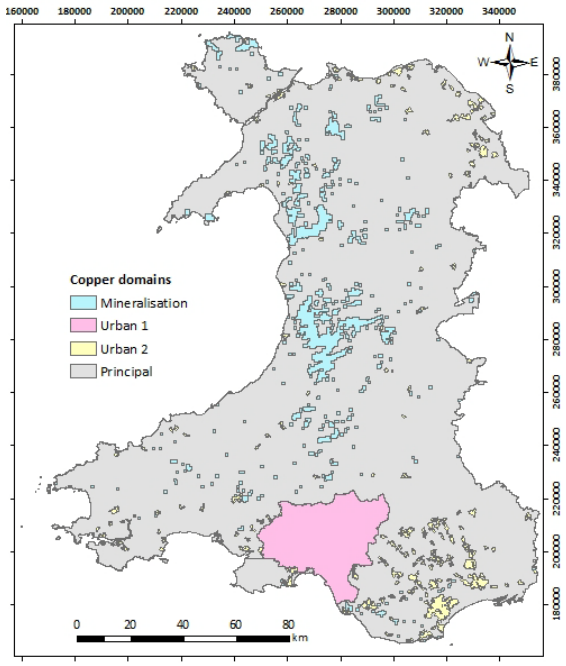

Figure 3: Copper domain map.

In the NBC attribution, only the most significant areas at the national scale with the highest concentration range are classified as domains. Although four domains have been distinguished, further spatial variability will occur within these domains. The Principal Domain, for example, will contain areas where historical land uses (*e.g.* metallurgical industries) may have caused an increase of Cu in the area's soil.

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 Cu concentration should be spatially located in one of the four domains described. This should be part of a preliminary step in which the scenario and conceptual site model are considered.
2. If the Cu 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 Cu (SG, Sections 5.2 – 5.4), that is, the land lies outside Categories 1 or 2.

4. If the Cu 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 Cu, for example, this may be an urban area within the Principal Domain where a particular land use has caused widespread low level diffuse pollution.
5. If the concentration of Cu 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 BGS high density 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: Copper. Technical Guidance Sheet No. TGS03, 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: Copper. British Geological Survey (Keyworth, Nottingham) and Defra (London). R & D Project SP1008, January 2013. Available on-line from Defra project SP1008 web page.

Llywodraeth Cymru
Welsh Government

defra
Department for Environment Food and Rural Affairs

BGS 1835

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL
Arolwg Daearegol Prydain
CYNGOR YMCHWILYR AMGYLCHEDD NATURIOL