The Draft Revised EC Sewage Sludge Directive (March 2000) in Relation to Concentrations of Copper, Lead, Nickel and Zinc in the Soils of England and Wales

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This document provides information on the metal levels in soils in England and Wales, specifically in relation to the application of sewage sludge. Its specific use is to inform negotiations between the UK and the European Commission on a proposed revision to the Sludge Directive.

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EXECUTIVE SUMMARY

This document provides information on the metal levels in soils in England and Wales, specifically in relation to the application of sewage sludge. Its specific use was to inform negotiations between the UK and the European Commission (EC) on a proposed revision to the Sludge Directive.

The spreading of Sewage Sludge on Land used for Agriculture is controlled by the Sludge (Use in Agriculture) Regulations (1989), which in turn relate to the European Directive 86/278/EEC. The EC has issued a draft revision to this Directive, which introduces a matrix of soil pH values and lower limits for permissible soil metal concentrations (soil limit values). The net effect of this is potentially to reduce the amount of agricultural land available for spreading sewage sludge in England and Wales. The draft Directive also includes a derogation where the values of the soil limit values may be increased by 50%, before sewage sludge can be used, where there is evidence of natural elevated levels, or geogenic enhancement, of metals. No guidance is given on the definition of geogenic enhancement nor on ways in which it may be identified unequivocally. Soil Survey and Land Research Centre (SSLRC) was asked to:

- examine the concept of geogenic enhancement as it applies to soil limit values in England and Wales.
- comment on the concept of 'total' metal content versus 'available' metal content.
- examine the effects of the current metal limits on the availability of agricultural land for the use of sewage sludge - in all of England and Wales and by water region.
- examine the effects of the draft Directive proposed limits on the availability of land for the disposal of sewage sludge - in all England and Wales and by water region.
- examine the effects of the geogenic derogation proposed in the draft Directive on the availability of land for the disposal of sewage sludge – broken down by water region.
- comment on the availability of soil metal content data within Member States.

It is concluded that:

- The concept of geogenic enhancement is flawed in the context of the Directive as no defensible way can be seen in which geogenically enriched areas can be separated consistently from areas enriched by human activity.
- There is no agreed basis upon which metal 'availability' can be determined at this time. There is poor agreement between widely-used measures of soil 'total' metal concentration and 'available' concentration for nickel and zinc, and a better agreement for copper and lead. None, however, is sufficient to deduce 'available' concentration from 'total' with confidence.
- The introduction of the limits proposed in the draft Directive would severely restrict the amount of land available for disposal of sewage sludge, especially in those water regions with an abundance of soils of lower pH (more acid). These soils are mostly in the north and west of England and Wales.
- The geogenic derogation would lessen the impact of the draft Directive but, given the difficulties of defining geogenic reliably, this is not regarded as practical.
- Only the UK, Denmark and Germany have representative and reliable data for metal concentrations in soils on a national basis. There is partial cover in France, The Netherlands, Austria, Finland and Sweden. It is difficult to see, therefore, how the effect of the draft Directive can be assessed in an equitable manner across the 15 Member States.

1. GEOGENIC DEROGATION

1.1. Introduction

Annex II of the draft Directive reads:

'When for geogenic reasons the concentration value of an element in the soil is higher than the concentration limit as set out in the table, Member States may allow recycling of sludge on that soil provided that the concentration value in soil does not deviate from the concentration limit set in the table by more than 50% before sludge spreading.'
'Geogenic' is taken to be synonymous with the more widely used term geochemical, both having implications for relationships with parent materials and properties inherited from them. Thus, this derogation is interpreted to mean that the stated limits in the table may be exceeded by 50% for one or more metals provided that the soil to receive sludge already contains these one or more metals at concentrations above the relevant limit (given the soil's pH at the time of sampling) as a consequence of the geochemical composition of its parent material. No justification or reasoning is given as to the basis of this derogation.
This section considers the implications of this clause for England and Wales and its likely operability and desirability. Comments are based on England and Wales data for 'total', i.e. extractable by hot 'aqua regia' (McGrath & Cunliffe, 1985), topsoil (0-15 cm depth, or less where rock intervenes) Cd, Cu, Ni, Pb, and Zn contents, but not Hg (for which there are no national data), and assumes that circumstances in Scotland and Northern Ireland will be little different.

1.2. Comment

This section is divided into three parts related to 1) implications, 2) operational considerations, and 3) general considerations of the clause's desirability.

1.2.1. The implications for England and Wales

Topsoil total metal data exist for the 'greenfield' intersects of a 5 km grid across England and Wales (5692 samples). These data have been published by McGrath & Loveland (1992) and indicate that soil metal values are extremely variable (Table 1.2.1.1).

Table 1.2.1.1 Statistical data for heavy metals[1]

Metal	Mean	50^{th} percentile (Median)	25th percentile	75th percentile	Maximum
Cd	0.8	0.2	0.2	0.3	40.9
Cu	23.1	18.1	12.6	24.9	1508
Ni	24.5	22.6	14.0	32.4	440
Pb	74	40	28	66	16338
Zn	97.1	82	59	108	3648

[1]All values are mg kg^{-1} dry soil

The differences between the mean and the median values in Table 1.2.1.1 show that the data are all positively skewed to a greater or lesser degree, something commonly found in geochemical data. Untransformed data indicate an association (adjusted R^2 >0.5) between Zn and Cd. Logarithmic transformation (base10) suggests a further association between Zn and Ni (McGrath & Loveland, 1992). Such associations are not unexpected given the ore chemistry of these elements (they are most frequently found as sulphide minerals emplaced during late-stage metasomatism associated with fluid injection of country rock). It should be stressed, however, that transformation of these data by whatever means, e.g. logarithms to different bases, square roots, Hermite polynomials etc., do not yield a data set with all the properties of a normal distribution for any of the metals. Again, this is not uncommon in such geochemical data. Whilst such non-normality is often taken as evidence of a geogenic signature in the data, e.g. in such areas as exploration mining geology, the consistent identification of a threshold above which values can be regarded as geogenically anomalous is still subject to much debate. The techniques fall into 4 groups:

a) Expert judgment, in which a decision is made that any value above a given limit is deemed to be geogenically anomalous. For example, the 90^{th}, 95^{th} or 98^{th} percentile values are often taken as 'natural' thresholds in environmental work. Whilst this has the merits of simplicity, it is a difficult argument to sustain one threshold against another in the face of a different, equally valid, expert opinion, unless there are supporting data which relate a chosen threshold to some other parameter of concern in a consistent manner, e.g. uptake of a metal by a crop.
b) The presence of sudden or unexplained changes in the slope of the distribution curve. Whilst such features are not unknown in geochemical investigations of ore bodies, none of the NSI data for these 5 elements show such features in their cumulative distribution curves. Other methods of interpretation of such curves have relied on the drawing of tangents to various parts of the curve, and assuming that any value above a particular intercept represents the geogenic component in the data (e.g. Sinclair, 1980) However, if this approach is not supported by marked changes in the slope of the cumulative curve, it is little more than an elaborated form of expert judgment.
c) The most widely used approach is that of box-plot analysis, which simply analyses the structure within the untransformed data. It has to be remembered, however, that box-plot analysis is simply a robust method of indicating outliers, i.e. those values above that of the limit of the upper whisker. Thus, one can have outliers for the complete data set, metal by metal, or outliers for each metal within each pH band, and these values would be different. The decision to label the values above the upper whisker as 'geogenic anomalies' is a matter for the user of the data - again it is an expert judgment as to the meaning of these high values. If these upper values can be shown to be associated with, for example, known orefields or areas of previous mining activity, then this assumption may well be reasonable. If such an association cannot be demonstrated, then one may have to seek other explanations, which may involve further investigations.
d) Geostatistical approaches to improved understanding of the spatial distribution of the NSI data are the subject of current research within SSLRC. The approach is based on an examination of the change in the spatial variance within the data, both in relation to the whole data set, and in relation to stated thresholds. Again, however, the setting of these thresholds is subject to the same constraints as indicated above. The work so far has demonstrated that there are parts of the landscape in which the variance in the data is greater than other parts, and that these areas generally conform to those areas highlighted by simple mapping of the data (McGrath & Loveland, 1992).

The spatial distribution of values indicates patterns across England and Wales, and the maps for some of the elements have what appear to be common features. The causative factors behind the patterns are likely to be varied. Attempts to separate and map areas of land with natural as opposed to anthropogenic contamination have encountered difficulties (Appleton, 1995). However, a number of subjective observations can be made for the metals concerned in this draft directive(Table 1.2.2).

Table 1.2.1.2 Comments on the spatial patterns of soil metal data in England and Wales

Metal	Observations on spatial pattern
Cd	Some suggestion of higher values in soils from Lias clays, but there are also concentrations of high values around industrial conurbations (Cardiff, Swansea and Leeds) and areas associated with ore smelting (Bristol, north-east Wales, Swansea valley) and ore fields (Derbyshire). High values in Chalk soils of Salisbury Plain and the Hampshire Downs may be associated with the war-time use of low grade phosphatic fertiliser, following conversion of grassland to cereal production.
Cu	The main concentrations of high values are around industrial conurbations (Swansea/Cardiff, Birmingham, Liverpool/Manchester, Leeds, Newcastle, London). Over and above these, ore fields and smelting areas show up (Cornwall - probably from Roman times, Anglesey and north-east and south Wales). There are high values spread around the rest of the country with no obvious pattern.
Ni	High values are encountered in the Swansea valley, Bristol area, Cornwall and the Derbyshire orefield but there are also broad sweeps of higher values in soils from Jurassic and Devonian rocks.
Pb	As for Cu, but with more widespread high values in upland areas such as Snowdonia, the Lake District and the Pennines.
Zn	As for Cd.
Hg	No available data

The accumulated metal content of topsoils is the result of a number of often inter-related processes and activities (Appleton, 1995) some of which have been in operation over long periods of time:

1. The weathering of soil parent material, including metalliferous ore-bearing rocks (geogenic source).
2. The disturbance and surface spreading (intentional or otherwise) of local metalliferous mineral materials over archaeological time (anthropogenic source).
3. The atmospheric deposition of long-range natural (mostly since the last or penultimate ice age) or anthropogenic (since the Bronze Age) particles (geogenic and anthropogenic sources).
4. The local deposition of particles from metal purification processes (grinding and smelting) (anthropogenic source).
5. The disposal of house and town waste (nightsoil) and, latterly, sewage sludge to land (anthropogenic source).
6. The spreading of other organic wastes to land (anthropogenic source).

7. The spreading of farm livestock wastes to land following the use of metal-rich additives in animal feeds (e.g. Cu in pig feed) (anthropogenic source).
8. The use of low-grade fertilisers (Cd) and plant protection compounds (Cu- and Hg-based fungicides) (anthropogenic source).
9. The re-distribution of any of these materials by natural processes, such as wind and water erosion, mass wastage across slopes, ice (last or earlier glaciations), accelerated in some cases by man's effect on the landscape.
10. It is possible that some landfill sites give rise to high metal values even in the upper 15cm of the soil (anthropogenic source).

It is not impossible that all of these processes have operated in certain areas, and thus the distinction between mainly natural and mainly anthropogenic influences is impossible to make in any consistent manner. Conceptually, the country can be divided into four classes of land on the basis of the above analysis:

1. Land with 'low' topsoil metal concentrations.
2. Land where topsoil metals are high for either natural geogenic or anthropogenic reasons or both.
3. Land where topsoil metals are high apparently for natural geogenic reasons only.
4. Land where topsoil metals are high apparently for anthropogenic reasons only.

There are two principal areas of the country where natural, geogenic anomalies appear to occur and have led to enhanced topsoil total metal concentrations:

1. the triangle of Jurassic rocks from the Severn estuary in the south-west that fans out north-eastward to spread between Lincoln in the north and Bedford in the south,

2. the Devonian rocks of Herefordshire.

It could reasonably be argued by a water services company that area 1 is associated with high Cd, Zn, Ni, while area 2 with high Ni. In all instances the concentrations are within or above the ranges stated in the draft directive and would therefore be operable were the derogation to become law. However, there is no means by which a soil within these loosely delineated areas can be categorically said to contain metals solely from natural, geogenic sources. Within these two geographical zones, as with everywhere else, soils have received a metal burden through the activities of man. No natural geogenic pattern is evident in data for Cu or Pb.

Conclusions

1. It may be possible to propose limited areas of England and Wales where geogenic sources account for the main soil metal burden.
2. The classification of some transport and deposition processes as geogenic or anthropogenic is open to interpretation and debate.
3. Only Cd, Zn and Ni, but not Pb or Cu (no data for Hg), appear to be associated with possible geogenic anomalies.
4. Most soils, even in the identifiable geogenic anomaly zones, are likely to have a metal burden that is the consequence in part of pre-industrial and industrial

human activity. The size and nature of this burden is variable and unquantifiable with any certainty.

5. It is impossible to categorically differentiate geogenic from anthropogenic soil metal loadings.

1.2.2 The operability of a geogenic derogation

Previous authors have attempted to establish target soil metal values based on 'background' levels, e.g. van Driele & Smile (1982) in The Netherlands, which they perceived to be the natural (*cf.* low) values in soils prior to the impact of human activities. Data for England and Wales (McGrath & Loveland, 1992) and for other countries, e.g. Germany (Wolff & Riek, 1997), Denmark (Jensen *et al.*, 1996), France (Baize, 1997), invalidate this concept by demonstrating a seamless range of values for all relevant elements, reaching and including values regarded as potentially harmful to human health and to the natural environment. This range can be interpreted as indicating either a) very variable natural metal concentrations, or b) a widespread but variable anthropogenic impact on soil metal loadings, or c) both in part. A number of conclusions can be drawn from the topsoil data for England and Wales and implied from sediment data (Appleton, 1995).

- no single background concentration is identifiable for any of the metals included in the draft directive,
- metal loadings associated with geogenic sources are indistinguishable from anthropogenic inputs at soil or field levels.

For this clause to be operable, water service companies need to argue with sufficient conviction and weight that the metal loading of a prospective 'receiving soil' is predominantly geogenic. Equally, the competent authority must be presented with, or in possession of, sufficient evidence to be satisfied that the argument is valid. Even in areas where geogenic anomalies appear to exist (e.g. zones 1 and 2, above), the metals in individual soil types and fields, despite exhibiting no visual signs of gross disturbance, may be anthropogenic. The water service company may argue that their records indicate that no sludge has ever been spread on the field, but atmospheric and water-borne deposits, the spreading of other organic wastes or of low grade fertilisers, and the activities of previous generations can all have resulted in anthropogenic metal contamination of the land.

Conclusions

1. The heavy metals in topsoils can derive from a wide range of sources.

2. Anthropogenic and geogenic metal contamination of agricultural topsoils are indistinguishable and inseparable at soil and field level even where, at the regional scale, there is some evidence for a geogenic influence.

3. The derogation is impractical and would present authorities charged with ensuring compliance with an insoluble problem.

1.2.3 Implications of the derogation for environmental protection

A principal of European law is that the implementation of individual legal instruments should be consistent with the spirit and intent of the law in general. Article 1 of the draft Directive details its main purpose - '..*to regulate the use of sewage sludge in agriculture ...to prevent harmful effects on soil, vegetation, animals and man.*' The preamble states that '...*use of sludge should be prohibited when the concentration of these metals in the soil exceed these limit values'*. It is the intention of the new draft Directive that the metal limits for sludge should become progressively more restrictive. The effect of the derogation would be to weaken controls over the further contamination of soils with metals. The derogation will lead to soil metal concentrations in excess of the stated limits and to levels judged to be unsafe to the soil, vegetation, animals or man. It therefore seems at variance with the central intent of the directive.

From a scientific standpoint, neither the impact of metals on soil ecosystems nor their mobility and leaching into groundwaters are fully understood. Most lowland UK agricultural soils are currently of neutral or alkaline pH because of artificial liming. The cessation of this practice through agricultural de-intensification or cost-cutting would lead to rapid acidification to pH levels of <6 in soils without excess natural buffering. Metal concentrations considered safe at current pH levels would become a cause for concern under the new pH regime.

Any move to allow metal concentrations to be raised above current limits should be resisted on a 'precautionary principle' basis. The toxicity of metals has no regard for their origin. The clause should be viewed as contrary to the objectives of the UK Strategy for Sustainable Development (HMSO 1994)

Conclusions

1. The derogation is at variance with the spirit and intent of the draft Directive.

2. The derogation should be resisted on a precautionary principle basis as contrary to the UK's strategy for sustainable development.

1.3 General Recommendation

1. Available data on the topsoil total metal concentrations of soils in England and Wales suggest that the derogation is unworkable, unenforceable and to be resisted.

2. The derogation, were it to be exploited, would lead to exceedence of the stated soil metal limits; limits that have been established as maximum safe soil concentrations. It is contrary to the spirit and intent of the directive, namely the prevention of harmful effects on soil, vegetation, animals and man and is therefore undesirable.

2. THE CONCEPTS OF 'TOTAL' AND 'AVAILABLE' METAL CONCENTRATIONS IN SOILS

2.1 'Total' metal concentrations

'Total' metal concentrations in soils are rarely measured. Chemical procedures such as digestion with hydrofluoric and perchloric acids are potentially hazardous, and there is much debate as to whether they give absolute total metal values in all soils. Instrumental procedures such as X-ray fluorescence analysis are insufficiently sensitive for some elements, and others - such as Instrumental Neutron Activation Analysis - are very slow. Because of this, most methods which are used to determine 'total' metal concentrations in soils are based on the use of hot *aqua regia* - a mixture of concentrated nitric and hydrochloric acids. The method is rapid, the hazards are well-understood and within the range encountered in general chemical analysis, and the resulting extracts lend themselves to a wide variety of sensitive instrumental techniques such as atomic absorption spectrometry (AAS), inductively-coupled plasma optical emission spectrometry (ICP) for the determination of the metals of interest. Several studies have shown a close relationship between values of the metals of interest in the draft Directive obtained by aqua regia extraction and those using more aggressive procedures (Utermann *et al.*, 1999). Because of this, there is a widespread view that the amount of a heavy metal NOT extracted by aqua regia is likely to be small in most soils, and any such unextracted fraction is unlikely to interact with soil biology within a meaningful time step. Thus the draft Directive lists ISO methods for the extraction of metals by aqua regia, and these methods have wide acceptance within Member States.

2.2 'Available' metal concentrations

Despite the fact that there is an enormous literature on the subject, there is no agreed definition of the meaning of, or the methodology for the determination of, 'available' metal contents in soils. For pragmatic reasons, however, it seems sensible to accept the fairly widespread view that 'available' means that fraction which is likely to be more readily taken up by plants. The approaches to the measurement of this fraction have focussed on pot experiments, chemical extraction, or both, with or without consideration of other soil factors such as organic matter content, pH and particle size distribution. Most chemical approaches have targeted so-called 'weak' extractants, usually in the form of simple salt solutions *e.g.* calcium chloride solution, or the use of solutions of mild complexing agents *e.g.* salts of EDTA. The National Soil Inventory (see Part 1) contains data for the latter, and these are summarised in Part 3 (below), but it must be stressed that no investigation has been made of plant uptake in relation to this dataset. Similarly, a 'rule-of-thumb' is often taken to be that the greater the proportion of the total metal concentration extractable by EDTA solution, then the greater the degree of availability. However, this is by no means proven, although it can be useful as a ranking exercise before more detailed research is carried out. McGrath & Loveland (1992) showed that there was a reasonable relationship (expressed as adjusted R^2 values) between the $\log_{10}$ transformed data for the 'total' and EDTA extractable 'available' contents of Cu (0.64), and Pb (0.68), but less so for Ni (0.31) and Zn (0.21). Figures 2.2.1 to 2.2.2 present these two classes of relationships graphically. In the absence of supporting plant uptake data, we hesitate to suggest other than that the relationships between total and extractable Cu, and similarly for Pb, might be taken as a guide to their availability to plants, but this does not extend to Ni or Zn. In all cases, the relationship should be taken very much as a guide and not be treated as unequivocal evidence for the likelihood of uptake into the food chain.

Figure 2.2.1 Relationship between aqua regia extractable copper (Cu) and EDTA-extractable copper (logarithmic scales) - NSI data.

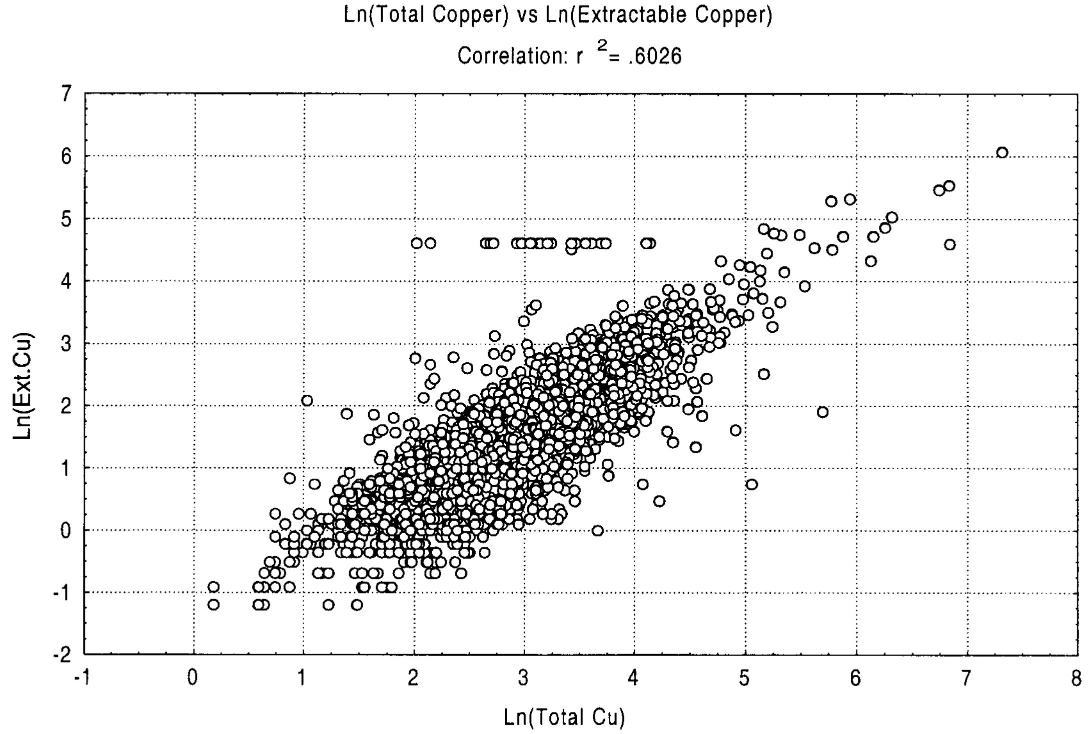
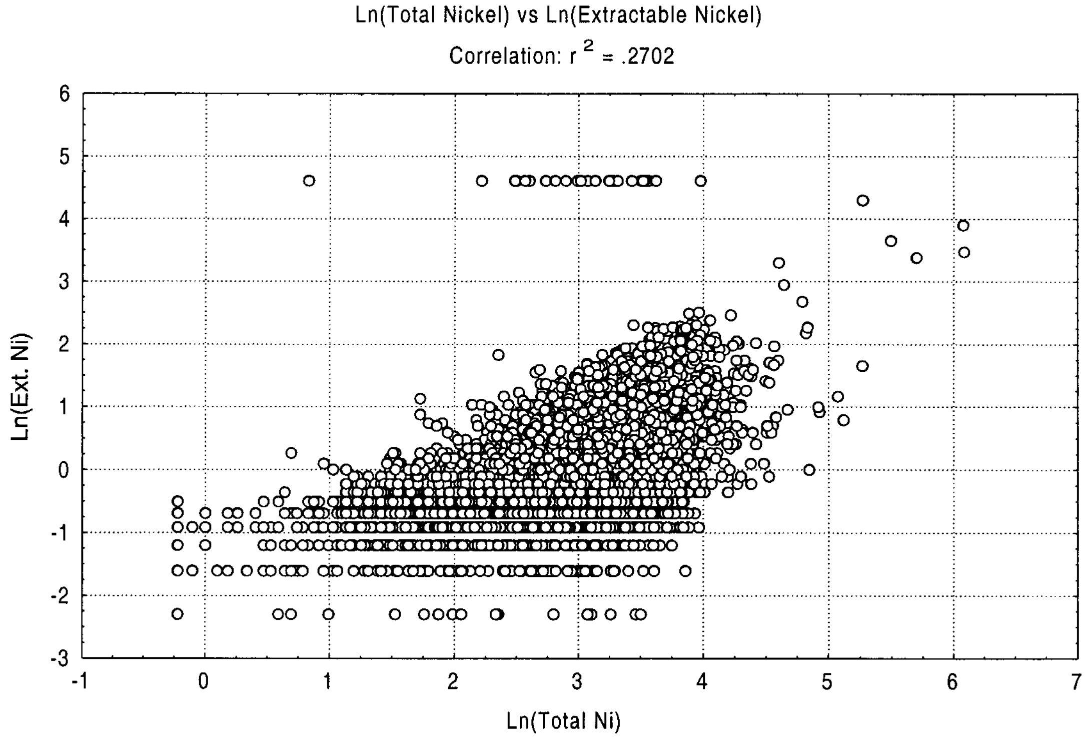


Figure 2.2.2 Relationship between aqua regia extractable nickel (Ni) and EDTA-extractable Ni (logarithmic scales) - NSI data.



3. PATTERNS OF LAND AVAILABILITY

3.1 Introduction

The effect of the proposals contained in the draft Directive, both in terms of the new limits and the 'geogenic derogation', need to be compared to the limits set out in the current Sludge (Use in Agriculture) Regulations (1989). For information, these are shown in Table 3.1.1. The following Tables (3.2.1. - 3.4.11.) give the proportions of land failing to meet the various criteria either nationally or by water region (boundaries supplied by the Environment Agency). Conversion from NSI data to area has been on the basis that one NSI point corresponds to 25 km^2. This does not mean that the geo-chemistry of each 25km square has uniform chemical properties. What it does mean is that, within the overall pattern of soil geo-chemistry within England and Wales, the *proportions* of land with a particular chemistry are reliably represented by these data, both nationally and regionally.

Note that for pragmatic reasons the data have most often been expressed (at the foot of the Table) in terms of land under arable cultivation, ley (short-term) grass and permanent (long-term, managed) grass. In the overwhelming majority of cases, these are the land uses which can be expected to receive sewage sludge. For reasons of access, remoteness, slope, climate etc., as well as pH, moorland, rough grazing, other hill land, heaths and so on have been excluded from consideration.

Table 3.1.1 Current values according to the DETR Code of Practice/1989 Regulation

Element	Limit values (mg.km^{-1} dm)			
	5<pH<5.5	<5.5pH<6	6<pH<7	7<pH
Cu	80	100	135	200
Ni	50	60	75	110
Pb	300	300	300	300
Zn	200	250	300	450

3.2 The effect of the current values according to the DETR Code of Practice - by Water Region

3.2.1. Number of NSI sites failing current values according to DETR Code of Practice/1989 Regulations (all England and Wales)

Metal	pH <5	pH >/=5 - <5.5		pH >/=5.5 - <6		pH >6/ - <7		pH >/ 7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	155	9	3	6	1	5	<1	4	<<1	<1
Ni	155	7	2	9	1	5	<1	4	<<1	<1
Pb	155	6	2	9	1	17	1	11	<1	1
Zn	155	12	3	16	3	26	2	7	<1	2
Any one or more metal	155	25	7	26	4	33	3	21	1	3
The 'any one or more metal' line values expressed as % of total agricultural area										
	4	<1		<1		<1		<1		3

Overall total number of sites = 4074 out of 5692= 71.6% in agricultural use
Number of sites >pH5 - 3919 out of 5692 = 68.8% in agricultural use

3.2.2. Number of NSI sites failing current values according to DETR Code of Practice/1989 Regulations: Anglian region

Metal	pH <5	pH >/=5 - <5.5		pH >/=5.5 - <6		pH >6/ - <7		pH >/ 7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	3	1	2	0	0	0	0	1	<<1	<<1
Ni	3	1	2	0	0	0	0	1	<<1	<<1
Pb	3	1	2	0	0	0	0	1	<<1	<<1
Zn	3	1	2	0	0	0	0	1	<<1	<<1
Any one or more metal	3	1	2	0	0	0	0	1	<<1	<<1
The 'any one or more metal' line values expressed as % of total agricultural area										
	<1	<<1		0		0		<<1		<<1

Overall total number of sites = 870 out of 1053 = 82.6 % in agricultural use
Number of sites >pH5 - 867 out of 1053 = 82.3 % in agricultural use

3.2.3. Number of NSI sites failing current values according to DETR Code of Practice/1989 Regulations: North West Region

Metal	pH <5	pH >/=5 - <5.5		pH >/=5.5 - <6		pH >6/ - <7		pH >/ 7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	24	1	2	3	4	2	2	0	0	2
Ni	24	1	2	1	1	4	4	0	0	2
Pb	24	4	8	1	1	1	1	0	0	2
Zn	24	2	4	2	3	3	3	0	0	3
Any one or more metal	24	4	8	3	4	4	4	0	0	4
The 'any one or more metal' line values expressed as % of total agricultural area										
	8	<1		<<1		<1		0		4

Overall total number of sites = 288 out of 563 = 51.1 % in agricultural use
Number of sites >pH5 - 264 out of 563 = 46.9 % in agricultural use

3.2.4. Number of NSI sites failing current values according to DETR Code of Practice/1989 Regulations: Northumbria Region

Metal	pH <5	pH >/=5 - <5.5		pH >/=5.5 - <6		pH >6/ - <7		pH >/ 7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	6	0	0	0	0	2	2	1	2	2
Ni	6	0	0	0	0	2	2	1	2	2
Pb	6	0	0	0	0	1	1	1	2	2
Zn	6	0	0	0	0	2	2	1	2	2
Any one or more metal	6	0	0	0	0	2	2	1	2	2
The 'any one or more metal' line values expressed as % of total agricultural area										
	3	0		0		1		<1		2

Overall total number of sites = 183 out of 361 = 50.7 % in agricultural use
Number of sites >pH5 - 177 out of 361 = 49 % in agricultural use

3.2.5. Number of NSI sites failing current values according to DETR Code of Practice/1989 Regulations: Severn Trent Region

Metal	pH <5	pH >/=5 - <5.5		pH >/=5.5 - <6		pH >6/ - <7		pH >/ 7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	20	2	4	1	1	2	1	2	1	1
Ni	20	2	4	2	2	3	1	2	1	1
Pb	20	6	13	2	2	8	3	5	2	3
Zn	20	5	10	6	6	8	3	4	2	3
Any one or more metal	20	9	19	6	6	11	4	11	5	6
The 'any one or more metal' line values expressed as % of total agricultural area										
	3	1		<1		2		2		5

Overall total number of sites = 683 out of 909 = 75.1 % in agricultural use
Number of sites >pH5 - 663 out of 909 = 72.9 % in agricultural use

3.2.6. Number of NSI sites failing current values according to DETR Code of Practice/1989 Regulations: South West Region

Metal	pH <5	pH >/=5 - <5.5		pH >/=5.5 - <6		pH >6/ - <7		pH >/ 7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	29	5	10	3	3	1	1	0	0	3
Ni	29	2	4	3	3	1	1	0	0	2
Pb	29	7	13	3	3	1	1	0	0	4
Zn	29	2	4	3	3	1	1	0	0	2
Any one or more metal	29	7	13	3	3	1	1	0	0	4
The 'any one or more metal' line values expressed as % of total agricultural area										
	9	2		1		<<1		0		4

Overall total number of sites = 309 out of 434 = 71.2 % in agricultural use
Number of sites >pH5 - 280 out of 434 = 64.5 % in agricultural use

3.2.7. Number of NSI sites failing current values according to DETR Code of Practice/1989 Regulations: Southern Region

Metal	pH <5	pH >/=5 - <5.5		pH >/=5.5 - <6		pH >6/ - <7		pH >/ 7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	15	0	0	1	3	0	0	0	0	<<1
Ni	15	0	0	1	3	0	0	0	0	<<1
Pb	15	0	0	1	3	0	0	0	0	<<1
Zn	15	0	0	1	3	0	0	0	0	<<1
Any one or more metal	15	0	0	1	3	0	0	0	0	<<1
The 'any one or more metal' line values expressed as % of total agricultural area										
	5	0		<<1		0		0		<<1

Overall total number of sites = 293 out of 455 = 64.4 % in agricultural use
Number of sites >pH5 - 278 out of 455 = 61.1 % in agricultural use

3.2.8. Number of NSI sites failing current values according to DETR Code of Practice/1989 Regulations: Thames Region

Metal	pH <5	pH >/=5 - <5.5		pH >/=5.5 - <6		pH >6/ - <7		pH >/ 7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	0	1	14	0	0	2	3	2	1	2
Ni	0	1	14	0	0	2	3	1	<1	2
Pb	0	1	14	0	0	2	3	1	<1	2
Zn	0	1	14	0	0	2	3	2	1	2
Any one or more metal	0	1	14	0	0	2	3	2	1	2
The 'any one or more metal' line values expressed as % of total agricultural area										
	0	<<1		0		<<1		<<1		2

Overall total number of sites = 298 out of 483 = 61.7% in agricultural use
Number of sites >pH5 - 298 out of 483 = 61.7 % in agricultural use

3.2.9. Number of NSI sites failing current values according to DETR Code of Practice/1989 Regulations: Welsh Region

Metal	pH <5	pH >/=5 - <5.5		pH >/=5.5 - <6		pH >6/ - <7		pH >/ 7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	29	1	1	2	1	5	3	1	3	2
Ni	29	2	2	3	2	5	3	2	6	3
Pb	29	2	2	1	1	4	2	1	3	2
Zn	29	2	2	3	2	5	3	1	3	3
Any one or more metal	29	2	2	6	5	5	3	2	6	4
The 'any one or more metal' line values expressed as % of total agricultural area										
	6	<1		1		1		<1		3

Overall total number of sites = 452 out of 825 = 54.8 % in agricultural use
Number of sites >pH5 - 423 out of 825 = 51.3 % in agricultural use

3.2.10. Number of NSI sites failing current values according to DETR Code of Practice/1989 Regulations: Wessex Region

Metal	pH <5	pH >/=5 - <5.5		pH >/=5.5 - <6		pH >6/ - <7		pH >/ 7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	13	1	4	6	14	4	4	1	<1	4
Ni	13	1	4	6	14	4	4	1	<1	4
Pb	13	1	4	3	7	1	4	1	<1	2
Zn	13	1	4	4	9	4	4	1	<1	3
Any one or more metal	13	1	4	6	14	4	4	1	<1	4
The 'any one or more metal' line values expressed as % of total agricultural area										
	4	<<1		2		1		<<1		4

Overall total number of sites = 317 out of 395 = 80.3 % in agricultural use
Number of sites >pH5 - 304 out of 395 = 77 % in agricultural use

3.2.11. Number of NSI sites failing current values according to DETR Code of Practice/1989 Regulations: Yorkshire Region

Metal	pH <5	pH >/=5 - <5.5		pH >/=5.5 - <6		pH >6/ - <7		pH >/ 7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	14	0	0	1	3	4	4	3	1	2
Ni	14	0	0	1	3	4	4	3	1	2
Pb	14	0	0	1	3	2	2	2	1	1
Zn	14	0	0	1	3	3	2	1	<1	2
Any one or more metal	14	0	0	1	3	4	4	3	1	2
The 'any one or more metal' line values expressed as % of total agricultural area										
	4	0		<<1		1		<1		2

Overall total number of sites = 363 out of 547 = 66.4 % in agricultural use
Number of sites >pH5 - 349 out of 547 = 63.8 % in agricultural use

3.3 The effect of the proposed limits in the draft Directive (WITHOUT the geogenic derogation)

3.3.1 The effect of the proposed limits in the draft Directive (all England and Wales)

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	155	417	46%	47	4%	13	<1%	12%
Ni	155	720	79%	54	5%	26	2%	20%
Pb	155	167	18%	186	16%	97	6%	11%
Zn	155	748	82%	138	12%	64	3%	24%
Any one or more metal	155	816	89%	269	23%	139	8%	31%
One or more metal line values expressed as % of total agricultural area								
	4%	20%		7%		3%		30%

Overall total number of sites = 1379 out of 4074 = 34%

3.3.2 The effect of the proposed limits in the draft Directive: Anglian Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	3	13	25	2	2	3	<1	2
Ni	3	44	83	6	6	8	1	7
Pb	3	3	6	2	2	10	1	2
Zn	3	40	75	10	10	9	1	7
Any one or more metal	3	45	85	15	11	23	3	10
The 'any one or more metal' line values expressed as % of total agricultural area								
	<<1	5		2		3		10

Overall total number of sites = 870 out of 1053 = 82.6 % in agricultural use
Number of sites >pH5 - 867 out of 1053 = 82.3 % in agricultural use

3.3.3. The effect of the proposed limits in the draft Directive: North West Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	24	65	56	10	1	1	2	29
Ni	24	86	74	3	<<1	1	2	34
Pb	24	38	32	27	25	6	15	27
Zn	24	87	74	8	<1	2	5	37
Any one or more metal	24	101	86	27	25	7	18	51
The 'any one or more metal' line values expressed as % of total agricultural area								
	8	35		9		2		47

Overall total number of sites = 288 out of 563 = 51.1 % in agricultural use
Number of sites >pH5 - 264 out of 563 = 46.9 % in agricultural use

3.3.4. The effect of the proposed limits in the draft Directive: Northumbria Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	6	7	18	5	11	8	13	11
Ni	6	22	58	1	2	8	13	18
Pb	6	12	32	23	42	8	13	24
Zn	6	27	71	10	18	4	7	23
Any one or more metal	6	32	84	23	42	8	13	36
The 'any one or more metal' line values expressed as % of total agricultural area								
	3	17		13		4		34

Overall total number of sites = 183 out of 361 = 50.7 % in agricultural use
Number of sites >pH5 - 177 out of 361 = 49 % in agricultural use

3.3.5. The effect of the proposed limits in the draft Directive: Severn Trent Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	20	71	50	11	4	2	<<1	13
Ni	20	123	87	19	7	6	3	22
Pb	20	39	27	45	16	19	8	16
Zn	20	130	92	44	16	21	9	29
Any one or more metal	20	132	93	75	27	27	11	35
The 'any one or more metal' line values expressed as % of total agricultural area								
	3	19		11		4		34

Overall total number of sites = 683 out of 909 = 75.1 % in agricultural use
Number of sites >pH5 - 663 out of 909 = 72.9 % in agricultural use

3.3.6. The effect of the proposed limits in the draft Directive: South West Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	29	95	68	9	8	1	3	38
Ni	29	110	79	11	10	1	3	44
Pb	29	17	12	14	13	7	24	14
Zn	29	113	81	10	9	3	10	45
Any one or more metal	29	129	92	26	23	9	31	59
The 'any one or more metal' line values expressed as % of total agricultural area								
	9	42		8		3		53

Overall total number of sites = 309 out of 434 = 71.2 % in agricultural use
Number of sites >pH5 - 280 out of 434 = 64.5 % in agricultural use

3.3.7. The effect of the proposed limits in the draft Directive: Southern Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	15	13	24	1	1	9	6	8
Ni	15	41	76	1	1	9	6	18
Pb	15	3	6	5	7	9	6	6
Zn	15	39	72	1	1	9	6	18
Any one or more metal	15	43	80	6	9	9	6	21
The 'any one or more metal' line values expressed as % of total agricultural area								
	5	15		2		3		20

Overall total number of sites = 293 out of 455 = 64.4 % in agricultural use
Number of sites >pH5 - 278 out of 455 = 61.1 % in agricultural use

3.3.8. The effect of the proposed limits in the draft Directive: Thames Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	0	7	28	4	20	1	<<1	4
Ni	0	22	88	5	7	5	2	11
Pb	0	1	4	8	12	10	5	6
Zn	0	19	76	7	10	3	2	10
Any one or more metal	0	22	88	14	20	15	7	17
The 'any one or more metal' line values expressed as % of total agricultural area								
	0	7		5		5		17

Overall total number of sites = 298 out of 483 = 61.7% in agricultural use
Number of sites >pH5 - 298 out of 483 = 61.7 % in agricultural use

3.3.9. The effect of the proposed limits in the draft Directive: Welsh Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	29	109	49	1	<<1	3	11	27
Ni	29	184	83	2	1	1	3	44
Pb	29	31	14	23	14	3	11	13
Zn	29	193	87	13	8	5	15	50
Any one or more metal	29	208	93	28	17	5	15	57
The 'any one or more metal' line values expressed as % of total agricultural area								
	6	46		6		1		53

Overall total number of sites = 452 out of 825 = 54.8 % in agricultural use
Number of sites >pH5 - 423 out of 825 = 51.3 % in agricultural use

3.3.10. The effect of the proposed limits in the draft Directive: Wessex Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	13	24	34	2	2	1	<1	9
Ni	13	53	75	4	4	4	3	20
Pb	13	14	20	11	6	10	7	12
Zn	13	60	85	18	20	8	6	28
Any one or more metal	13	62	87	23	25	16	11	33
The 'any one or more metal' line values expressed as % of total agricultural area								
	4	20		7		5		32

Overall total number of sites = 317 out of 395 = 80.3 % in agricultural use
Number of sites >pH5 - 304 out of 395 = 77 % in agricultural use

3.3.11. The effect of the proposed limits in the draft Directive: Yorkshire Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	14	13	25	6	6	1	<<1	6
Ni	14	33	65	2	2	19	9	15
Pb	14	9	18	28	29	14	7	15
Zn	14	38	75	17	18	9	4	18
Any one or more metal	14	40	78	32	33	19	9	26
The 'any one or more metal' line values expressed as % of total agricultural area								
	4	11		9		5		25

Overall total number of sites = 363 out of 547 = 66.4 % in agricultural use
Number of sites >pH5 - 349 out of 547 = 63.8 % in agricultural use

3.4 The effect of the geogenic derogation, i.e. to increase the draft limits by 50%

3.4.1. The effect of the geogenic derogation (all England and Wales)

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	155	166	18	11	1	7	<<1	5
Ni	155	477	52	5	<1	5	<<1	12
Pb	155	90	10	94	8	45	2	6
Zn	155	454	50	44	4	22	1	13
Any one or more metal	155	600	65	111	9	60	3	20
The 'any one or more metal' line values expressed as % of total agricultural area								
	4	15		3		1		19

Overall total number of sites = 4074 out of 5692= 71.6% in agricultural use
Number of sites >pH5 - 3919 out of 5692 = 68.8% in agricultural use

3.4.2. The effect of the geogenic derogation: Anglian Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	3	6	11	1	1	1	<<1	1
Ni	3	34	64	1	1	1	<<1	4
Pb	3	34	63	1	1	4	<1	4
Zn	3	21	40	1	1	1	<<1	2
Any one or more metal	3	34	64	1	1	5	<1	5
The 'any one or more metal' line values expressed as % of total agricultural area								
	<<1	4		<,1		<1		5

Overall total number of sites = 870 out of 1053 = 82.6 % in agricultural use
Number of sites >pH5 - 867 out of 1053 = 82.3 % in agricultural use

3.4.3. The effect of the geogenic derogation: North West Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	24	33	28	3	3	3	7	15
Ni	24	43	37	15	14	3	7	23
Pb	24	21	18	12	11	3	7	13
Zn	24	48	41	6	6	3	7	22
Any one or more metal	24	63	54	15	14	3	7	31
The 'any one or more metal' line values expressed as % of total agricultural area								
	8	22		5		1		28

Overall total number of sites = 288 out of 563 = 51.1 % in agricultural use
Number of sites >pH5 - 264 out of 563 = 46.9 % in agricultural use

3.4.4. The effect of the geogenic derogation: Northumbria Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	6	3	8	1	1	3	5	5
Ni	6	11	29	10	13	3	5	14
Pb	6	6	16	10	13	3	5	10
Zn	6	15	39	5	6	1	2	12
Any one or more metal	6	19	50	10	13	3	5	18
The 'any one or more metal' line values expressed as % of total agricultural area								
	3	10		5		2		17

Overall total number of sites = 183 out of 361 = 50.7 % in agricultural use
Number of sites >pH5 - 177 out of 361 = 49 % in agricultural use

3.4.5. The effect of the geogenic derogation: Severn Trent Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	20	29	20	2	<1	2	1	5
Ni	20	87	61	3	1	2	1	14
Pb	20	23	16	25	9	12	5	9
Zn	20	100	70	12	4	9	4	18
Any one or more metal	20	114	80	27	10	18	8	24
The 'any one or more metal' line values expressed as % of total agricultural area								
	3	17		4		3		23

Overall total number of sites = 683 out of 909 = 75.1 % in agricultural use
Number of sites >pH5 - 663 out of 909 = 72.9 % in agricultural use

3.4.6. The effect of the geogenic derogation: South West Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	29	40	29	3	3	3	10	16
Ni	29	83	59	10	9	3	10	34
Pb	29	8	6	7	6	2	7	3
Zn	29	66	47	1	1	1	3	24
Any one or more metal	29	97	69	10	9	3	10	39
The 'any one or more metal' line values expressed as % of total agricultural area								
	9	31		3		1		36

Overall total number of sites = 309 out of 434 = 71.2 % in agricultural use
Number of sites >pH5 - 280 out of 434 = 64.5 % in agricultural use

3.4.7. The effect of the geogenic derogation: Southern Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	15	2	4	3	4	2	1	3
Ni	15	28	52	3	4	2	1	12
Pb	15	1	2	3	4	2	1	2
Zn	15	13	24	3	4	2	1	6
Any one or more metal	15	30	56	3	4	2	1	13
The 'any one or more metal' line values expressed as % of total agricultural area								
	5	10		1		<1		12

Overall total number of sites = 293 out of 455 = 64.4 % in agricultural use
Number of sites >pH5 - 278 out of 455 = 61.1 % in agricultural use

3.4.8. The effect of the geogenic derogation: Thames Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	0	2	8	5	7	1	<1	3
Ni	0	17	68	2	3	1	<1	7
Pb	0	1	4	3	4	2	1	2
Zn	0	11	44	1	1	2	1	5
Any one or more metal	0	17	68	5	7	4	2	9
The 'any one or more metal' line values expressed as % of total agricultural area								
	0	6		2		1		9

Overall total number of sites = 298 out of 483 = 61.7% in agricultural use
Number of sites >pH5 - 298 out of 483 = 61.7 % in agricultural use

3.4.9. The effect of the geogenic derogation: Welsh Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	29	33	15	13	8	2	6	11
Ni	29	122	55	13	8	3	9	33
Pb	29	12	5	13	8	2	6	6
Zn	29	118	53	6	4	2	6	30
Any one or more metal	29	151	68	13	8	3	9	39
The 'any one or more metal' line values expressed as % of total agricultural area								
	6	33		3		<1		37

Overall total number of sites = 452 out of 825 = 54.8 % in agricultural use
Number of sites >pH5 - 423 out of 825 = 51.3 % in agricultural use

3.4.10 The effect of the geogenic derogation: Wessex Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	13	12	17	8	10	1	<1	7
Ni	13	39	55	8	10	1	<1	16
Pb	13	11	15	4	5	6	4	7
Zn	13	42	59	6	7	1	<1	16
Any one or more metal	13	49	69	8	10	8	6	21
The 'any one or more metal' line values expressed as % of total agricultural area								
	4	15		3		3		21

Overall total number of sites = 317 out of 395 = 80.3 % in agricultural use
Number of sites >pH5 - 304 out of 395 = 77 % in agricultural use

3.4.11. The effect of the geogenic derogation: Yorkshire Region

Metal	pH <5	pH >/=5 - <6		pH </=6 - <7		pH >/=7		All failed sites pH>/=5
		Failed sites	As % of pH band	Failed sites	As % of pH band	Failed sites	As % of pH band	As % of total agricultural area with pH>5
Cu	14	6	12	2	2	11	5	5
Ni	14	11	22	19	20	11	5	12
Pb	14	7	14	17	18	9	4	9
Zn	14	19	37	6	6	5	2	9
Any one or more metal	14	24	47	19	20	11	5	15
The 'any one or more metal' line values expressed as % of total agricultural area								
	4	7		5		3		15

Overall total number of sites = 363 out of 547 = 66.4 % in agricultural use
Number of sites >pH5 - 349 out of 547 = 63.8 % in agricultural use

4. DATA FROM OTHER EU MEMBER STATES

4.1 Introduction

Arrouays *et al.* (1997) and Syed *et al.* (1999) report on European and international initiatives to collate information about the nature and state of soils. Arrouays *et al.* (*loc. cit.*) conducted a questionnaire survey of all EU Member States to elicit information on national soil monitoring initiatives.

4.2 International Soil Monitoring Projects

Most international initiatives are focused on land management and conservation and do not contain information on soil metals. Only the *International Co-operative Programme on the Assessment and Monitoring of Air Pollution on Forests* (Vanmechelen *et al.*, 1997) involves the specific collection of information on soil metal concentrations in forest soils.

The ICP programme began in 1985. It is an integral part of the Co-operative Programme for Monitoring and Evaluation of long-range transmission of Air Pollutants in Europe (EMEP) and of the Long-Range Transboundary Air Pollution (LRTAP) convention. In order to contribute to a better understanding of air pollution and other factors which may influence forest ecosystems, a programme for intensive and continuous monitoring was implemented. A systematic large scale network (16x16 km grid) was established (ICP Forests, Level 1). This was extended to include the intensive and continuous monitoring of a forest ecosystems network (ICP Forests, Level II) containing crown condition assessments, soil and foliar surveys, increment (tree growth) studies, deposition measurements and the observation of meteorological parameters over a period of at least 15-20 years. At the moment, 440 permanent observation plots for intensive monitoring have been selected and installed in the European Union. Aqua regia extracts for total metal content of the six metals listed in the directive are optional parameters for analysis within the project.

The nature of information on soil metal concentrations included in EU Member State reports to the European Commission under Directive 86/278/EEC (sewage sludge used in agriculture) is unknown. This information will be skewed in that the sample population is weighted in favour of soils that are likely to have a previous history of sludge applications. It is also likely to be highly aggregated and lacking in information on individual sites. It is also uncertain whether site data are geo-referenced in an internationally consistent manner - if at all - which would allow them to be examined and manipulated within a GIS.

4.3 National initiatives

The following summary is based on information collated by Arrouays *et al.* (1997) as part of the work programme of the European Topic Centre on Soil. The information was collated from responses to a questionnaire sent out to representatives in Member States as part of Task 5 of the Environmental Topic Centre for Soil work programme. A nil response for a country implies that no extensive monitoring is or has taken place, but cannot be taken as an absolute statement to that effect.

Austria The *Bodenzustandsinventur (BZI)* is a soil inventory based on a 4 km orthogonal grid and managed by each provincial authority. The BZI includes analysis for a range of heavy metals (Blum *et al.*, 1996). There has been a drive to harmonise procedures and the Austrian Federal Environment Agency (UBA) is developing *BORIS*, a soil information system for the uniform capture and combination of existing and future soil data.

Belgium No information is available on any soil monitoring for metals, but an official soil monitoring system for Wallonia is being established within the Walloon Ministry of the Environment.

Denmark Heavy metals have been monitored (including the six metals of the draft Directive) at 400 sites on the *National Gridnet System* that includes sites in agricultural use (Jensen *et al.*, 1996). Information is also available for each site on other soil properties and the use of sludge. In addition, the Technical University of Denmark (Lyngby) has Cd data dating from 1923 for 16 plots.

Fennoscandia The geochemistry of the soils of parts of Finland, Norway and Sweden have been mapped under a co-operative project between these countries (Bœlviken, 1986). Work in individual countries has also continued to a greater or lesser degree and details of this are given under those countries.

Finland The *Environmental Soil Mapping Programme* - led by the Geological Survey of Finland - involves study of acidification and weathering rates including the mobility of metals. The Programme is based on 12 soils. In another study, twenty research stations are collaborating in the monitoring of nutrient and heavy metals in cultivated soils. The *Chemical Characteristics of Finnish Agricultural* Soils project established 2000 sites close to anthropogenic zones (railways, highways, farm lanes *etc.*) in 1974. The majority of these were sampled in 1987 for determinations including heavy metals. A further sampling is being planned (Sippola & Yli-Halla, 1999).

France The *Observatoire de la Qualité des Sols* is a national monitoring network somewhat like the UK Environmental Change Network. Eleven sites were in existence in 1997 with a target of fifty by 2005. Heavy metal analysis is a component.

Germany Länder have established some 600 *Permanent Soil Monitoring Sites* for which there are soil heavy metal data. The sites are unevenly distributed and chosen on the basis of 'representativeness' for a number of factors. The *German Environmental Sample Bank* is part of a monitoring and archiving programme for the Ministry of Environment, Nature Protection and Reactor Safety. It contains only a small number of sites. *A National Air Pollution Monitoring Network* of 37 sites involves analysis of soil heavy metals.

Greece No information other than involvement in the ICP Forest programme.

Iceland No information.

Ireland No information other than involvement in the ICP Forest programme.

Italy No information on monitoring programmes.

Luxembourg No soil monitoring is taking place.

Liechtenschtein The EU has reported that a monitoring network is established, but no information was forthcoming from the ETC questionnaire.

Netherlands It is reported that soil monitoring occurs in a national soil and groundwater monitoring programme organised by the National Institute of Public Health and Environment and the TNO Institute for Applied Geoscience (van Tooren, 1993).

Norway No soil metal data have been reported.

Portugal No information.

Spain No soil metal data have been reported.

Sweden The *National Survey of Forest Soils and Vegetation* involves the analysis of heavy metals from large numbers of forest soils. There is also a database for lead, cadmium and selenium based on sampling of the root zone close to streams, as this is thought to be the 'bio-active zone' which closely controls streamwater chemistry (Ek *et al.,* 1989).There are plans to establish a programme to monitor agricultural soils, but the finance had not been cleared in 1997.

Scotland There are soil inventory data for Scotland, including heavy metal concentrations at the intersects of a 10 km grid. This survey was carried out by the Soil Survey of Scotland in parallel with the National Soil Inventory of England and Wales (see Part 1 of this Report).

Northern Ireland A soil survey has been made based upon a systematic grid of 1km x 1km. This survey is very similar to the basic Phase 1 of the National Soil Inventory of England and Wales. A geochemical survey was made at the same time (but excluding Hg) of all enclosed land, i.e. agricultural. Very approximately, 'enclosed' means all land below 200m O.D. (Jordan *et al.*, 1998).

4.4 Future Initiatives

The drafting of the current proposed revision to the Sewage Sludge Directive has drawn attention to the paucity of integrated information on the state and quality of soils at a European level. As a result, DGXI of the European Commission has requested that the European Soil Bureau and the European Environment Institute (based at the EU Joint Research Centre, Ispra, Italy) co-ordinate a short term action to draw together data on soil metal concentrations from Member States (H. Langenkamp, *pers. comm.*). It is hoped that the first results of this short-term action will be available in early May 2000.

4.5 Conclusions

1. Reliable, national-scale information on topsoil total metal concentrations exists for the UK, Denmark and possibly Germany. There are some data for The Netherlands and France.
2. The United Kingdom has statistically reliable, high quality information on soil heavy metal data. The data are the product of grid surveys conducted by the national soil surveys for England and Wales, Scotland and N.I. during the national mapping programmes of the 1980s and 1990s Some re-sampling of the sites in England and Wales was been carried out in1995/6.
3. Denmark has comparable grid data from its National Gridnet System.
4. Germany is the only other country with significant national data on soil metal concentrations but these are from subjectively chosen sites which are not uniformly spread across Federal Germany.

5. The majority of Member States and the Commission itself are in a position of relative ignorance regarding the heavy metal contents of agricultural soils.
6. It is uncertain how comparable even the most comprehensive data are between the UK, Denmark and Germany in terms of analytical methodology.

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