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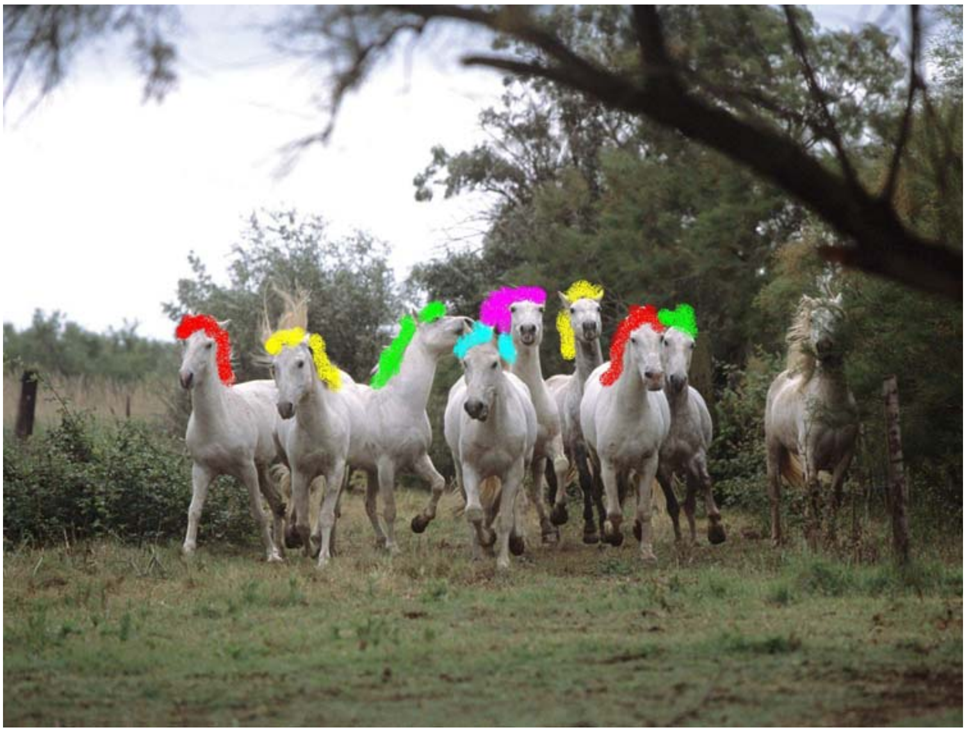
DERIVATION METHODS OF SOIL SCREENING VALUES IN EUROPE. A REVIEW AND EVALUATION OF NATIONAL PROCEDURES TOWARDS HARMONISATION

EDITOR

CLAUDIO CARLON



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A REVIEW AND EVALUATION OF NATIONAL PROCEDURES TOWARDS HARMONISATION

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DERIVATION METHODS OF SOIL SCREENING VALUES IN EUROPE

A REVIEW AND EVALUATION OF NATIONAL PROCEDURES TOWARDS HARMONISATION

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EXECUTIVE SUMMARY

Problem definition

Soil Screening Values (SVs) are generic quality standards that are used to regulate land contamination. Soil SVs adopted in European countries are widely variable in multiple aspects. The use of SVs varies from setting long term quality objectives, via triggering further investigations, to enforcing remedial actions. Derivation methods of SVs have scientific and political bases; they also differ from country to country, and SVs numerical values vary consequently. In relation to the common market and common environmental policies in Europe, this variability has raised concern among both regulators and risk assessors. As reported in the Soil Thematic Strategy discussion documents (Van Camp et al., 2004), a further alignment of European SVs derivation methods is generally supported. To what extent this can be done and the possible drawbacks are still matter for discussion. The idea of a toolbox approach, which addresses the harmonization of specific building blocks of SVs derivation procedures while giving wide room for national diversities, was already discussed and encountered significant favor in an expert meeting in Ispra in February 2005 (Carlon, 2005). Nevertheless, it was also clear at that time that a detailed analysis of commonalities and differences among European national approaches, essential for the evaluation of the technical feasibility of harmonization, was lacking. In particular, besides the identification of differences, a further insight was necessary on the reasons for the differences. Based on this consideration, the idea of the present review was launched.

Objectives

The present review analyses the bases of screening values used in EU Member States and initiated a discussion on the reasons for their differences. Specific objectives of the review were the following:

- to describe the state of the art of SVs derivation methods and their application in Europe,
- to assess commonalities and main differences among national methods,
- to gain a further insight in reasons of differences,
- to identify opportunities for harmonization.

The work focused on soil contamination, but also investigated the relation between the soil and groundwater SVs.

The survey concerned a representative group of countries, encompassing old and new EU Member States, i.e. Austria, Belgium (Walloon, Flanders and Brussels), The Czech Republic, Germany, Denmark, Spain, Finland, France, Italy, Lithuania, The Netherlands, Poland, Slovenia, Sweden and United Kingdom. The analysis was done at the level of the main assumptions, methods and technical elements. A detailed comparison of algorithms and input values could be addressed in a subsequent analysis.

Procedure for collecting information

The collection of information was obtained with the voluntary contribution of experts from the investigated countries. The information was requested by means of a questionnaire and in the form of a country profile. The questionnaire was based on multiple choices and concerned all the building blocks of the derivation of SVs. It was subdivided in three sections:

- the regulatory framework and main features;
- the exposure and toxicological assessment for human receptors;
- the exposure and toxicological assessment for ecological receptors.

The country profiles intended to be an explanatory text in support of the interpretation of the questionnaire response.

Building a coherent framework for comparing risk based screening values

The variable regulatory significance in different countries led to the proliferation of soil SVs denominations, like screening values, guidance values, target and intervention values, maximum acceptable concentrations, cut off values, trigger values, environmental quality objectives, et cetera. The diversity of terms reflects the lack of a coherent framework in Europe for the derivation and in the use of SVs. But it also could be noted that SVs are derived for different purposes, with reference to various levels of risk. In general three levels can be distinguished: negligible, intermediate (or warning) and potentially unacceptable risk. The level of risk is usually related to the intended application of the SV. With this regard, there are no fixed rules, but common practices. The negligible risk, for example, is usually used for the definition of long term environmental objectives. The need for actions is often related to levels indicating a potential unacceptable risk. The term action is here intended in a broad sense including remediation, restrictions in land use, urgency for remediation, further investigations and/or the application of site specific risk assessment. In some cases the need for further investigation is not related to potentially unacceptable risk levels, rather than intermediate (warning) risk levels. Based on this rationale, in some countries three sets of SVs are derived on the basis of negligible, intermediate (warning) and potentially unacceptable risk levels. Nowadays in many countries the preferred use of SVs is that of trigger values for site specific investigations, while the final decision of remediation is based on a site-specific assessment (considering acceptability under site-specific land use and environmental conditions).
SVs are often classified on the basis of their use. Drawbacks of this type of classification is that the prescribed use of SVs is specific to each national regulatory framework, and often includes a complex system of rules and exemptions on several aspects (e.g. time when contamination was determined) and type of substances (e.g. mobile and non mobile). Moreover, the use of SVs is currently changing in many countries without changes in SVs derivation methods. Based on these considerations, and in accordance with the scope of the study, in this review the classification of SVs is focused on derivation methods; in particular a classification

of SVs on the basis of the risk levels (negligible, intermediate and potentially unacceptable) was attempted.
In addition, a framework for the description and comparison of regulatory systems was adopted which consisted of three axes:

- the *screening risk assessment axis*, providing screening values according to various levels of protection,
- the *site-specific risk assessment axis*, providing site-specific values according to various levels of protection, equivalent to that considered in the screening assessment, but in a more realistic derivation,
- the *risk management axis*, along which policy makers decide how to implement the values provided by the former two axes.

All national regulatory systems were described on the basis of this general scheme.

Methods for the analysis of relevance and reasons of differences

Derivation methods of soil SVs were analysed regarding their main building blocks. For each building block, the relevance of observed differences among national systems was assessed in relation to their influence on the variability of SVs. For this purpose, two factors were considered: the ***magnitude of differences*** and their ***sensitivity*** in the determination of SVs. The two factors were scored on the basis of expert judgment.
Analogously, for each building block reasons of differences were investigated. Five categories of reasons were defined:

1) ***Geographical and biological***, associated to the environmental variability across Europe,
2) ***Socio-cultural***, associated to the variability of social behaviors and land use across Europe,
3) ***Regulatory,*** associated to regulatory requirements, such as constitutional aspects or commonalities with other existing laws,
4) ***Political,*** associated to the prioritization of environmental and economic values, as it is usually made by policy makers and regulators,
5) ***Scientific***, associated with arguments of different scientific views.

Results: overview of soils screening values derivation methods in Europe

The following conclusions were drawn:

- in most countries, soil SVs are based on the application of exposure and toxicological modeling. In some countries, mainly new EU Member States, current SVs are based on the (review of) SVs adopted by other countries;
- main methodological references followed by EU countries are the European Commission Technical Guidance Document on Risk Assessment (ECB, 2003), the procedures developed by RIVM in The Netherlands, methods developed in United States (e.g. ASTM, 1998), the former Soviet Union procedures and values (mainly in Central and East European Countries). For the ecological risk assessment, some countries consider the Canadian Guidelines (CCME, 1999);
- the derivation of soil SVs is far from being a consolidated and fully implemented process; in fact, the SVs derivation procedures are currently undergoing further implementation or revision in most of the EU countries; in many countries ecological risk SVs are under development or revision or have not been adopted yet;
- the number of substances for which soil SVs are provided widely vary across Europe, ranging from less than 20 to 234 substances, with about 60 as the most common substances;

- the group of substances for which soil SVs are most commonly generated includes heavy metals and metalloids (As, Cd, Cr, Cu, Hg, Pb, Ni, Zn), aromatic hydrocarbons (e.g., benzene, ethyl benzene, toluene), polycyclic aromatic hydrocarbons (e.g., naphthalene, anthracene, benzo(a)anthracene, benzo(ghi)perylene, benzo(a)pyrene), chlorinated aliphatic hydrocarbons (dichloromethane, trichloroethylene, tetrachloromethane), chlorinated aromatic hydrocarbons (chlorobenzene, hexachlorobenzene), pesticides (atrazine, DDT), dioxins and dioxin like PCBs.

Weaknesses and needs for implementation were recognised. Some problems are related to the regulatory framework, e.g.:

- the lack of legal recognition of SVs,
- the misuse of SVs beyond their significance and intended application,
- the lack of transparency and documentation of the SVs derivation process (in most of the countries).

Other problems are the large uncertainties of risk assessment, in particular for ecological receptors, e.g.:

- the adoption of ecological soil SVs is hindered by their conservatism (which partly reflects lack of knowledge),
- transfer and exposure modeling should be further validated,
- bioavailability and biodegradability are not (properly) considered,

Relation between soil and groundwater screening values

As a general remark, soil SVs and groundwater SVs are often derived separately and not related. The protection of groundwater resources from leaching of soil contaminants is included in the derivation of soil SVs in about 50% of the participating countries. Nevertheless, groundwater SVs play a relevant role in the management of contaminated soil. In some countries the protection of groundwater resources is the main concern and groundwater SVs are the driving factors of contaminated land remediation.

The main weaknesses of current groundwater SVs appear to be the following:

- the lack of specific groundwater SVs, with explicit choice of receptors to be protected, and the use of drinking water objectives instead,
- the fact that ecotoxicological criteria are rarely taken into account; therefore the potential impact of groundwater contamination on the aquatic and terrestrial ecosystem is not properly considered,
- the fact that hydrogeological conditions and water use scenarios are not taken into account,
- the lack of harmonization with SVs of other compartments, in particular with soil,
- the missing distinction between point and regional contamination.

Relevance of variability among national derivation methods

Four groups of risk assessment building blocks were defined, i.e. building blocks with:

- **high magnitude** of variation across Europe and **high sensitivity**, therefore with **high relevance for the variability** of SVs,
- **high magnitude** of variation across Europe but **limited sensitivity**, therefore with limited relevance for SVs variability,
- **high sensitivity** but **limited magnitude** of variation across Europe, therefore with limited relevance for SVs variability,
- **low sensitivity** and **low magnitude** of variation across Europe, therefore with very limited relevance for SVs variability.

About the first group of building blocks, i.e. the group with **high magnitude of variation and high sensitivity**, which is accounting for about 30% of the building blocks, the following conclusions can be drawn:

- many fundamental choices are included in the conceptual models of the building blocks, like receptors to be protected and exposure pathways to be included,
- concerning the selection of exposure pathways, the inclusion/exclusion of "indoor air exposure" and "consumption of home-grown vegetables" vary across Europe and has a striking impact,
- in the human health risk assessment, the inclusion/exclusion of exposure sources that are not related to soil is a relevant factor of difference,
- analogously, in the ecological risk assessment, the different ways to account for the average background concentration is a relevant factor,
- in regard to the acceptable level of incremental risk, a more or less general agreement is observed for the human health risk assessment (e.g., 10^{-5} additional cases of a tumor for carcinogenic substances), while it is still a matter of discussion for the ecological risk assessment (e.g., HC50),
- toxicological data sources seem to be critical for both the human health and the ecological risk assessment.

Among the building blocks with **high sensitivity** but **limited magnitude of variability,** there is a large range of technical issues for which reference is made to national or international guidelines of more advanced countries. It is an indication of a spontaneous alignment of methods based on common scientific agreement, which is mainly notable in ecological risk assessment.

Variability of screening values

SVs were mutually compared for a representative group of contaminants. Four types of SVs were distinguished and separately compared:

- negligible risk based SVs;
- intermediate (warning) risk based SVs, residential site use;
- potentially unacceptable risk based SVs, residential site use;
- potentially unacceptable risk based SVs, industrial site use.

As a general conclusion, the high variability of derivation methods is reflected in the large variation among soil SVs. For the same contaminant, the difference between the lowest and highest national SVs is often more than one order of magnitude. In general, the differences are larger for organic contaminants than for metals and metalloids. Trends in regard to consequent overestimating or underestimating for specific countries are not evident, which indicates that the differences are not simply related to the general higher or lower conservatism of some national approaches.

Reasons for differences of derivation methods

The analysis of possible reasons of observed differences among national procedures (geographical and biological, socio-cultural, regulatory, political or scientific) led to the following conclusions:

- in general, more than one factor is at the basis of differences between derivation methods,
- many differences in elements of risk assessment can be attributed to political/regulatory factors,
- differences in scientific approaches also have a large impact, in particular for more technical issues,
- geographical and biological differences throughout Europe do have a limited impact on elements of risk assessment,

- with specific regard to the human health risk assessment, political/regulatory reasons are usually interrelated with scientific reasons. Geographical and biological and socio-cultural reasons do play a role in many cases, but rarely are the most relevant reasons;
- with specific regard to the ecological risk assessment, reasons of differences are primarily scientific reasons, followed by political/regulatory and in few cases geographical and biological or socio-cultural.

As a general remark, it can be noted that the systematic analysis of building blocks of risk assessment shows a poor relation between the variability in national procedures and geographical and biological and socio-cultural variability across Europe. Reasons of differences are never very clear. It can be argued that many differences are due to incidental reasons, like the period in which procedures were developed and the persons in charge of their development. On the other hand, the limitations of the performed analysis on reasons of differences in risk assessment elements should be borne in mind, i.e. the poor knowledge of the rationale behind national procedures and, in particular, the relevant interrelation of reasons (e.g. political and socio-cultural reasons).

Harmonization perspective

Although the use of SVs in different countries can be different, it can be argued that there are possibilities for the alignment of derivation methods for soil SVs. This alignment of derivation methods should be approached at the level of building blocks of risk assessment elements. Components that are more suitable for alignment are those primarily related to risk assessment elements that differ for scientific reasons. The geographical and biological and socio-cultural differences seem to be marginal reasons for differences and, therefore, not essential for harmonization. By contrast, political factors are essential reasons for differences. However, the extent to which political choices can be and must be smoothed should be seen in the light of the objectives of EU soil policy and is beyond the objective of this report. It should be noted that political and scientific reasons for diversity or uniformity in risk assessment elements are often interrelated and difficult to separate.

As a final remark, it is notable that most of the national procedures are in development or under revision. In particular for the ecological risk assessment, many countries are considering its inclusion in the derivation of soil SVs, but in few cases national procedures have been already adopted. In this context the promotion of information exchange and harmonized methodologies can be utmost welcomed and beneficial.

THE HERACLES FRAMEWORK
HUMAN AND ECOLOGICAL RISK ASSESSMENT FOR CONTAMINATED LAND IN EUROPEAN MEMBER STATES
Towards the development of common references

PREFACE

The idea of this review was launched at the first meeting of the HERACLES research framework, in February 2005.

HERACLES, **H**uman and **E**cological **R**isk **A**ssessment for **C**ontaminated **L**and in **E**uropean Member **S**tates, is a long term research framework to promote the development of common references of risk assessment for contaminated land in Europe. For this scope, HERACLES combines two parallel activities: (1) working groups' discussion and (2) research and pilot projects.

While the EC Joint Research Centre ensures the maintenance/coordination of the HERACLES network and is responsible for the achievement of some specific tasks, the success of the overall HERACLES initiative is mainly based on the voluntary participation of other European research institutes. Operationally, the research framework has been structured along three types of risk assessment, also named pillars:

(1) *Relative Risk Assessment*, i.e. methods for risk based inventory of contaminated sites at regional scale,
(2) *Screening Risk Assessment*, i.e. methods for the derivation of concentration screening/guidance values of contaminants in soil,
(3) *Site-specific Risk Assessment*, i.e. the assessment of the risk to human health and the environment based on specific environmental and exposure conditions at the site.

The present review is the first study launched along the second pillar, in support to the development of common references for the Screening Risk Assessment. In the spirit of HERACLES, the study is the concerted product of a large group of experts from several European countries. It was both the prerequisite for collecting accurate information and the opportunity of sharing views and conclusions.

Rather than deriving conclusions on such a complex issue, the aim of this study is to outline boundaries and critical issues for a technical discussion on needs and possibilities of harmonization of risk assessment procedures for contaminated land in Europe.

1

INTRODUCTION TO SOIL SCREENING VALUES

Claudio Carlon

1.1 The meaning, basis and use of screening values

1.1.1 Definition of screening values

Soil Screening Values (SVs) are generic quality standards adopted in many countries to regulate the management of contaminated land. They are usually in the form of concentration thresholds ($mg/kg_{soil\text{-}dry\ weight}$) of contaminants in soil above which certain actions are recommended or enforced.

The implications of exceeding the soil SVs vary according to national regulatory frameworks. They range from the need for further investigations to the need for remedial actions. Along with their various roles in national regulatory frameworks, soil SVs have been given various names in their original languages that, translated into English, range from *trigger values* to *reference values*, *target values*, *intervention values*, *clean up values*, *cut-off values*, *and many others*.

The strength of enforcement can also vary. In some countries the reference to generic screening values is obligatory and the derivation of alternative values based on site-specific risk assessment is only possible under certain conditions. In other countries screening values are provided to risk assessors as generic guidance on the significance of contaminant concentrations in soil in a first tier of investigation, followed by a site-specific risk assessment in a higher tier.

1.1.2 Derivation basis

Screening values of contaminants are usually derived on the basis of the potential risk that contaminants pose to protected receptors (e.g. human beings, the ecosystem). The risk relates to the toxicity (an intrinsic property) of the contaminant and the exposure of the receptors of concern to the contaminant.
In the last twenty years, risk assessment for contaminants in soil has evolved in several formal technical procedures that imply the combination of exposure and toxicological modeling for the characterization of the risk. The toxicological assessment estimates the contaminant tolerable daily intake, e.g. by humans. The exposure assessment estimates daily intakes based on the contaminant fate, transport and intake via oral, inhalative and skin contact routes. At its simplest form, risk assessment consists of comparing the estimated actual/potential daily intake with the estimated tolerable daily intake.
It is evident that the exposure assessment is largely dependent on site conditions, (e.g. soil type and soil properties, depth of groundwater table, et cetera), and on the land-use (e.g. receptors characteristics, activity on the site, type of buildings). In the derivation of generic screening values, the exposure assessment refers to standard scenarios that are often designed to be protective even in (reasonable) worst cases, i.e. where (realistic) unfortunate conditions may lead to highest exposure. From another perspective, standard scenarios represent the potential use of the site that the regulator intends to protect by applying the screening values.
From a pragmatic perspective, different standard scenarios can be derived according to current or planned use of the site, e.g. industrial or residential, in order to tune protection requirements to more realistic conditions in the short-medium time perspective. This is the *fitness for use* concept that historically superseded the more ambitious *multifunctional* approach, aimed at enabling any potential use of the site, including the most sensitive one.
In accordance with the terminology used in a large part of the scientific literature, in this report the risk assessment applied to standard scenarios is referred to as *screening risk assessment*, and the resulting generic environmental quality standards are referred to as *screening values*. When the risk assessment takes into consideration specific conditions of one particular site, it is referred to as *site-specific risk assessment*. It is clear that the site-specific risk assessment can substantially improve the accuracy of risk estimations for that particular site by reducing the extent of generic and precautionary assumptions underlying screening values. It is notable that in the UK they moved away from using site-specific risk assessment and have opted to use Detailed Quantitative Risk Assessment (DQRA) for human health risk assessment, because of criticisms by some who say that all risk assessments are by their very nature site specific.

1.1.3 Advantages and drawbacks of using screening values

Advantages and potential drawbacks of using screening values have been pointed out by several authors (e.g. Siegris, 1990; Nathanail and Earl, 2001) and confirmed in practice by the long experience of application in many countries.
Clear advantages are the speed and ease of application, the clarity for polluter and regulators, the comparability and transparency and the easy understanding by a wide variety of non-specialist stakeholders. Screening values can reduce the costs and simplify the decision making in the initial stage of risk assessment.
One of the major limitations is that crucial site-specific considerations cannot be included. Screening values may give rise to a misleading feeling of certainty, knowledge and confidence. This feeling of certainty on the screening risk assessment can raise reluctance on the application of the site-specific risk assessment.

However, uncertainties in the screening risk assessment are usually tackled by using conservative assumptions that may overestimate the risk.
Today, it is recognized that screening values can play an important role in the efficient management of contaminated land. The debate has moved from merits and demerits towards the appropriate use of screening (generic) values as part of a wider procedure, including the possibility for site-specific risk assessment. A panel of European experts working within the EU funded Concerted Action for Contaminated Sites (CARACAS) reported in 1998 that "a combined approach using guideline values to streamline the preliminary stages of decision making and site-specific risk assessment to achieve fine-tuning in later stages of an investigation, is generally considered the most appropriate" (Ferguson et al., 1998).

1.1.4 Scientific and political issues

The derivation of risk based screening values has both a scientific and political bases. Political and scientific issues can often be closely linked and difficult to distinguish. One example is the definition of "acceptable risk" for non-threshold compounds (genotoxic carcinogens). It is expressed in terms excess lifetime cancer risk and ranges between 10^{-6} and 10^{-4} in the EU Member States. It can be interpreted as a political choice, but the implementation in risk assessment procedures is not solely political. "10^{-6} excess lifetime cancer risk" should not simply be treated as a quantitative statement about risk. i.e. "1 excess cancer over 1 million exposed persons". The significance of "10^{-6} excess lifetime cancer risk" has to be judged in relation to the conservative assumptions adopted in the risk estimation and finally compared to the level of risk posed by other sources, e.g. risk of inhalation of contaminated air or risks from smoking (as it is estimated under the same conservative assumptions). In practice, "10^{-6} excess lifetime cancer risk" is an operational threshold agreed between policy makers and scientists based on judgments of conservatism, public perception and social acceptability of implications; it is therefore "conventional" (Ferguson and Denner, 1994).
Another example is the definition of the exposure conceptual model, i.e. the identification of potential pathways of exposure to contaminated soil for human and ecological receptors. It can be interpreted as a scientific issue, but it is not solely scientific. By defining the potential receptors of concern and types of use of the land, the conceptual model sets what type of use of the land has to be assured and the extent of protection for most sensitive subgroups of the population. The conceptual model, therefore, is "conventional" and based on both the political and scientific judgment. The merging of scientific and political judgment is present in both the screening and site-specific risk assessment, but is clearly more relevant in the screening due to the application of standard conceptual models. The emphasis in this text on "conventional" aspects is not to say that scientific and political issues in risk assessment cannot be distinguished. On the contrary, it is important that "conventional" components of risk assessment are clearly identified to make the interaction between scientist and decision makers more transparent and efficient.

1.2 Comparison of screening values

1.2.1 Variability in Europe

During the last years, along with the development of a more integrated market economy and common environmental policies, the large variability of screening values adopted by European countries has raised questions among risk assessors and regulators. This variability can be associated with multiple reasons. National regulatory frameworks are different, and screening values can be used for different purposes. At the European scale, methods adopted by national authorities to derive screening values are very variable. In some cases, differences can be attributed to environmental or socio-cultural factors. In other cases differences can reflect different national strategies in environmental policies. Moreover, several scientific issues can still be debated and national differences can reflect a substantial disagreement within the scientific community. In other cases, however, no clear reasons for differences are recognized and incidental factors seem dominant, such as the personal experience of people in charge of the definition of methods, historical aspects, et cetera.

1.2.2 Previous studies

So far the variability of screening risk assessment methods in Europe has been poorly analyzed, while a number of studies were focused on the comparison of site-specific risk assessment practices and software tools (Whittaker *et al*., 2001; Rikken et al., 2001; Evans *et al*. 2002; Swartjes, 2002 and the NICOLE comparison study performed by Geraghty&Miller International Inc., 2004, Quercia et al., 2006). Bearing in mind that in some cases the site-specific risk assessment is based on the same modeling used in the screening risk assessment, the results of these studies can help in the interpretation of differences among screening values. In any case, these studies were limited to the human health risk assessment.
The most comprehensive review on the variety of risk assessment practices for contaminated land in Europe are the two volumes published in the frame of the EC funded Concerted Action on Risk Assessment for Contaminated Sites in Europe (CARACAS, 1996-1998). Volume 1 (Ferguson et al., 1998) addresses the scientific basis of risk assessment and Volume 2 (Ferguson and Kasamas, 1999) provides a picture of national policy frameworks for the management of contaminated land in Europe. With special regard to the screening risk assessment, Volume 1 explains differences and commonalities of the screening (generic) and site-specific risk assessment. It also provides a scheme for ranking screening/guidance values in Europe into three types, according to their role in decision making. Type A values represent a limit above which remediation interventions will be required, Type B values indicates the need for further investigations and Type C values are optional references mainly in support to the application of the site-specific risk assessment.
In a more recent study insight was given in the variability among screening values for eight metals adopted in 10 different countries, among them six EU Member States, (Provoost et al., 2006). However, a comprehensive in depth analysis of the variability of the derivation procedures of screening values in the representative EU Member States is still lacking and the reasons for national/regional differences are largely to be explored.

1.2.3 The present review

The present review analyses the basis of the screening values used in EU Member States and must initiate a discussion on the reasons for their differences. For this purpose, it starts with listing the main features and building blocks of technical procedures in order to analyze them one by one. Representatives of all EU-countries were asked to provide appropriate information on these risk assessment elements on the basis of a questionnaire. Because the contamination of soil and groundwater below is closely related, also the relation between soil and groundwater screening values was explored.

The results of the review are described in the following chapters: Chapter 2 introduces the rationale, i.e. the general methods of the review; Chapter 3 provides an analysis of variability of elements of risk assessment and reasons of differences; Chapter 4 illustrates how differences in the derivation basis are reflected in the variability of screening values among the Member States; Chapter 5 provides an insight in the relation between soil and groundwater screening values in EU countries; Chapter 8 draws up conclusion remarks and the outlook.

2

RATIONALE AND METHODS OF THE REVIEW

Claudio Carlon, Frank Swartjes

2.1 Objectives

The present review analyses the bases of screening values used in EU Member-States and initiated a discussion on the reasons for their differences. Specific objectives of the review were the following:

- to describe the state of the art of SVs derivation methods and their application in Europe,
- to assess commonalities and main differences among national methods,
- to gain a further insight in reasons of differences,
- to identify opportunities for harmonization.

The analysis encompasses regulatory threshold values based on both human health and/or ecological risk. Rather than undertaking a detailed analysis of specific algorithms and input values, it focuses on the main features of technical procedures (e.g. conceptual models, methodologies applied, et cetera). It was assumed that differences in basic assumptions and approaches can explain most of the differences observed in screening values. Moreover, at this level scientific and political issues are often intermingled and not clearly identified. The recognition of scientific and political factors and their role in shaping the risk assessment procedures is one of the objectives of the present survey as a prerequisite for harmonization. A detailed analysis of algorithms and input values will be the objective of a follow up review, in the future.

The review concerns a representative group of European countries. A comprehensive picture of all 27 EU Member States would be very demanding and of limited added value, because of similarities and the fast development of new regulations in many countries.

That would likely make the review outdated just after its completion. After an initial survey extended to all European Countries, the review is focused on 15 countries. The selection was limited by the need of proactive and voluntary contributions from contacted experts, but finally included the most relevant examples of risk-based regulations of contaminated land in Europe. It encompasses old and new EU Member States, i.e. Austria, Belgium (Wallonia and Flanders), Czech Republic, Germany, Denmark, Spain, Finland, France, Italy, Lithuania, The Netherlands, Poland, Slovenia, Sweden and United Kingdom.

2.2 A coherent framework for comparing risk based screening values

2.2.1 Terminology and meaning

As mentioned in Chapter 1, soil screening values can have various applications, and can be grouped into three types:

- triggering further investigations,
- enforcing , or setting the urgency for remedial actions,
- targeting long term or short term objectives for remedial actions.

The variable regulatory significance in different countries led to the proliferation of soil SVs denominations, like screening values, guidance values, target and intervention values, maximum acceptable concentrations, cut off values, trigger values, environmental quality objectives. The diversity of terms reflects the lack of a coherent framework in Europe for the derivation and use of screening values.

2.2.2 Type of screening values

The type of SVs can be related to different levels of risk, e.g. negligible risk or potentially unacceptable risk levels. In general terms, the derivation of negligible risk levels aims at excluding that any type of adverse effect occur even in the most sensitive land use. It is characterized by the very high conservatism, the comprehensive protection of the natural environment and the definition of long term sustainability objectives. On the other hand, the derivation of potentially unacceptable risk levels aims at preventing that significant adverse effects occur. It is characterised by a lower conservatism and a functional perspective of soil protection directed to the support of human living and main ecological functions. It is important to keep in mind that by definition SVs are related to generic scenarios/land uses and do not take into account site specific conditions. For this reason the term "potentially" is here used to differentiate from the "actual" risk that might be estimated in consideration of the current specific land use and environmental conditions.
Which level of risk to consider in the derivation of a specific screening value is usually related to the intended application within the legal framework. With this regard, there are no fixed rules, but common practices. *Long term objectives* for soil quality, for example, are usually based on the negligible risk level; in this case SVs might relate to multifunctional uses of the site or could be a representation of sustainable soil quality. By definition and practical reasons, natural average background values are often regarded to be associated to negligible risk level (soil quality objectives lower than the average background level would be not feasible).
On the other hand, *the possible need for actions* is often related to levels indicating a potential unacceptable risk. In an extended definition, actions can include remediation, restrictions in land use, urgency for remediation, further investigations and/or the application of site specific risk assessment. While in the past SVs were widely applied for defining land use restrictions and forcing remediation works, nowadays in many countries SVs are only used as trigger values for site specific

investigations, whose outcomes are then considered in relation to needs and objectives of remediation works.
In some cases *the need for further investigations* is related to some intermediate risk levels. A useful intermediate risk is then associated with a scenario based on generic (protective) assumptions, the validity of which could be checked in a site-specific risk assessment. A higher conservatism of intermediate risk thresholds with respect to potentially unacceptable risk thresholds is the basis for the discrimination between soils of sufficient quality and soils that warrant further investigations. Therefore, in some cases three sets of SVs can be derived on the basis of negligible, intermediate (warning) and potentially unacceptable risk levels, and these SVs be applied as long term quality objectives, trigger values and cut-off (remediation needed) values, respectively, as it is exemplified in figure 2.1.

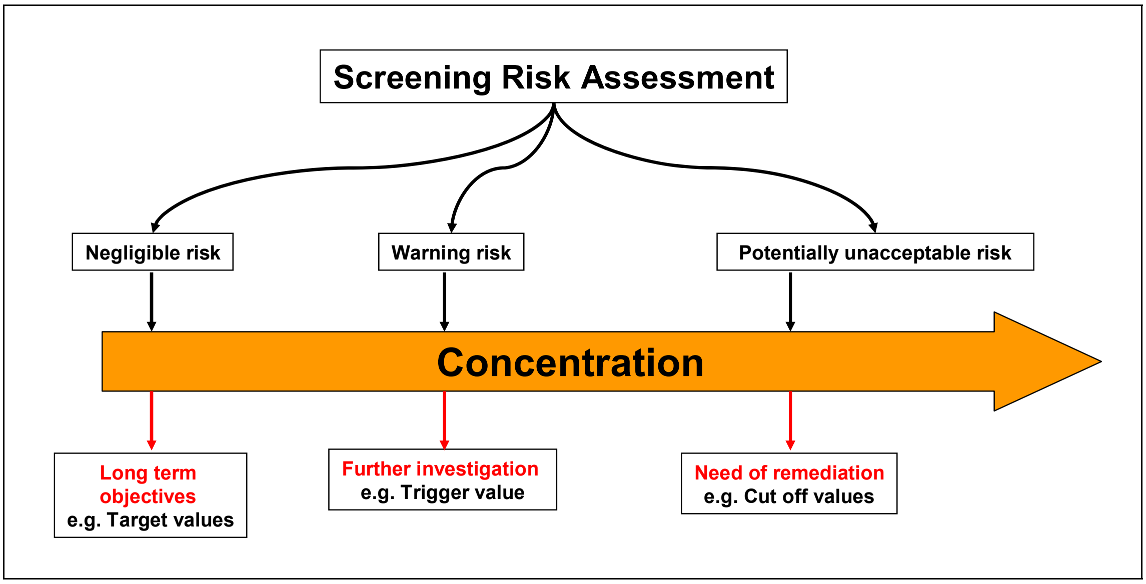


Figure 2.1. Example of derivation of screening values based on various risk levels and different screening values applications

In summary, screening values can be classified into different risk categories, broadly termed negligible risk, warning risk and potentially unacceptable risk. The appreciation triggered by each risk category, however, depends on the national regulation. Moreover, they can be distinguished into screening risk and site-specific risk concentration values.

2.2.3 Framework for the risk based regulation of contaminated land

The screening risk assessment usually overestimates the risk due to conservative assumptions. By taking full account of local circumstances (e.g. soil type and soil properties, climate, specific use of the land, human behavior patterns, background intake, et cetera), the site-specific risk assessment allows the reduction of conservatism. As a consequence, more consistent, usually less stringent, threshold values can be derived. It means that providing the same level of protection (or risk) site-specifically based risk concentration values are usually higher than screening risk concentration values.

Screening values and site-specific values are both valuable tools for managing the risks at contaminated sites which are often used in combination. Regulators prescribe how to use them in national frameworks.
The framework for the risk based regulation of contaminated land can be schematized by three axes, as represented in Figure 2.2:

- the *screening risk assessment axis*, providing screening values according to various risk levels;
- the *site-specific risk assessment axis*, providing site-specific threshold values according to various risk levels (in general only the unacceptable risk level), equal to that considered in the screening assessment, but based on a more realistic derivation;
- the *risk management axis*, along which policy makers decide how to implement the values provided by the former two axes.

Along the risk management axis, the use of screening and site-specific threshold values is prescribed. In the hypothetical example of Figure 2.2, the exceeding of screening values for warning risk leads to the estimation of site-specific values. If the latter are exceeded, the remediation can be enforced up to the achievement of negligible risk levels, according to screening values.

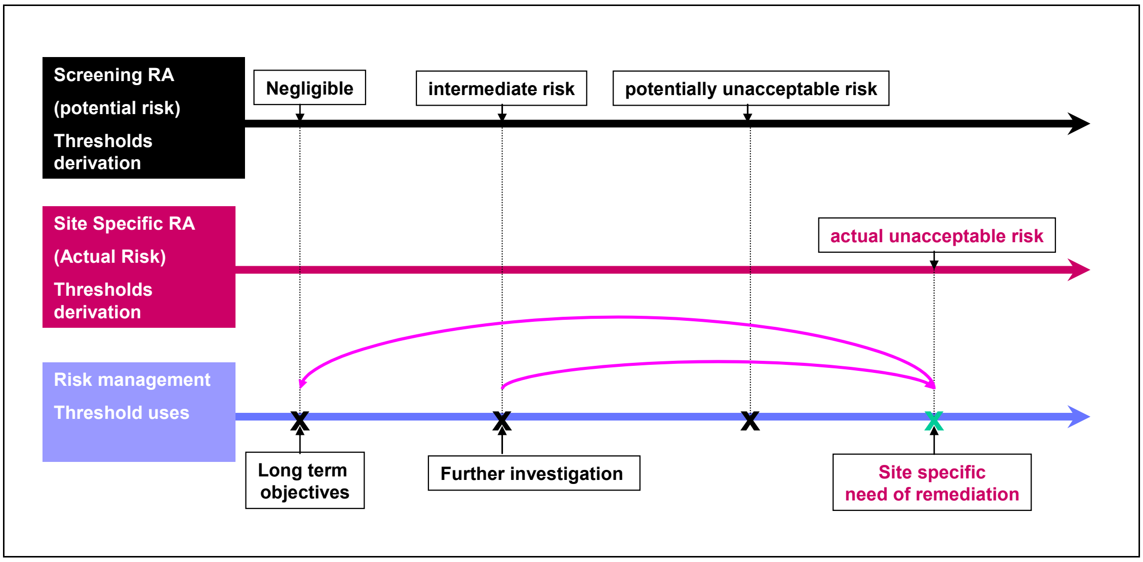


Figure 2.2. Example of a framework for the derivation and use of risk based threshold values.

In the ideal world, scientists developing SVs methods would closely collaborate with decision makers defining the SVs application. In practice, the derivation methods of SVs may be decided and discussed, e.g. within the scientific community, without specific reference to the use of SVs. Analogously, the application of SVs may be decided without full account of the rational and methods behind their derivation. Moreover, changes in the application of SVs don't always imply changes in derivation methods. The representation of different axes for the derivation of "screening RA values", of "site specific RA values" and for the "definition of uses" out-points the fact that these are usually performed by different actors, e.g. scientists in national authorities, risk assessment practitioners and regulators respectively. Although this is the most common case, it should not refrain from considering the need of coordination. Table 2.1 is an example of how the risk management of contaminated soil in various countries can be described and compared with reference

to risk levels addressed in the derivation of screening and site specific values (in column) and the regulatory application of these values (as specified by the text in the table cells). Based on Table 2.1, the two limit situations appear to be Poland, not considering site-specific risk values, and Greece, not using screening values. In most countries "intermediate" or "potentially unacceptable" screening values are used to trigger further investigations, while site-specific values are used to indicate the need of remediation. In some countries, remediation targets are fixed according to negligible risk criteria (provided the ALARP - As Low As Reasonably Practicable – principle). It can be also noted that the site specific risk assessment is never applied to identify negligible risk levels.
It should be clearly anticipated that the classification of screening values according to risk levels requires a deep knowledge of applied derivation methods and in some cases can end out with arguable results. For this reason Table 2.1 should be regarded as a tentative description of national approaches. On the other hand, the classification according to risk levels shows clear advantages in terms of consistency and usability of results with respect to the classification according to uses. The classification according to screening values uses easily leads to a complex situation in which differences are made for classes of contaminants, time to which the contamination was discovered and other boundary conditions. Moreover, the prescribed use of screening values is changing in many national regulatory framework without related modifications of derivation methods.

Table 2.1. Type of screening values and site-specific risk assessment in European Member States (16 countries)

Legend: Austria (AUT); Belgium Flanders (BE(F)); Belgium Bruxelles (BE(B)), Belgium Walloon (BE(W)); Czech Republic (CZE); Finland (FIN); Italy (ITA); Lithuania (LTU); Netherlands (NLD); Poland (POL); Slovakia (SVK); United Kingdom (UK); Denmark (DNK)

Countries	**NEGLIGIBLE RISK**		**INTERMEDIATE RISK**		**UNACCEPTABLE RISK**	
	Screening RA	**Site-specific RA**	**Screening RA**	**Site-specific RA**	**Screening RA**	**Site-specific RA**
AT			**Trigger value** Further investigation		**Intervention values** (in principle to be remediated) (only for some contaminants)	**SS-Inter.** Define the need for remediation and target concentrations
NL	**Target value** (long term objectives)				**Intervention values**	Define **urgency of remediation**. Remedial concentration targets for immobile contaminants
IT					**Limit values** (in principle to be remediated)	**SS-Inter.** Define the need for remediation and target concentrations
BE-FL	**Background** first target for remediation, but BATNEEC applies		**Further investigation** (for historical contaminants only)		**Clean-up standards** (for new contaminants only	**SS-Inter.** Only for historic pollution: need for remediation. It can support BATNEEC
BE-W	**Reference value (Background)** Target for remediation		**Trigger values** Further investigation		**Intervention values** (in principle to be remediated)	**SS-Inter.** Only for historic pollution: need for remediation. It can support BATNEEC

Table 2.1. Continuation

Coun-tries	NEGLIGIBLE RISK		INTERMEDIATE RISK		UNACCEPTABLE RISK	
	Screening RA	**Site-specific RA**	**Screening RA**	**Site-specific RA**	**Screening RA**	**Site-specific RA**
CZ	**A.** (long term objectives)		**B.** Further investigation		**C.** (in principle to be remediated)	
DK			**Soil Quality Criteria**		**Cut-off values** (in principle to be remediated – for immobile cont.)	
DE			**Trigger values** Further investigation		**Action levels** (in principle to be remediated)	**SS-Inter.** Define the need for remediation and target
ES			**Guidance values** Further investigation, or site specific assessment			**SS-Inter.** Define the need for remediation and target
FI			**Threshold values site specific assessment required**		**Lower and Upper guidelines**	
SE			**Trigger values** Further investigation			
SK	**A** Target for remediation in groundwater sensitive area		**B** target for remediation in groundwater less sensitive areas		**C** Intervention values (in principle to be remediated)	
PL					**Maximum Permissible Concentrations** (in principle to be remediated)	
LT					**Maximum Permissible Concentrations** (in principle to be remediated)	
IT					**Limit values** (in principle to be remediated) also remediation targets	**SS-Inter.** Define residual concentration limits
UK			**Soil Screening Values for ecological receptors**. Triggers for further investigation	Refinements made to measured field concentrations (the PEC) and then compared with SSVs for ecological receptors. Triggers for further investigation	**Soil guideline values** Site specific assessment required	**SS-Inter.** Define the need and target for remediation

2.3 Methods for collecting information

The collection of information was obtained with the voluntary contribution of experts from several EU countries. The information was requested by means of a questionnaire and in the form of a country report.
The questionnaire, reported in Annex 1, was intended to be a tool for the analysis of technical aspects of soil SVs derivation methods. It was based on multiple choices and investigated all the building block of the derivation of screening values. It was subdivided in three sections:

- the regulatory framework and main features (first and last part of the questionnaire);
- the exposure and toxicological assessment for human receptors;
- the exposure and toxicological assessment for ecological receptors.

Questions on the regulatory framework concerned the purpose, meaning, status and documentation of the guidelines. Questions on main features consisted of the scientific basis, protected receptors, the inclusion of economic and social factors and the comparison with monitored concentrations. Questions on the human health and ecological risk assessment consisted of main methodological aspects in the exposure and toxicological assessment.
The country report, reported in Annex 2, is primarily intended to be an explanatory text in support of the interpretation of the questionnaire answers. For this purpose they have a similar structure of the questionnaire.
The review was extended to groundwater screening values in order to explore their relation with soil screening values. Information on groundwater screening values was only gathered from the country reports.

2.4 Methods for the analysis of relevance and reasons of differences

2.4.1 Relevance of differences

The analysis of the variability among countries was performed for each building block of the technical derivation procedure for soil SVs. The relevance of observed differences in technical procedures was considered in relation to the effect on SVs variability, and expressed by the combination of two factors: the magnitude of differences and their sensitivity in the estimation of SVs. The two factors were scored as described below.

Magnitude of differences

The Magnitude indicates the extent of heterogeneity among Member States. In most cases questions require Boolean answers (e.g. “Yes/No” on the possible adoption/inclusion of a specific element for risk assessment). In that case the Magnitude score is related to the percentage of Member States that does, or does not, include this specific element. In the case of quantitative questions on input values, for which many numerical answers are possible, the Magnitude is expressed as percentage of Member States using values that deviate from the most commonly used value. Scores from 0 to 3 were given according to the following scale:

Magnitude Score	Differences in elements of risk assessment
0	No differences
1	Exceptions: only 1-2 Members States use an approach that deviates from the majority
2	Circa 25% Members States (i.e. 3-4 Member States, according to the total number of respondents) use an approach that deviates from the majority
3	Circa 50% Members States (i.e. 6-8 Member States, according to the total number of respondents) use an approach that deviates from the majority

Sensitivity

The *Sensitivity* indicates the power of differences of that specific component to lead to numerical differences in the estimated screening values. In the case of Boolean (e.g. "Yes/No") answers, the sensitivity was scored on the basis of the expected effects of different options (e.g. adoption /inclusion of specific risk elements) on the SVs estimation. In the case of numerical answers, the sensitivity score is related to both the relevance of the specific input value and the observed range of variability, as it appears from the minimum and the maximum values reported in the questionnaires. Scores from 0 to 3 were allocated according to the following scale:

Sensitivity Score	Effect on SVs
0	No effects on screening values
1	Negligible effect on screening values: choice for elements of risk assessment could affect screening value with no more than a factor of 2
2	Substantial effect on screening values: choice for elements of risk assessment could affect screening value with a factor of 2 to 10
3	Huge effect on screening values: choice for elements of risk assessment could affect screening value with more than a factor of 10

The sensitivity scores were assessed on the basis of expert judgment, accompanied by notes and, where possible, supported by scientific references. Scores were given by the authors (Claudio Carlon and Frank Swartjes) independently and compared. In case of differences the authors discussed the Sensitivity of the specific element of risk assessment until consensus was reached. In some cases, e.g. for regulatory or legal aspects, the sensitivity scoring was not applicable.
The final outcomes have been peer reviewed by the wide group of experts that contributed to the country reports (the list in page III).

2.4.2 Reasons of differences

Five categories of reasons for differences have been defined:

1. ***Geographical and biological***, associated to the environmental variability across Europe, and in particular to:
    - regional factors affecting the *potential exposure of receptors to, or mobility and environmental availability of, soil contaminants*, such as groundwater depth, rainfall, snow cover, typical organic content of soil, typical soil texture, vicinity of surface water body, temperature for evaporation,
    - physical factors affecting the *sensitivity of human receptors*, such as average body weight, life duration,
    - physical factors affecting the *sensitivity of ecological receptors*, such as the presence of vulnerable species,
2. ***Socio-cultural***, associated to the variability of social behaviors and land use across Europe, and in particular to factors affecting the *potential exposure of receptors to soil contaminants*, such as frequency and duration of open air activities of kids, typical building construction, gardening and consumption of homegrown vegetables
3. ***Regulatory*,** associated to regulatory requirements, such as constitutional aspects or complementarities with other existing laws,
4. ***Political*,** associated to the prioritization of environmental and economic values, as it is usually made by policy makers and regulators,
5. ***Scientific***, associated with arguments of competing scientific views.

When no clear reasons for differences were identified and incidental factors seem dominant, such as the personal experience of people in charge of the definition of methods, historical aspects, et cetera, this was also reported in a separate column (*Remarks*). On the basis of expert judgement the reasons for differences in elements of risk assessment have been identified. When multiple reasons were identified, the reasons were ranked, being 1 the most important reason, 2 the second important reason, et cetera.
It is important to take into consideration that this exercise was addressed to identify reasons that might explain the observed differences. The approach is different from the definition of potential reasons for differences. Some reasons for adopting different approaches might be reasonable, but apparently not considered in practice in the participating countries.
The identification of reasons for differences was performed by the authors (Claudio Carlon and Frank Swartjes) independently and compared. In case of differences the authors discussed the Sensitivity of the specific element of risk assessment until consensus was reached. In some cases, e.g. for regulatory or legal aspects, the sensitivity scoring was not applicable.

3

ANALYSIS OF VARIABILITY AND REASONS OF DIFFERENCES

Claudio Carlon and Frank Swartjes

The analysis has been described in three different sections, i.e. for the regulatory framework and main features (section 3.1), the human health risk assessment (section 3.2) and the ecological risk assessment (section 3.3).

3.1 Regulatory framework and general features

The elements of risk assessment related to the regulatory framework and general features are incorporated at the beginning and the end of the questionnaire. There are 11 main topics encompassing questions on the type of regulatory instruments, their purposes and their harmonization with other environmental regulations.
The answers of all the countries that returned the questionnaire (17 participating countries) have been listed in a summary table presented in Annex 1.
For each topic, the relevance and the reasons of the variability are discussed and scored, below. The relevance of variability is discussed in terms of magnitude only, because for these topics the sensitivity term is usually not applicable. The results are also summarised in Table 3.2

Legal framework

Overview
In most countries, soil SVs are provided by special laws for contaminated sites. In some cases they are provided by soil and groundwater protection laws and in few cases by waste management laws. In most cases soil SVs are defined by national laws. In Germany and Spain federal/ national framework laws demand most of the

matter to the regional regulation. In Belgium, there are regional laws for Flanders, Walloon and Brussels regions.
Relevance of variability
Concerning the object of the law, (e.g., special for contaminated land, general on soil protection or waste management) the magnitude of the variability can be scored *very high*. With regard to the national or regional domain of the law, the variability is scored *high*.
Reasons of differences
Reasons for differences are political and regulatory.

Purpose

Overview
The terms of application of soil SVs are usually articulated and make difficult to distinguish between trigger values (triggering actions) and intervention values (enforcing actions). The application can change for historical (prior to a certain date related to the entry into force of the law), recent or future contamination. The implication of exceeding SVs can also differ between contaminants, e.g. mobile or less mobile. In the last ten years in many countries the use of soil screening values has been more strongly combined with the application of site-specific risk assessment: obligations to clean up have been changed into requests of site-specific assessments and eventual risk based management or remediation. As a result, SVs are more and more often used as trigger values.
Relevance of variability
The magnitude of the variability can be evaluated as *very high*.
Reasons of differences
Reasons for differences are clearly political and regulatory. Clean up values lead to strict targets and simplified administrative procedures. The use of trigger values in combination with site-specific risk assessment leaves a wider room for site-specific tailored solutions.

Status

Overview
In some countries SVs have been proposed but not legally adopted, while in other cases their formulation is still under development or revision. In some countries the use of SVs is only advised and not obligatory.
Relevance of variability
The variability of legal status is *high*.
Reasons of differences
Reasons for differences are clearly *political* and *regulatory*.

Scientific basis

Overview
For the derivation of SVs, 11 countries developed national risk assessment models. Rather than starting a new modeling exercise, 5 other countries (AT, CZ, LT, SL, and PL), adopted, and eventually adapted, SVs formulated by other countries.
The most common methodological references were: EC Technical Guidance Document on risk assessment (1996 and implementations), US-EPA and US-ASTM guidance, methods developed in The Netherlands and methods/values from the Russian federation (ex Soviet Union). Directly or indirectly, SVs are always based on a risk-based approach.

Relevance of variability
The distinction between countries with or without national proprietary models shows a high variability across Europe.
Reasons of differences
Reasons of difference are political, regulatory and socio-cultural. However, historical (incidental) reasons seem to have played an important role. Some countries were aware of the problem of soil pollution before others. Also the vicinity to the US experience in the application of risk assessment modeling for contaminated land was different from country to country. Another critical factor has been the fast evolution of environmental regulatory frameworks in some countries, like in the new EU Member States, which obviously led to the reference to procedures or values already adopted in other countries.

Level of Public domain of the methodology

Overview
The methodology is published only in few cases and it is often not accessible. The result is that derivation methods behind screening values are often not transparent. This lack of transparency for the screening risk assessment has also drawbacks on the application of the site-specific risk assessment, which is usually a site-specific application of the same methods as for screening risk assessment.
Relevance of variability
The magnitude of variability is very high, with almost 50% of countries without published and/or accessible technical information on national SVs.
Reasons of differences
Reasons are political. Transparency in technical regulations is advocated where the need of a constructive dialogue among stakeholders is taken in consideration.

Revision

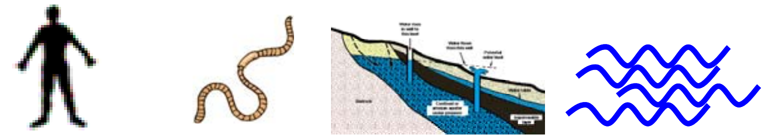
Overview
Revisions of soil SVs are generally occasional, with exception of three countries (AT, DE and NL) where periodical revisions are planned.
Relevance of variability
The magnitude of variability is low, with the wide majority of EU countries in similar conditions (occasional revisions).
Reasons of differences
Reasons can be mainly found in the political sphere. In some countries the political interest in the soil pollution problem also led to scientific programs and structures in support of long term soil protection policies.

Protected receptors

Overview
The results are presented in Table 3.1, showing that all participating EU countries primarily address the protection of human health as is illustrated by the number of shaded boxes in the human health column. Many countries (11 out of 14) also consider the protection of ecological receptors, even if few of them already adopted ecological SVs. In Flanders and Walloon regions in Belgium, Czech Republic, UK and Denmark, ecological SVs have been derived but not implemented by the current legislation. The soil-groundwater leaching pathway is considered in ca. 50% of the countries, while the protection of surface water is usually not included, with exception for Spain (only in the natural land use) and Sweden. More about the inclusion

of soil-groundwater leaching pathways is reported in chapter 5 - Relation between soil and groundwater screening values.

Table 3.1. Protected receptors considered in the derivation of soil screening values in 15 EU countries. For the terrestrial ecosystem, green cells indicate that methods and values are already in use in the current regulatory system, while yellow cells indicate that a proposal is under evaluation and will be possibly adopted in the future.



	Human health	Terrestrial Ecosystem	Groundwater drinking	Surface Water
Austria				
Walloon (BE)				
Flanders (BE)				
Czech Rep.				
Denmark				
Germany				
Finland				
Italy				
Lithuania				
Netherlands				
Poland				
Spain				
Sweden				
UK				

<u>Relevance of variability</u>
The magnitude of variability is *very high*. The sensitivity is also *very high* because the inclusion/exclusion of protected receptors strongly affects the resulting SVs.
<u>Reasons of differences</u>
Reasons of differences are complex and not always evident.
First there are *political* decisions for extending the protection from merely the human health to the soil ecosystem and wildlife.
Geographical and biological factors can also play a relevant role: e.g., the inclusion of surface water receptors in the standard conceptual model can be due to their large presence all over the country (e.g. Sweden). The higher relative importance of ecological resources in small sized and intensive populated countries, like NL, can be a reason for including ecological protection. Besides, the national importance of groundwater as a source for drinking water can be a reason for its inclusion among the considered receptor. In Finland, groundwater and surface water pathways are not included in the derivation of SVs because they should be considered at site specific level; difficulties in modeling (the heterogeneity of soil, fragmentation of the bedrock and the variability in the size, quality and sensitivity of the Finnish aquifer and surface water) and the importance given to groundwater and surface water resources are the reasons indicated by the Finnish competent authority.
In any case, *social and cultural factors* obviously drive political decisions. *Regulatory* boundary conditions can also affect the inclusion or exclusion of receptors. In particular, the inclusion or exclusion of the leaching-groundwater pathway can be partly justified by a separate legislation for groundwater protection.

Scientific arguments can be also indicated, e.g. a reason for excluding certain pathways such as the surface water pathway is the limited significance of modeling results for generic scenarios (large variability in groundwater discharges and surface water rates are hard to capture in generic models).
However, based on the reasons above it is often difficult to explain the differences among technical procedures in EU countries. It is difficult to explain, for example, why great differences exist between geographically related countries, or do not consider geographical variability within the country. It is reasonable to think that incidental reasons, e.g. historical circumstances, contingent political concerns, personal views, have also played a relevant role in shaping the national SVs.

Integration of screening risk values for different receptors

<u>Overview</u>
In some countries human health and ecological risk screening values are integrated in one value by choosing the lowest between the two. When the lowest value is affected by high uncertainty, weighted averages between the lowest and the highest values can be preferred. In some other countries the integration is avoided and both values are presented. The extrapolation of one reference value out of the two is made case by case (e.g., DE, UK, under discussion in Flanders).
<u>Relevance of variability</u>
The magnitude of the variability is *high*, since there is not a clear trend in Europe towards one of the two options.
<u>Reasons of differences</u>
Reasons are *political* and *scientific*.
Politically speaking, it can be argued that the separate consideration of human health and ecologically based values is more transparent. However, it should be noted that the formulation of integrated SVs does not exclude the indication of the separate human health based and ecologically based values.
Scientifically speaking, the method for the integration of the two values can be matter of discussion, in particular where uncertainty-based weighted averages are applied.

Economic or social factors

<u>Overview</u>
Economic and social factors are not generally included in the derivation of SVs, but are implicit in basic assumptions, methodological choices and default input values. Nevertheless, for some substances, i.e. total hydrocarbons, a risk-based approach is not feasible (it is a variable mixture with not defined toxicological properties) and the derivation of SVs is mainly based on political and pragmatic considerations. The consideration of economic and social factors in the screening values is reported only for Flanders, but it may be common in other countries as well: proposed values are discussed with stakeholders and compared with results from soil investigations (in case of revision) before they are finalized.
<u>Relevance of variability</u>
The assessment of socio-economic feasibility is a general process in the derivation of legally binding values. However, it is important that transparency is maintained in the derivation process, so that scientific proposals and values resulting from socio-economic decisions can be distinguished. There is a general consensus on the fact that political and economic factors should not be included. The magnitude of variability is low.
<u>Reasons of differences</u>
Reasons are political.

Comparison with measured concentration

Overview

In most cases, screening values refer to total contents (or chemical species like Cr^{VI}) in soil. In few cases leaching concentrations are considered for the soil groundwater or soil-plant transfer pathways (e.g. DE).

Only in Spain, in the ecological screening risk assessment, results of bioassays are considered along with chemical screening values. In other countries the combination of bioassays and chemical analysis is not performed in a risk screening phase but is possible, or recommended, for the site-specific risk assessment (e.g. TRIAD approach for assessing site-specific ecological risks in NL and UK) (Burton et al. 2002a; Burton et al. 2002b).

Screening values are expressed in terms of $mg/kg_{soil\text{-}dry\ weight}$.

Some countries compare soil volume averaged measured concentrations with SVs (in NL at least 25 m^3 soil volume is considered), however in most of the countries the comparison is made with concentrations observed per soil sample.

Poor information has been collected about the depth of top soil and whether or not the subsoil, and to which depth, is considered in relation to SVs.

Contaminant concentration is usually analyzed in the fraction sieved at < 2 mm, with the exception of Lithuania (<1mm).

Relevance of variability

The variability shows a *low* magnitude, but *high* sensitivity, since different comparison methods may heavily affect the final results.

Reasons of differences

Reasons are basically scientific, since all these operational choices are intended to provide scientifically meaningful results. The consideration of top soil or the inclusion of subsoil horizons has both scientific and political implications.

Table 3.2. Relevance and reasons of variability in the regulatory framework and main features of soil screening values derivation methods.

<table>
<tr><th></th><th></th><th colspan="2">Relevance</th><th>Geographical and biological</th><th>Socio-cultural</th><th>Regulatory</th><th>Political</th><th>Scientific</th></tr>
<tr><th></th><th></th><th>Sensitivity</th><th>Magnitude</th><th></th><th></th><th></th><th></th><th></th></tr>
<tr><td rowspan="6">Legal framework</td><td>Special law for contaminated sites</td><td rowspan="3">N.A.</td><td rowspan="3">3</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3">2</td><td rowspan="3">1</td><td rowspan="3"></td></tr>
<tr><td>Soil protection or groundwater protection law</td></tr>
<tr><td>Waste management law</td></tr>
<tr><td>National law</td><td rowspan="3">N.A.</td><td rowspan="3">2</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3">2</td><td rowspan="3">1</td><td rowspan="3"></td></tr>
<tr><td>Regional law</td></tr>
<tr><td>Other</td></tr>
</table>

Table 3.2. Continuation

		Relevance		Geographical and biological	Socio-cultural	Regulatory	Political	Scientific
		Sensitivity	Magnitude					
Purpose (more than one use is possible)	Target values of negligible risk	**N.A.**	**3**			**2**	**1**	
	Trigger values: further investigations,							
	Trigger value: restrictions in land use,							
	Trigger value: site specific risk assessment,							
	Target values: remediation objective							
	Cut off values for urgent remediation							
	Other							
Status	legal,	**N.A.**	**2**			**2**	**1**	
	In development							
	Obligatory							
	Advised							
	Other							
Scientific basis	Risk based	**N.A.**	**2**		**3**	**2**	**1**	
	Background natural concentrations							
	Reference to procedures or values of other coun-tries (specify which)							
	Other (specify if known)							
Level of public domain of method-ology	Published methodology for SSV derivation	**N.A.**	**3**				**1**	
	Not published, but accessible							
	Not published and not accessible							
Revision	Continuous revision	**N.A.**	**1**			**2**	**1**	
	Periodical revision (every n. years)							
	Occasional revision of some values							
	Revision not planned							

Table 3.2. Continuation

		Relevance		Geographical and biological	Socio-cultural	Regulatory	Political	Scientific
		Sensitivity	Magnitude					
Protected receptors	Human Health							
	Ecosystem							
	Groundwater for drinking uses							
	Groundwater (as a receptor, not solely a pathway) Groundwater is considered a receptor when Soil Screening Values have to comply with groundwater quality criteria.	3	3	2	3	4	1	
	Surface water							
	Adopted when (specify): • Always • Only when (specify criteria)							
Integration	Integration with soil screening values derived by human health RA	3	2				1	2
	Other (e.g. uncertainty based)							
Economy	Consideration of economic or social factors	3	1				1	
	No							
Measured concentration	Total concentration							
	site-specific corrections for bioavailability	3	1					1
	operational concentration (reported to standard soil)							
	dry soil	3	1					1
	moist soil							
	sieved soil. Specify size (e.g. 2 mm)	3	1					1
	top soil							
	top soil + subsoil	3	3				1	2
	not defined							

3.2 Human health risk assessment

The answers of all the countries that returned the questionnaire (17 participating countries) have been listed in a summary table presented in Annex 1.
For each topic, the relevance and the reasons of the variability are discussed and scored, below. The results are also summarised in Table 3.6.

Status

<u>Overview</u>
Human health based SVs are still under approval in some countries. In most of the cases there is an on-going activity for the extension of the SVs list. The analysis of

type and number of substances included in the current national SVs lists is presented in chapter 4.
Relevance of variability
The magnitude of variability is high.
Reasons of variability
Political and regulatory reasons.

Generic or land-use specific

Overview
Land use scenarios for SVs values in the participating EU countries are shown in Table 3.3. It can be noted that most of the countries adopted land-use specific SVs, with exception of The Netherlands and Slovak Republic (which refers to Dutch values). In the case of Denmark, generic soil values are provided but different compliance requirements (in terms of soil depth) are set according to the land use.
The land use scenarios considered in all the other countries are widely variable and reported in Table 3.3 with reference to the most common classification into agricultural, natural, recreational, residential and industrial land use. Further distinctions can be made for the presence/absence of gardens in the residential scenario (e.g. in UK), or for the relevance of groundwater resources (e.g. Sweden and Poland). On the other hand, different land uses can be aggregated in single classes, like recreational, residential and natural in Italy and Finland. The industrial use is usually considered, with exception of Austria and Lithuania. In Austria, the contamination of industrial land has to comply with groundwater contamination thresholds, while soil SVs are not provided. The agricultural use is often addressed by a different legislation. It usually implies that agricultural SVs are derived on the basis of different assumptions and modeling than those applied for industrial and residential contaminated sites.
Relevance of variability
The variability is *very high*.
Reasons of variability
The choice of land-uses mainly concerns a political decision and the compliance with the land planning system. In principle geographical and socio-cultural aspects can be also expected to play a role, like the relevance of specific type of land use (e.g. residential gardens or ground water supply). However, the application of this type of reasoning does not explain the differences observed among EU countries.

Table 3.3. Land use applications of screening values in the participating EU countries

<table>
<tr><th>COUNTRY</th><th colspan="7">LAND USE APPLICATION FOR SVs</th></tr>
<tr><th></th><th colspan="2">agricultural</th><th>natural</th><th>recrea-tional</th><th colspan="2">residential</th><th>industrial</th></tr>
<tr><td>Austria</td><td colspan="3">agricultural or gardening purposes, as well as non-agrarian ecosystems</td><td colspan="3">residential areas, sport fields, playgrounds</td><td></td></tr>
<tr><td>Belgium – Flanders</td><td colspan="2">agricultural</td><td>nature</td><td>recreational</td><td colspan="2">residential</td><td>industrial</td></tr>
<tr><td>Belgium – Walloon</td><td colspan="2">agricultural</td><td>natural</td><td>recreational</td><td colspan="2">residential</td><td>industrial</td></tr>
<tr><td>Czech Republic</td><td colspan="2">agricultural</td><td>natural</td><td>recreational</td><td colspan="2">residential</td><td>industrial</td></tr>
<tr><td>Denmark</td><td colspan="2"></td><td colspan="5">Generic</td></tr>
<tr><td>Finland</td><td colspan="2"></td><td colspan="5">residential</td></tr>
<tr><td>Germany</td><td colspan="2">agricultural</td><td>green land</td><td>parks/recreation</td><td>Play ground</td><td>residential</td><td>industrial</td></tr>
<tr><td>Italy</td><td colspan="2"></td><td colspan="4">Residential/green areas</td><td>Commercial/industrial</td></tr>
<tr><td>Lithuania</td><td colspan="6">Agricultural, recreational and residential</td><td></td></tr>
<tr><td>Poland</td><td colspan="2">Agricultural and urbanized land</td><td>Nature and groundwater protection</td><td colspan="3">Agricultural and urbanized land</td><td>Industrial, mining and transportation</td></tr>
<tr><td>Slovak Republic</td><td colspan="2">Agricultural</td><td colspan="5">Generic</td></tr>
<tr><td>Spain</td><td colspan="2"></td><td>natural</td><td colspan="3">urban/residential</td><td>industrial</td></tr>
<tr><td>Sweden</td><td colspan="2"></td><td colspan="4">Sensitive land uses</td><td>Less sensitive with or without GW protection</td></tr>
<tr><td>Netherlands</td><td colspan="2"></td><td colspan="5">Generic</td></tr>
<tr><td>United Kingdom</td><td></td><td>Allotments</td><td>Natural (ERA SSVs)</td><td colspan="2">Residential with plant uptake</td><td>Residential without plant uptake</td><td>Commercial/industrial</td></tr>
</table>

Soil type dependence

<u>Overview</u>

In general SVs are derived for standard soil conditions and applied for a wide range of soil types. Since the mobility and bioavailability of soil contaminants can be strongly related to specific soil characteristics, like pH, clay and organic matter content, in a few countries SVs are provided as functions of these parameters (Table 3.4). In the Flemish region (Belgium) and The Netherlands soil SVs are corrected for the clay (for inorganics) and organic matter content (for inorganics and organics). In the UK, different soil SVs are published for pH (6-7-8) and organic matter content (1%- 2.5% – 5%). In Lithuania different background values are provided for sandy-loamy and loamy-clayey soils. In Poland, where the main concern is the groundwater contamination, different values are provided for depth classes and the hydraulic conductivity (below and above 10^{-7} m/s). In some countries (e.g. Sweden) limits are given for soil properties (e.g. pH and organic matter) for which the generic guidelines are applicable.

Table 3.4. Countries where different screening values are provided according to soil type and soil properties considered

Country	Soil type function	
Austria	No	
Belgium - Flanders	Yes	clay and organic matter
Belgium - Walloon	No	
Czech Rep.	No	
Denmark	No	
Finland	No	
Germany	No	
Italy	No	
Lithuania	No	
Netherlands	Yes	clay and organic matter
Poland	Yes	saturated hydraulic conductivity
Spain	No	
Sweden	No	
United Kingdom	Yes	organic matter and pH

Relevance of variability
There is a *high* variability in whether or not considering soil type dependence. Sensitivity is dependent on the contaminant and the variability of soil properties within a region.
Reasons of variability
This is mainly due to political reasons. In principle there might be geographical reasons related to the soil type variability within the country. However, spatial variability of soil is such high, that even in the most little countries there would be no consistent scientific reasons for assuming homogeneous soil type conditions.

Background values

Overview
The consideration of average background concentrations in the derivation of soil SVs mainly concerns naturally occurring substances, and in particular metals and metalloids. How to relate risk based estimated concentrations and background concentrations raises scientific, practical and political questions, to which EU countries gave variable answers.
Historically, before formal risk based approaches were developed (i.e. the combination of toxicological and exposure evaluation), regulatory limits were simply referred to background concentrations. In some countries, in particular that from Central East Europe (e.g. Lithuania), the definition of regulatory values is still based on the statistical evaluation of expected background levels combined with toxicological evaluations. In Spain the derivation of regulatory limits for metals is devolved upon the regional authorities; as far other values are not provided, the mean plus two times the standard deviation of background values, measured in a surrounding clean area of similar physico-chemical characteristics, can be used in

site-specific assessment. In countries where formal risk assessment modeling is applied, for many naturally occurring substances the estimated negligible risk concentrations may be lower than, or comparable to, natural background levels. For these substances in most of the countries the average natural background levels are referred to as soil quality standards instead of negligible risk based concentrations. It is the case e.g. of "target values" in Flanders (90^{th} percentile of background concentrations) and Walloon Region (2 times the background concentration) in Belgium and in Finland. In The Netherlands the "added risk" approach is applied for the derivation of target values of metals, where the "natural background" concentration is added to the risk based concentration.

Relevance of variability

There is a substantial variability in whether or not background concentration is taken into account.

Reasons of variability

The consideration of the background concentration raises political and scientific questions. While the reference to the natural background concentration has a high ethical appeal, the adoption of risk based objectives can be desiderable in a sustainable development perspective. For the choice, scientists can be asked to evaluate the uncertainty and the reliability of risk-based estimations. Other questions concern the bioavailability of background concentrations compared to added concentrations from past industrial activities.

Mixture effects

Overview

Mixture effects are generally not considered in the formulation of SVs, with exception of groups of contaminants for which there is a clear similar mode of action, like PAHs, dioxins, furans and dioxin-like compounds. Usually, no synergistic or antagonistic effects are considered, but effects are added linearly. While the application of Toxicity Equivalency Factors (TEF) is a common practice, the aggregation of substances for the derivation of cumulative SVs can vary from country to country. The result is that cumulative SVs in different countries are hardly comparable. Mixture effects are usually not considered for metals, with the exception of synergic effects of Manganese and Vanadium in Lithuania. Mixture effects are generally accounted in the site-specific risk assessment.

Relevance of variability

In general the magnitude of the variability is low (mixture effects are not considered), with exception for the chemical composition of cumulative SVs for PAHs, dioxins, furans and PCBs, that can be slightly different from country to country. The impact of considering mixture effects or not (like for PAHs and TPH, in which there are differences between countries), can be high.

Reasons of variability

The possibility of considering mixture effects primarily depends on scientific reasons. In Flanders, the reason for not considering mixture effects for PAHs and TPH was based on feasibility considerations.

Pathways of exposure

Overview

The pathways of exposure considered in the investigated EU countries are presented in Table 3.5, with exclusion of those countries that do not apply a quantitative risk assessment modeling. From Table 3.5 it can be noted that:

- outdoor exposure to soil is usually considered for all potential pathways,
- the indoor exposure is considered in many countries, related to dust ingestion and inhalation of soil originated vapors,
- in a few exceptions also the indoor inhalation of groundwater vapors is considered,
- with regard to the exposure through the diet, the consumption of homegrown vegetable is considered in many cases, and in a consistent number of cases also the ingestion of soil attached to vegetables is accounted,
- the uptake of homegrown fruits is seldom included and the consumption of meat and dairy products is considered for the agricultural use only (in Flanders, Belgium),
- the consumption of groundwater contaminated by soil leaching is considered in five countries (Germany, Italy, The Netherlands, Sweden and Belgium-Flanders for the agricultural scenario),
- in three cases (the Flemish and Walloon regions in Belgium and Finland) the consumption of contaminated domestic water is not (only) related to the soil leaching process to groundwater, but rather to the contamination of drinking water by permeation through service pipes.

Relevance of variability

The magnitude of variability is generally high. The sensitivity should be evaluated with consideration of the pathways that contribute more to the overall exposure. Based on the results of sensitivity analyses and from 15 years experience at RIVM, the pathways that are likely to contribute more to the overall exposure are:

- soil ingestion (for immobile contaminants),
- consumption of homegrown vegetables (for mobile contaminants),
- indoor inhalation of soil originated vapors (for volatile contaminants),
- groundwater consumption (for mobile contaminants).

On the contrary, dermal contact is usually not relevant, with the exception of some PAHs or the bathing scenario. The consumption of homegrown fruits generally contributes less than 10% compared to consumption of vegetables. Contaminant permeation in drinking-water pipes generally provides a low contribution. The consumption of meat and dairy products can contribute significantly, but they are appropriate for a rural scenario. The ingestion of contaminated surface water can be significant. Bearing in mind these considerations, it is evident that the exclusion of indoor scenarios and of the consumption of homegrown vegetables in some countries potentially leads to an underestimate of exposure.

Reasons of variability

Whether or not specific exposure pathways are included is based on a combination of geographical and cultural reasons and political decision making. Differences in model algorithms and parameters selection can mainly be attributed to scientific reasons. As an example, the inclusion of the fish consumption pathway in Sweden is a political decision coherent with the tradition of fishing and the public expectation of surface water quality. The consumption of homegrown vegetables is related to habits and expectations of people with gardens in different countries. With regard to the consumption of groundwater, in some countries there is the assumption that drinking water will be treated before use, and that the direct ingestion of water from a private pumping well is not a reasonable worst case. In other countries private wells with no or limited water treratment are very common. Above all, it seems that rather than actual differences in the use of the land in different EU countries, the selection of exposure pathways depends on the public perception of the problem and the related environmental quality expectation. Among scientific reasons for the inclusion/exclusion of pathways, the reluctance for including uncertain models seems also to play a role e.g. in Austria.

Table 3.5. Pathways of exposure considered in the derivation of soil screening values in the investigated countries

	PATHWAYS	**AUT**	**BE(W)**	**BE(F)**	**DEU**	**DNK**	**ESP**	**FIN**	**ITA**	**LTU**	**NDL**	**SWE**	**UK**
Soil outdoor exposure	Soil ingestion	X	X	X	X	X	X	X	X	X	X	X	X
	Dust ingestion		X	X	X	X	X	X	X	X	X	X	X
	Dermal exposure		X	X	X	X	X	X	X	X	X	X	X
	Inhalation of soil vapors		X	X	X	X	X	X	X		X		X
	Inhalation of soil derived dust		X	X	X	X		X	X	X	X	X	X
Soil indoor exposure	Dermal exposure to soil derived dust		X	X				X	X			X	X
	Inhalation of soil originated vapors		X	X				X	X		X	X	X
	Inhalation of groundwater vapors										X		
Soil derived diet exposure	Consumption of homegrown vegetables		X	X	X			X		X	X	X	X
	Ingestion of soil attached to homegrown vegetables				X			X			X		X
	Consumption of homegrown fruits				X					X		X	
	Ingestion of soil attached to homegrown fruits				X								
	Consumption of meat			X									
	Consumption of dairy products			X									
Soil-Groundwater pathways	Consumption of groundwater		X		X				X		X	X	
	Drinking-water contaminated by permeation through pipes		X	X				X					
	Inhalation of volatilized domestic water							X			X		
	Showering (dermal contact + inhalation)		X	X				X			X		
Soil- surface water	Swimming: dermal contact + water ingestion + suspended matter ingestion												
	Consumption of fish and shellfish											X	

Exposure time

Overview

The definition of averaging time and exposure time, for (genotoxic) carcinogens and non-carcinogens and for different land uses, is not uniform among EU countries. From the collected information the following considerations can be drawn:

- the averaging time for carcinogens is usually the combination of 6 years childhood and 64 years adulthood, with little variability among countries, in particular for averaging methods,
- the exposure time for carcinogens showed a significant variability. In particular, the exposure assumed for the industrial land use varies from 30 years (Italy) to 40 years (Finland), 43 years (UK) and 45 years (Belgium Flanders),
- the frequency of exposure according to the land use can be a source of differences. It is usually equal to the number of days per year in recreational (e.g. 230), residential (e.g. 350) and industrial land (e.g. 250). For the industrial land-use the sleeping hours can be subtracted. It is notable that in UK values are based on the occupational statistics provided by the National Statistics Office which collates data on the number of hours people spend at work at different work places.
- in case of non-carcinogenic substances, the exposure during childhood and adulthood are calculated and assessed separately in some countries. In other countries they are averaged or only childhood or adulthood is considered.

In the UK averaging time for both carcinogens and non-carcinogens is equal to the exposure period: for the industrial use 43 years, while for the residential use 6 plus 64 years. This is because of the potential for more life long effects to be seen if children are damaged when they are at the highest level of growth and exposure.

Relevance of variability

Except for the exposure averaging period for carcinogenic substances, the other elements of risk assessment related to exposure time show a high variation. In addition, the sensitivity is either substantial or high. From this combination it can be concluded that the differences in elements of risk assessment related to exposure time are very significant for variation in screening values.

Reasons of variability

Reasons for differences are mainly due to scientific reasons and to a lesser extent to cultural reasons, related to professional exposure time. The implementation of the precautionary principle also influences decisions on exposure averaging time: i.e. can we accept children to exceed the TDI, in the absence of data on children's vulnerability?

Exposure parameters

Overview

From the collected information, the following considerations can be drawn:

- in all the countries exposure parameters are defined according to the land use,
- in some countries the tuning of exposure parameters is more refined than in other countries, e.g. the UK CLEA model takes into consideration also gender differences,
- while the deliberate ingestion of soil is usually considered, soil-PICA behavior is often not included (e.g. not in Finland),
- a wide variability can be observed for the assumed contribution of home-grown vegetables and for the distinction of inhalation activity patterns. As an example, the percentage of consumed vegetables that are assumed to be

homegrown ranges from 10% in Finland to 20% in Walloon, 25% in Flanders (50 % in agricultural scenario), 30% in Sweden and 100% in UK (value under revision).

Relevance of variability

For the combination of very high magnitude and high sensitivity, it can be concluded that the variation in contribution of homegrown vegetables and inhalation activity patterns distinction is very significant for variations in the screening values. The variability or alignment of European exposure data should find scientific basis on exposure factor sourcebooks. A preliminary Exposure Factors Sourcebook for European Population with focus on UK data was published by ECETOC in 2001 (ECETOC, 2001).

Reasons of variability

The variation is mainly due to scientific reasons, and to a lesser extent due to political decision making and cultural aspects. In principle, it can be argued that the proportion of homegrown vegetables in the average diet is a socio-cultural factor, however in practice this value is mainly defined on conservative assumptions slightly correlated to country specific characteristics. The protection of subgroups of the population with atypical habits is a political matter. The definition of a reasonable extent of conservativeness implies also scientific considerations. It is notable that the potential correlation between national socio-cultural habits and the assumed values is not evident.

Aggregate exposure

Overview

The overall human exposure is usually estimated by summation of single pathways. Some countries add oral and inhalative pathways separately. In some cases the groundwater pathway is presented apart, e.g. in Germany.

Relevance of variability

The elements of risk assessment related to aggregate exposure are very sensitive but show limited variation. It can be concluded that this source of variability can have major influence on the general variability of the screening values.

Reasons of variability

The lack of variation is due to scientific consensus.

Inclusion of non-soil sources of exposure

Overview

The contribution of non-soil sources of exposure (to the same substance) is considered in about 50% of the participating countries, i.e. in Flanders, Germany, Denmark, Spain, Sweden and UK. A proportion of the Tolerable Daily Intake (TDI) is allocated to exposure sources not related to the contaminated site, like background concentrations in water, air and food. So doing, the derivation of soil SVs refers to only a fraction of the TDI, also named Tolerable Daily Soil Derived Intake (TDSI). The estimation of the TDSI fraction, which depends on the contaminant of concern, is variable from country to country. As an example:

- in Germany and the UK the TDSI can be as little as 20% of TDI,
- in Denmark as little as 10% of TDI,
- in Spain from 5% to 20% according to the type of contaminant;
- in Belgium-Flanders the contribution is determined on a contaminant-specific basis

In particular for Spain, the proportion of exposure allocated to the contaminated soil is 5% for pesticides, 20% for organochlorinated compounds, 5% for PAHs and 10% for Monocyclic Aromatic Hydrocarbons.

Relevance of variability
The inclusion or exclusion of non-soil sources is highly variable (it concerns only 50% of the countries) and has a very high sensitivity. Moreover, the allocation of the soil related exposure is also variable. It can be concluded that it is a major factor of variability in soil SVs in Europe.
Reasons of variability
Non-soil sources are generally only included for threshold contaminants. Whether or not including it, is related to the focus of the risk assessment concept and is partly political. It relates to aspects as: assessment of health effects due to living on a contaminated site (including all exposures, also those with a non-local character); assessment of health effects solely due to the presence of the contamination; importance of local contamination and general background in total exposure (relevance of soil remediation to reduce exposure/risk).
Reasons of inclusion/exclusion of non-soil related sources are primarily political, but the possibility to develop adequate means for the inclusion needs to be scientifically evaluated.

Toxicological data sources

Overview
Toxicological databases developed by competent national institutions in Europe are very limited. Only three countries, i.e. The Netherlands, Germany and Italy, indicate they mainly refer to their national databases. The data published by RIVM in The Netherlands are often a source of data for other EU countries.
Most of the EU countries refer to databases developed by other national or international organizations and published on the internet, among which the databases developed by:

- the World Health Organization within the International Programme on Chemical Safety (IPCS), (www.who.int/ipcs/en/)
- the International Agency for Research on cancer (IARC), (www.iarc.fr/)
- Risk Assessment Reports (RARs) published by the European Chemical Bureau of the EU Commission (www.ecb.jrc.it)
- the United States Environmental Protection Agency, Integrated Risk Information System (IRIS), (www.epa.gov.iris)
- the United States Department of Energy (DoE), Risk Assessment Information System (RAIS), (http://risk.lsd.ornl.gov/)
- the United States Agency for Toxic Substances and Disease Registry (www.atsdr.cdc.gov/)
- the United States National Library of Medicine, Hazardous Substances Data Bank (HSDB), (www.toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB).

For the purpose of deriving soil SVs, national committees or expert groups are often established, e.g. in Germany, Lithuania, The Netherlands and UK, to evaluate toxicological data from variable data sources. In other countries, like Flanders, the data from international bodies are listed and a ranked list of preferred data sources combined with an assessment of the data themselves lead to the choice of the toxicological reference value.
Relevance of variability
For the same contaminant, toxicological values from different databases can easily differ by more than one order of magnitude. Therefore, which data source is used is a very sensitive factor and widely variable across Europe, thus it is very significant for variation in soil SVs.
Reasons of variability
Differences in toxicological values are partly due to scientific reasons, like use of more recent data, but the differences are often caused by differences in expert judgment on assessment factors. Also political and feasibility decisions, such as the

costs for national evaluations and the focus on international harmonisation play a significant role. It is mainly due to scientific reasons and to a lesser extent to political decision making. It can be argued that the creation and management of consistent toxicological databases implies long term programs and investments, and these programs can only be launched if politically supported.

Toxicological assessment

Overview

With slight differences among countries, chronic effects are considered with inclusion of carcinogenic and genotoxic effects, reproductive and developmental effects and neurobehavioral toxicity. Skin irritation is also included in UK. Acute effects are considered for some substances, like cyanides.

Toxico-kinetic and epidemiological studies are usually not performed, but the results are used when available. For threshold contaminants a tolerable daily intake (TDI) is derived and compared with the estimated exposure.

For non-threshold contaminants a dose-response (incremental risk) curve is usually estimated which assumes risk at even very low concentrations. Thresholds are defined on the basis of the definition of acceptable incremental risk levels. In UK a different approach is adopted: Index Doses are derived that convey minimal risk levels, with the additional requirement to keep any intake as low as reasonably practicable (ALARP).

Relevance of variability

Which types of toxicity effects are considered is clearly a very sensitive factor in the derivation of SVs, but do not show much variation cross Europe.

Reasons of variability

The low variation is mainly due to scientific consensus

Acceptable risk

Overview

For non-threshold contaminants, acceptable incremental risk levels are defined that vary from 10-4 (The Netherlands) to 10-6(Italy), while 10-5 is adopted by the large majority of countries. It is notable that in Italy a new regulation is under adoption that raises the acceptable incremental risk level to 10-5. In UK an acceptable risk level has not been defined, while a hierarchy of authoritative sources have been developed specifically for soil contamination (Defra and Environmental Agency, 2002). For threshold substances the exposure concentration is deemed acceptable up to a threshold dose (based on toxicological evidences and assessment factors), in all countries.

Relevance of variability

While very sensitive, the magnitude of variability is very low.

Reasons of variability

The lack of variation in the elements of risk assessment related to the acceptable risk is due to consensus in both policy making and in the scientific community.

Deterministic and probabilistic approaches

Overview

All EU countries, with the exception of the UK, apply deterministic approaches. In the UK, the CLEA model is based on a probabilistic estimation of exposure. Some input parameters are defined by probability density functions (PDF) and so it is the estimated exposure. The 95^{th} percentile of the exposure is selected from the PDF for each year and averaged for the exposure time.

Relevance of variability
The sensitivity of the choice for a deterministic or probabilistic approach is substantial, but does not show much variation.
Reasons of variability
The choice between a deterministic or probabilistic approach is primarily based on scientific reasons. The preference of decision makers for deterministic or probabilistic modeling outcomes can also play a role.

Table3.6. Relevance and reasons of variability in the human health risk assessment building blocks of soil screening values derivation methods.

		Relevance						
		Sensitivity	**Magnitude**	***Geographical and biological***	**Socio-cultural**	**Regulatory**	**Political**	**Scientific**
Status	Approved technical guideline	**NA**	**2-3**			**2**	**1**	
	Proposal under approval							
	In development							
Generic or land-use specific	Land use based	**NA**	**3**			**2**	**1**	
	Residential with garden and allotments (incl. home grown vegetables)							
	Residential with garden (excl. home grown vegetables)							
	Residential with children playing fields							
	Public green areas							
	Nature conservation areas							
	Industrial or commercial							
	Agricultural							
Soil type dependent	Yes	**NA**	**2**	**2**				**1**
	No							
Background concentration	Not considered	**NA**	**2**				**1**	**2**
	Added							
	Considered instead when above screening value							
	Other							

Table3.6. Continuation

		Relevance						
		Sensitivity	**Magnitude**	***Geographical and biological***	**Socio-cultural**	**Regulatory**	**Political**	**Scientific**
Mixture effects	Considered or non considered	**NA**	**0**					**1**
	Effect additivity (TEF) for PAHs	**NA**	**1**					**1**
	Effect additivity (TEF) for dioxins, furans and PBC dioxin-like compounds	**NA**	**1**					**1**
Pathways	Outdoor: soil ingestion	**3**	**0**	**1**			**3**	**2**
	Outdoor: dust ingestion	**1**	**1**	**1**			**3**	**2**
	Outdoor: dermal exposure to soil	**1**	**1**	**1**			**3**	**2**
	Outdoor: inhalation of soil vapours	**1**	**1**	**1**			**3**	**2**
	Outdoor: inhalation of soil derived dust	**1**	**1**	**1**			**3**	**2**
	Outdoor: inhalation of volatilized irrigation water	**1**	**0**			**1**	**3**	**2**
	Indoor: dermal exposure to soil derived dust	**1**	**2**	**4**	**3**		**5**	**1**
	Indoor: inhalation of soil originated vapours	**3**	**2**	**3**	**2**		**4**	
	Indoor: inhalation of groundwater vapours	**3**	**2**	**3**	**4**		**5**	**1**
	Indoor: inhalation of volatilized domestic water	**1**	**2**				**3**	**1**
	Indoor: showering (dermal contact + inhalation of vapours)	**1**	**3**				**3**	**1**
	Resident diet: consumption of groundwater	**3**	**3**		**3**		**1**	
	Permeation in drinking water pipelines	**1**	**2**					**1**
	Res. diet: intake of homegrown vegetables	**3**	**2**		**1**		**3**	
	Res. diet: Ingestion of soil attached to homegrown vegetables	**2**	**3**		**3**		**4**	**1**

Table3.6. Continuation

		Relevance		Geographical and biological	Socio-cultural	Regulatory	Political	Scientific
		Sensitivity	**Magnitude**					
Pathways	Res. diet: intake of homegrown fruits	**1**	**2**		**3**		**4**	**1**
	Res. diet: ingestion of soil attached to homegrown fruits	**1**	**1**		**3**		**4**	**1**
	Res. diet: consumption of meat	**2**	**1**		**1**	**2**	**3**	
	Res. diet: consumption of dairy products	**2**	**1**		**1**	**2**	**3**	
	Surface water consumption of fish and shellfish	**1**	**1**	**1**	**2**		**3**	
	dermal contact surface water (swimming)	**3**	**1**		**2**		**3**	**1**
	ingestion surface water (swimming	**1**	**1**		**2**		**3**	**1**
	ingestion suspended matter (swimming)	**1**	**1**		**2**		**3**	**1**
Exposure time	Differences according to land uses: Y/N	**2**	**2**					**1**
	Carcinogenic: exposure averaging period	**2**	**1**		**2**			**1**
	Carcinogenic: exposure duration	**2**	**2**		**3**			**1**
	Non carcinogenic: exposure period	**3**	**2**		**3**			**1**
Exposure parameters (excluded duration)	For the same receptor, differences according to land uses: Y/N	**3**	**1**					**1**
	Differences according to sex	**2**	**1**					**1**
	Soil ingestion: deliberate ingestion of soil considered	**2**	**1**				**2**	**1**
	Contribution of home grown vegetable consumption to total vegetable consumption: • 100% rate (specify which one)	**3**	**3**		**3**		**2**	**1**
	Inhalation: Activity patterns distinction	**2**	**3**					**1**
	Inhalation: age- body weight related	**3**	**0**					**1**
	Dermal absorption: Activity pattern related	**2**	**0**					**1**
	Dermal absorption: Age-body weight related	**3**	**0**					**1**
Aggregate exposure	Combined from multiple pathways	**3**	**1**					**1**
	Most critical exposure pathways	**3**	**1**					**1**

Table3.6. Continuation

		Relevance						
		Sensitivity	**Magnitude**	***Geographical and biological***	**Socio-cultural**	**Regulatory**	**Political**	**Scientific**
Uptake modeling Non soil sources	Ingestion: substance-specific rate of resorption in the intestinal tract, when available	**2**	**1**					**1**
	Inhalation: substance-specific absorption coefficient for respirable fraction (<10 µm), when available	**2**	**1**					**1**
	Dermal uptake: evaporation of volatile contaminants from skin surface	**1**	**1**					**1**
	Dermal uptake: permeability coefficients based default or chemico-physical models	**1**	**3**					**1**
	Inclusion of non soil related source of exposure	**3**	**3**				**1**	**2**
Data sources	National DB (specify)	**3**	**3**				**2**	**1**
	DB public on the web (specify, e.g. IPCS, US-EPA IRIS, IARC, ATSDR)							
	Peer revisions of national committees							
Toxicity effects	Chronic effects:	**3**	**1**					**1**
	• Carcinogenicity and genotoxicity							**1**
	• Reproductive and developmental effects							**1**
	• Neurobehavioural toxicity							**1**
	Other							**1**
Dose-response curve for carcinogens	Yes	**3**	**1**					**1**
	When possible							
	Threshold mechanism preferred							
	No							
Acceptable risk	For carcinogens: incremental risk = 10^{-6}, 10^{-5}, 10^{-4} (specify), other (specify)	**3**	**1**				**1**	**2**
	For not carcinogens: hazard quotient 1, other (specify)	**3**	**0**				**1**	**2**
Deterministic or probabilistic approach	Deterministic	**2**	**1**				**2**	**1**
	Probabilistic (exposure assessment)							
	Probabilistic (exposure + toxicological assessment)							
	If probabilistic, screening value is: 50- 75- 95- 99^{th} percentile? (specify)							
	top soil + subsoil							
	not defined							

3.3 Ecological risk assessment

The answers of all the countries that returned the questionnaire (17 participating countries) have been listed in a summary table presented in Annex 1.
For each topic, the relevance and the reasons of the variability are discussed and scored, below. The results are also summarised in Table 3.9.

Status

Overview
As presented in Table 3.1 in chapter 3, ecological receptors are considered in many EU countries, including Austria, Wallonia and Flanders in Belgium, Germany, Finland, Spain, Denmark, The Netherlands and United Kingdom. However much is still under approval and in development. Ecological technical guidelines have been legally approved only in three countries, i.e. Germany, Finland (expected by March 2007) and The Netherlands. In Sweden ecological technical guidelines have been formally issued, but were not legally approved. In two other countries, (Flanders - Belgium, UK and Denmark), ecological SVs have been derived but not adopted by the current legislation. In Italy, UK and Czech Republic ecological SVs guidelines are in development.
Relevance of variability
There is a very high variability among SVs approved, proposed or in development.
Reasons of variability
Reasons are political and regulatory.

Generic or land-use specific

Overview
In some EU countries soil ecological SVs (eco-SVs) are not land use-specific. Exceptions are Flanders and Walloon regions in Belgium, Finland and Sweden. In Belgium different soil eco-SVs for nature conservation, residential, industrial, agricultural and public green areas are derived. In Finland "lower" and "upper guideline values" are derived for the residential and the industrial use, respectively. Similarly, in Sweden sensitive and less sensitive land uses are distinguished. The general principle is that less sensitive land uses are prescribed a lower percentage of protected species along the Species Sensitivity Distribution (see after "level of protection in the application of SSD). In some countries, like Spain and UK, eco-SVs are expected to be used in natural areas only.
Relevance of variability
The variability has a high magnitude (almost 50% of the countries with land-use specific values) and also very sensitive.
Reasons of variability
Reasons are mainly scientific and political. Politically speaking, it is usually accepted that ecological quality objectives are tuned according to the natural sensitivity of the area. At scientific level there is a lively discussion on the feasibility of land-use specific ecological criteria. The applicability of procedures for the definition of different minimum ecological requirements according to the land use is still under discussion (Faber, 1998; Hersteren et al., 1999; Leemkule et al., 1999; Rutgers et al., 2000; ANPA, 2002). So far, the definition of different levels of protection along the SSD curve is applied. Moreover, in some countries the ecological protection has been intended only for sensitive areas (or with conservation value).

Considered receptors

Overview
The ecological receptors considered in the derivation of ecological soil SVs in the investigated EU countries are shown in Table 3.7. It can be noted that microbiological processes, soil fauna and plants are usually considered. In Austria, only effects associated to plant uptake are considered. Above soil ecosystem receptors, i.e. terrestrial vertebrates and invertebrates, are included in many countries, but only when the secondary poisoning due to bioaccumulating contaminants can be relevant. Effects on the aquatic ecosystem are accounted for in Walloon region, Spain and Sweden, only.
Relevance of variability
There is a high variability in the considered ecological receptors. Besides, sensitivity is also high.
Reasons of variability
The choice of receptors mainly concerns a political decision, but is strongly supported by scientific knowledge. Socio-cultural aspects can also play a role, where the preservation of specific species is associated to their cultural importance, e.g. their symbolic value in the national or local tradition.

Table 3.7. Ecological receptors considered in the derivation of ecological soil screening values in the investigated EU countries

	Microbiol. Processes	Soil fauna	Plants	Above soil ecosystem	Aquatic ecosystem
Austria					
Belgium – Waloon					
Belgium – Flanders					
Czeck Rep.					
Germany					
Spain					
Finland					
Netherlands					
Sweden					
United Kingdom					

Considered ecotoxicological endpoints

Overview
In regard to the ecotoxicological endpoints, effects on survival, growth, reproduction, mobility, microbial mediated processes and enzyme activities, appear to be taken into account in all countries, with slight variability. It is notable the exception of the Czech guideline proposal, that not includes survival effects and focuses only on more sensitive effects like growth impairments.
Relevance of variability
The variability is low, but high sensitivity.
Reasons of variability
Reasons are scientific.

Soil type dependent

Overview
In the participating countries, soil eco-SVs are always derived for standard soils and soil type adjustments are recommended for site-specific assessment.
Relevance of variability
There is a low variability in whether or not considering soil type dependence.
Reasons of variability
This is mainly due to political reasons, scientific feasibility and, in principle, also due to variability of soil types within the country.

Mixture effects

Overview
Mixture effects are never considered in the screening risk assessment phase, i.e. derivation of eco-SVs, but in the site-specific assessment only. Exceptions can be groups of compounds with the same Toxic Mode of Action, (e.g. PAHs) for which eco-SVs are defined by concentration additivity.
Relevance of variability
There is no variability.
Reasons of variability
The reason is scientific consensus.

Pathways

Overview
Bioconcentration in soil organisms and plants is always considered. Secondary poisoning is usually estimated for only few substances that are likely to bioaccumulate, e.g. some heavy metals and organic chemicals with logKow >5, (e.g. Walloon, Finland, The Netherlands, UK).
Relevance of variability
The variability is low, but the sensitivity is high.
Reasons of variability
Scientific reasons.

Inclusion of non-soil sources

Overview
Differently from human health, non-soil related sources are not taken into account for the derivation of eco-SVs.
Relevance of variability
The variability is null.
Reasons of variability
(-)

Data sources

Overview
Ecotoxicological databases developed by competent national institutions in Europe are very limited. Five countries, i.e. The Netherlands (e-tox), Spain (BaseTox developed by the Bask Government), Germany, Czech Republic and Flanders in Belgium, indicate the presence of supporting national databases. The Dutch e-tox database developed by RIVM is a common reference also for other EU countries, to-

gether with other databases developed by national or international organizations and published on internet, among which:

- ECOTOX developed by the United States Environmental Protection Agency, (www.epa.gov/ecotox/),
- Risk Assessment Reports (RARs) published by the European Chemical Bureau of the EU Commission (www.ecb.jrc.it),
- other United States databanks already quoted for human toxicological values, like IRIS, RAIS, HSDB, et cetera,
- data published by the Canadian Council of Ministers of the Environment (CCME).

For the purpose of deriving soil eco-SVs, national committees are often established, e.g. in Spain and The Netherlands, to evaluate toxicological data from variable data sources.

<u>Relevance of variability</u>

For the same contaminant, toxicological values from different databases can easily differ by more than one order of magnitude. The selection of data sources used for parameter selection is very sensitive and shows a large variation, thus it is very significant for variations in soil SVs.

<u>Reasons of variability</u>

It is mainly due to scientific reasons and, to a lesser extent, to political decision making.

Normalization to standard soil

<u>Overview</u>

Normalization of toxicological values to standard soil properties are performed in all participating countries. Normalization parameters are organic carbon and, for metals only, clay content. In Czech Republic, Finland and Sweden, the empirical reference lines developed by RIVM in The Netherlands are applied (Sijm et al., 2002).

<u>Relevance of variability</u>

From the sketchy information that was collected it was impossible to evaluate differences in applied normalization methods.

<u>Reasons of variability</u>

Reasons are scientific.

Extrapolation of representative NOEC from toxicity data

<u>Overview</u>

Extrapolation methods of NOEC (No-Observed-Effects-Concentration) from multiple toxicity data for the same toxicological endpoint is generally based on the geometric mean. When data are available for more endpoints for that species, the most sensitive is taken.

<u>Relevance of variability</u>

The magnitude of variability is very limited.

<u>Reasons of variability</u>

The variation in toxicity data is limited due to scientific consensus.

Terrestrial and aquatic organisms tox data

<u>Overview</u>

When no, or insufficient, ecotoxicological data on terrestrial species are available, representative NOECs values can be extrapolated from observed effects on aquatic organisms. For this purpose, the equilibrium partitioning method is applied (ECB, 2003). All the participating countries, with exception of Denmark, adopt this method.

Relevance of variability

Although the inclusion of aquatic organisms tox data is a sensitive factor, it is not a critical factor in the variation of eco-SVs, because the magnitude of variation is very limited.

Reasons of variability

Reasons are scientific.

Application of Species Sensitivity Distributions (SSD) or Assessment Factors

Overview

Species Sensitivity Distributions (SSD)**,** (Aldenberg *et al.*, 2002), are usually applied if sufficient ecotoxicological data are available. In general, at least 4 NOECs values representing different taxonomic groups are requested. If ecotoxicological data are not sufficient, Assessment Factors are applied. The only exception is Spain, where Assessment factors are always preferred to the SSD statistical extrapolation.

For the application of the SSD extrapolation, the lognormal distributions is assumed in all countries.

Relevance of variability

The variability magnitude is very low. Therefore, in spite of its sensitivity, it is not a relevant source of variability of European eco-SVs.

Reasons of variability

Uniformity is due to scientific consensus.

Level of protection in SSD application

Overview

Protection levels are defined in term of percentage of species to be protected along the SSD curve and range from the 95% (HC5) to the 50% (HC50). The levels of protection applied in the participating countries for the derivation of negligible-warning- and potentially unacceptable- risk SVs are presented in Table3.8. It can be noted that the negligible risk is usually associated with HC5 (effects on 5% of the species) and the relevant risk with HC50. In case of land use dependent SVs, HC50 is kept for the less sensitive use while higher protection levels (up to HC20) are set for sensitive uses. In Flanders HC20 applies only for agricultural land uses; other land uses have no specified HC levels, but the way the data are used differs, resulting in higher levels for recreational and industrial land-use

Relevance of variability

The magnitude of the variability is limited, but the sensitivity on the variation of SVs is very high.

Reasons of variability

Reasons for differences are mainly political, but they have to be supported by scientific hypotheses about the relation between the fraction of species potentially affected and the impairments foreseen at ecosystem level.

Table 3.8. Protection levels applied to the SSD curves for the derivation of soil screening values associated to negligible, warning and potentially unacceptable ecological risk.

	Negligible risk	Warning risk	Relevant risk
Walloon (BE)			HC20 (natural areas) HC40 (residential) HC50 (industrial)
Flanders (BE)			HC20 (agricultural)
Germany		HC50	
Denmark	HC5		
Finland	HC5		HC50
Netherlands	HC5/100		HC50
Sweden			HC25 (sensitive area) HC50 (less sensitive)
UK		HC5	

Applied Assessment Factors

Overview
The application of Assessment Factors usually refer to the values recommended by the EC Technical Guidance Document (ECB, 2003).
Relevance of variability
The magnitude of the variability is very low and in spite of its sensitivity is not expected to have significant effects on the SVs variation.
Reasons of variability
Reasons for differences are mainly political, but they have to be supported by scientific hypotheses.

Background concentration

Overview
The average background can be differently considered in the derivation of negligible risk values. In some countries it is taken as reference value; in other countries it is added to the estimated negligible risk concentrations; in other countries it is taken as reference concentration if it exceeds the estimated negligible risk concentration. The use can differ between naturally occurring substances and new chemicals. It should be borne in mind that for heavy metals the average background is usually much higher (one order of magnitude or more) than the estimated negligible risk concentration.
Relevance of variability
The magnitude of variability is high and highly sensitive on the derivation of SVs.
Reasons of variability
Reasons are primarily scientific, but also due to political decision making.

Probabilistic modeling

Overview
Probabilistic modeling is usually not applied, but not excluded.
Relevance of variability
The sensitivity of the choice for a probabilistic approach is substantial, but does not show much variation. From this combination it can be concluded that the variation in the probabilistic approach is not very significant for variation in screening values.

Reasons of variability
The limited application of probabilistic approaches reflects the general scientific consensus about its limited feasibility in the derivation of ecological screening values (Verdonck et al., 2003).

Table 3.9. Relevance and reasons of variability in the ecological risk assessment building blocks of soil screening values derivation methods.

		Relevance						
		Sensitivity	**Magnitude**	**Geographical and biological**	**Socio-cultural**	**Regulatory**	**Political**	**Scientific**
Status	Approved technical guideline,	**N.A.**	**3**			**2**	**1**	
	Proposal under approval,							
	In development							
	None							
Generic or land-use specific	Generic	**3**	**2**		**3**		**2**	**1**
	Nature conservation areas							
	Residential							
	Industrial or commercial							
	Agricultural							
	Public green areas							
Considered receptors	Soil microbial processes	**3**	**1**					**1**
	Soil fauna							
	Plants							
	Wildlife	**3**	**3**	**3**			**1**	**2**
	• terrestrial vertebrates							
	• terrestrial invertebrates							
	• others							
	Aquatic ecosystem	**3**	**2**	**1**				**2**
Considered ecotoxicological endpoints	Survival	**3**	**2**					**1**
	Growth							
	Reproduction							
	Mobility							
	Microbial mediated processes							
	Enzyme activities							
Soil type dependent	Y/N	**N.A.**	**1**	**4**			**1**	**2**

Table 3.9. Continuation

		Relevance						
		Sensitivity	**Magnitude**	**Geographical and biological**	**Socio-cultural**	**Regulatory**	**Political**	**Scientific**
Mixture effects	Not considered	**N.A.**	**0**					**1**
	Considered (specify)							
Pathways	Bioconcentration in soil organisms and plants	**3**	**0**					
	Secondary poisoning for all substances. If not, specify which one	**3**	**1**					**1**
	Bioaccumulation modeling of belowground food web	**2**	**0**					**1**
Exposure calculation for secondary poisoning	Empirical soil-to-tissue bioaccumulation factors (e.g. BAF)	**2**	**0**					**1**
	Biomagnification algorithms	**2**	**1**					**1**
Inclusion of non-soil sources	No	**3**	**0**				**1**	**2**
	Yes, (specify how)							
Inclusion of other types of stress sources	Y/N (specify)	**3**	**0**				**1**	**2**
Data sources	National DB (specify)	**3**	**3**				**1**	**2**
	Available DB on the web (specify e.g. US-EPA ECOTOX, RARs, etc.)							
	Peer reviews of national committees							
Normalisation to standard soil	Normalisation to standard soil (specify which parameters and values of standard soil)	**2**	**3**					**1**
	Method: empirical reference lines (Dutch method)							
	Method: other (specify)							
Eco-epidemiological studies	Y/N	**N.A.**	**0**					**1**

Table 3.9. Continuation

		Relevance		Geographical and biological	Socio-cultural	Regulatory	Political	Scientific
		Sensitivity	**Magnitude**					
Toxicity data extrapolation	Toxicity data extrapolation	**3**	**1**					**1**
Terrestrial and aquatic organisms tox data	Only terrestrial Terrestrial and/or Aquatic Terrestrial + Aquatic if no statistical differences	**3**	**0**					**1**
Application of Species sensitivity distribution (SSD)	When (specify): • Always • Only if sufficient data (specify criteria) • Never	**3**	**1**					**1**
	Assumed statistic distribution (specify): • a-Loglogistic • b Lognormal • c other	**1**	**1**					**1**
	Protection level (specify) • a HC5 • b HC50 • c other	**3**	**2**				**1**	**2**
Application of assessment factors	When (specify): • a Always • b Only if not sufficient data for SSD (specify criteria) • c Never	**3**	**1**				**2**	**1**
	Protection level (specify): • a EC Technical Guidance Document (TGD) (CEC, 1996) • b Modified TGD (specify reference) • c EPA method • d Modified EPA methods (specify reference) • e other	**3**	**1**				**1**	**2**
Background concentration	Use of background concentration	**3**	**2**				**2**	**1**
Probabilistic modeling	Not adopted Adopted when (specify): • Always • Only when (specify criteria)	**2**	**0**				**2**	**1**

4

VARIABILITY OF SOIL SCREENING VALUES

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4.1 Procedure

This chapter examines the variability of the screening values between Member States. In chapter 1 a definition of screening value was given. Besides it was mentioned that the implications of exceeding the screening values can vary according to the national regulatory frameworks. Although there might be minor differences in exact meaning and implications it does make sense to compare the numerical values of screening values of the same type and for the same land-use.

Types of screening values

In section 2.2.3 it was explained that three types of screening values could be distinguished, i.e. related to:

- negligible risk;
- intermediate (warning) risk;
- potentially unacceptable risk.

In section 2.2.4 all soil screening guidelines have been categorized into one of these types of screening values. Negligible risk values are generally not related to the land use. On the contrary, for intermediate (warning) risk and the potentially unacceptable risk, different values for two soil-uses, i.e. residential and industrial, are commonly considered.

As a consequence, four types of screening values are compared in this chapter, i.e.:

- negligible risk;
- warning risk (residential use);
- potentially unacceptable risk, residential site;
- potentially unacceptable risk, industrial site.

Some countries provide SVs dependent on soil types or groundwater levels. In these cases the SVs are selected in analogy with the most commonly assumed conditions in the derivation of SVs in other EU countries.

As far the warning screening values in the UK, the SVs for residential with plant intake are considered. The values for pH = 7, being the most common pH value, are chosen. For some compounds a differentiation for organic matter contents is made. Here, the value for an organic matter content of 5% is chosen, once again because this is assumed as the most representative value for Europe.

Polish SVs values depend on the groundwater table depth and hydraulic conductivity (below and above 10^{-7} m/s). The SVs in the category between 0.3 and 15 meters (the most common groundwater depth throughout Europe) are used in the comparison. Besides the average between the two saturated hydraulic conductivity classes is used in the comparison.

Comparison

With the purpose to facilitate interpretation, graphs are presented in this section showing SVs for the metals and metalloids and a selection of representative organic contaminants. For the organic contaminants a series of representative contaminants was selected based on the following criteria:

- Frequency of occurrence in soils throughout Europe (and, hence, incorporation of screening values).
- Variation in behavior in soil, and hence, exposure to humans and the ecosystem.

The metals and metalloids and selected organic contaminants are listed in Table 4.1.

Table 4.1. Contaminants selected for the comparison of screening values

Metals and metalloids	**Organic contaminants**	
Arsenic	*Aromatic*	*Aliphatic Alogenated*
Beryllium	Benzene	Dichloromethane
Cadmium	Ethyl benzene	Trichloroethylene
Cobalt	Toluene	Tetrachloromethane
Chromium (total)	Xylene	Hexachlorobenzene
Chromium (VI)	Phenol	1,1,1-tricholoroethane
Copper	Cresols	*Aromatic Halogenated*
Mercury	*Polycyclic Aromatic PAHs)*	Chlorobenzenes
Lead	Naphthalene	*Dioxins and PCBs*
Molybdenum	Anthracene	PCDD/PCDF
Nickel	Benzo(a)anthracene,	PCB
Tin	Benzo(a)pyrene	*Pesticides*
Selenium	Benzo(ghi)perylene,	Atrazine
Thallium	PAH total	Sum DDT/DDE/DDD
Vanadium		*Others*
Zinc		MTBE

4.2 Results

4.2.1 Screening values for negligible risk

Screening values for negligible risk have been derived in Belgium (Walloon region), the Czech Republic, the Netherlands and Slovakia. In Flanders background levels are considered. Most of the screening values for negligible risk are not related to land use.

Metals and metalloids

In the comparison of negligible risk values for metals and metalloids it should be stressed that they are usually related to national background concentrations. In some countries they are only based on statistics on average background concentrations. In other countries a negligible risk concentration is estimated and compared or added to (average) background concentrations. When the estimated risk based concentration is lower than the average background concentration, which is frequently the case, often the background concentration is taken. Besides, it should be kept in mind that different definitions of background concentration exist, e.g. focused on contaminants that have a "natural" origin ("natural" background) or concentrations that are found in large areas, including man-influenced agricultural land. Moreover, different statistics can be used to derive background representative values, e.g. the mean value or a specific percentile. As a consequence, (differences in) negligible risk values can not always be related to (differences) in risk procedures between countries. It is not possible within the framework of this study to relate differences between negligible risk SVs to the variability of background concentrations across Europe. In Table 4.2 all available screening values for negligible risk for metals and metalloids have been listed. Besides, these values have been plotted in Figure 4.1.

Table 4.2. Screening values for negligible risk for metals and metalloids (mg/kg d.w.)

	Belgium Wa	Czech Republic	Netherlands	Slovakia
As	12	30	29	29
Ba		600	160	500
Be		5	0.04	3
Cd	0.2	0.5	0.80	0.8
Co		25	0.38	20
Cr	34	130	100	130
Cr(VI)	2.5			
Cu	14	70	36	36
Hg	0.05	0.4	0.3	0.3
Pb	25	80	85	85
Mo		0.8	0.13	1
Ni	24	60	35	35
Sb			0.13	
V		180	42	120
Zn	67	150	140	140

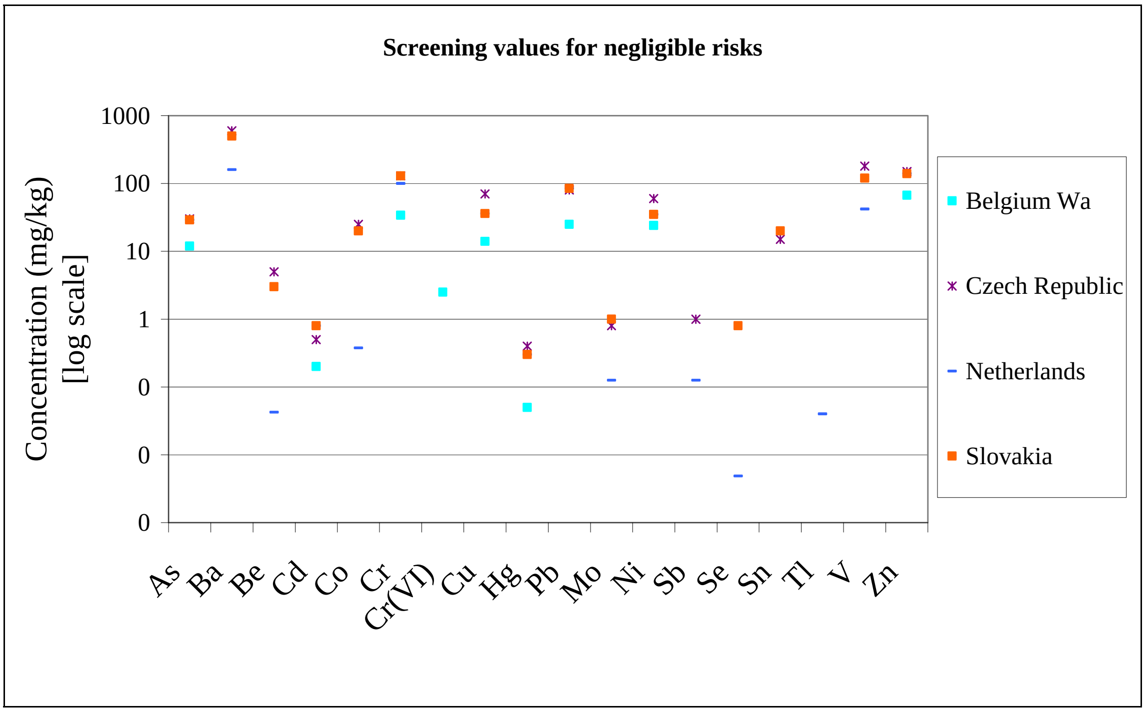


Figure 4.1. Screening values for negligible risk for the metals and metalloids.

From the graph it can be concluded that the highest and lowest values often differ around one order of magnitude (barium, cadmium, chromium, copper, lead, mercury, molybdenum and vanadium). A relatively low variability between screening values for negligible risk for metals and metalloids is shown for nickel and zinc (a factor of 3 and 2 respectively between the highest and lowest values; 3 entries for both metals). At the other hand a relatively high variability between screening values for negligible risk for metals and metalloids is found for cobalt (a factor of 70; 3 entries) and mainly for beryllium (a factor of 13,000; 3 entries).

From the graph it also can be concluded that there is no clear trend in regard to negligible risk SVs for metals and metalloids, in terms of relatively high or low values related to countries.

Organic contaminants

In Table 4.3 all available screening values for negligible risk for organic contaminants have been listed. Besides, these values have been plotted in Figure 4.2 for the most relevant organic contaminants. In Flanders: background levels are equal to detection limit – except for PAHs.

Table 4.3. Screening values for negligible risk for organic contaminants (mg/kg d.w.).

	Belgium Wa	Czech Rep.	Netherlands	Slovakia
Benzene	0.1	0.03	0.01	
Ethylbenzene	0.1	0.04	0.0021	
Toluene	0.1	0.03	0.0007	
Xylene	0.2	0.03	0.0007	
Naphtalene		0.05		0.01
Anthracene		0.1		0.1
Benzo(a)anthracene	0.01	0.1		1
Benzo(g,h,i)perylene	0.01	0.05		10
Benzo(a)pyrene	0.01	0.1		0.1
Trichloroethylene			0.1	0.01
PCB		0.02	0.02	

From the graph it can be concluded that the highest and lowest values often differ around one order of magnitude (benzene, naphthalene, benzo(a)pyrene and tri-chloroethylene). However, the number of entries for these contaminants is limited (2 to 4). No organic contaminants show a much lower variability between screening values for negligible risk than one order of magnitude between the highest and lowest values, except for PCB (values equal, but only two entries). A relatively high variability between screening values for negligible risk for organic contaminants, in between 2 and 3 order of magnitudes between the highest and lowest values, is found for toluene, xylene, benzo(ghi)perylene. The highest and lowest values for ethylbenzene differ with a factor of around 250. From the graph it also can be concluded the screening values for negligible risk for the organic aromatic compounds (BETX) for the Netherlands are relatively low.

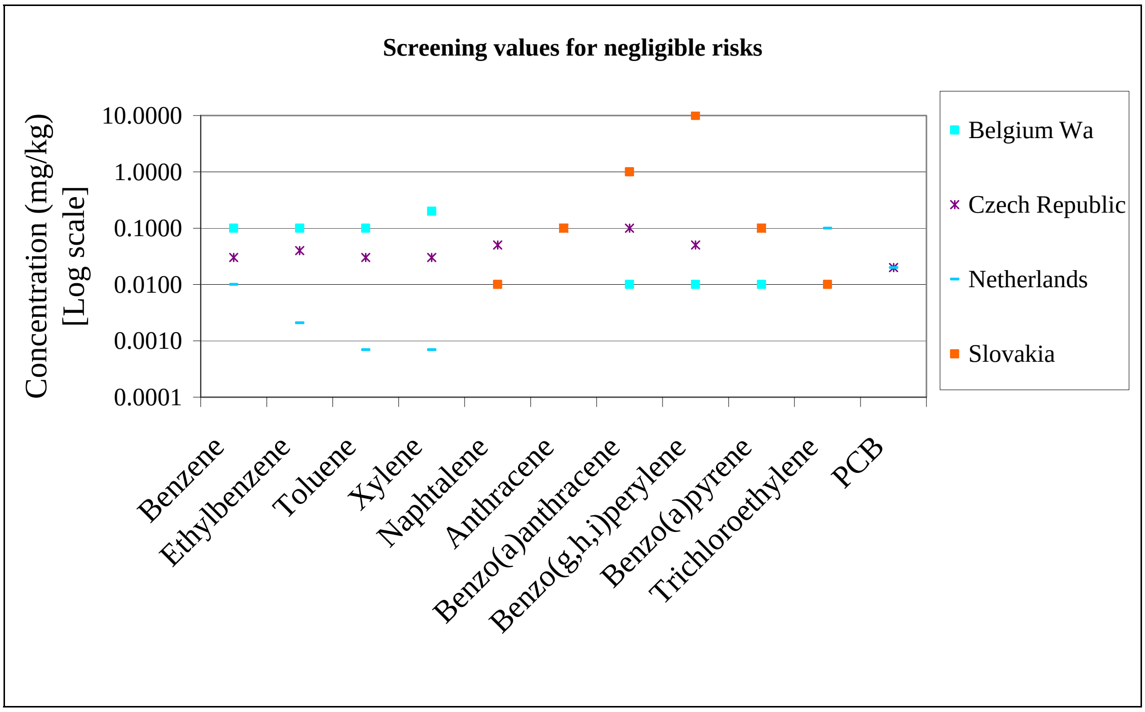


Figure 4.2. Screening values for negligible risk for the most relevant organic contaminants.

4.2.2 Screening values for intermediate (warning) risk

Screening values for intermediate (warning) risk have been derived in Austria, Belgium (Walloon region), the Czech Republic, Germany, Slovakia, Denmark, Finland, Belgium (Flanders) and Sweden. Only values for the residential use were considered, since SSVs for other soil uses have hardly been derived .

Metals and metalloids

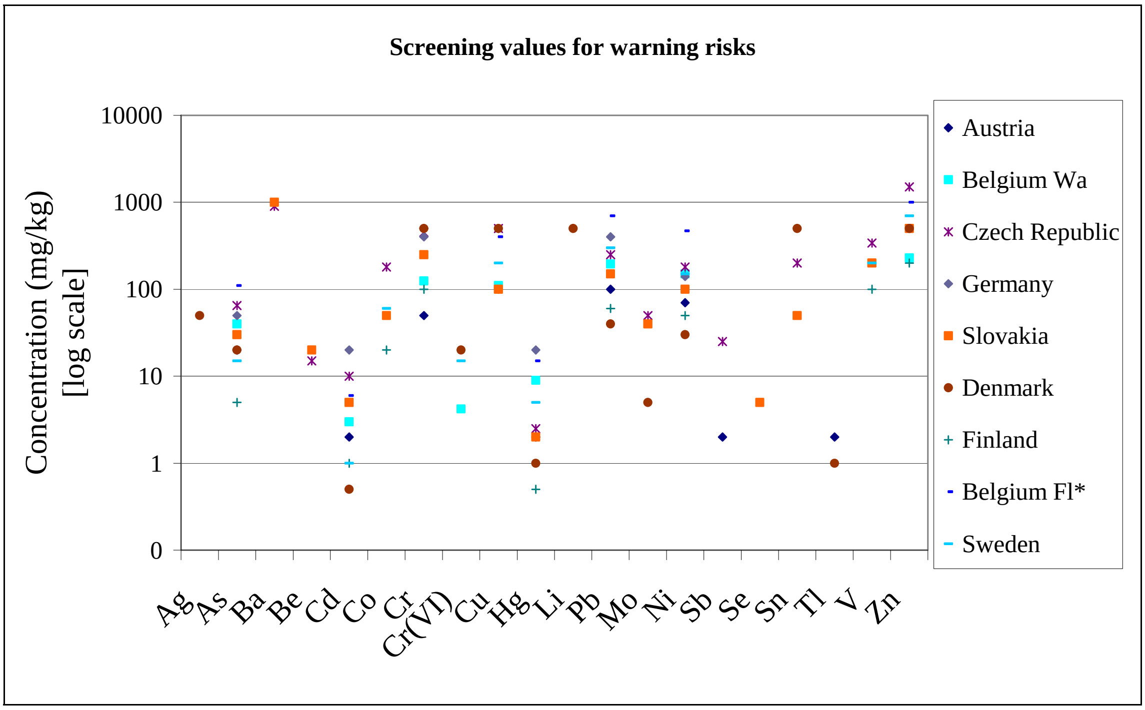
In Table 4.4 all available screening values for warning risk for metals and metalloids have been listed. Besides, these values have been plotted in Figure 4.3 for the most relevant metals and metalloids.

Table 4.4. Screening values for warning risk for metals and metalloids (residential use) (mg/kg d.w.)

	Austria	Belgium Fl*	Belgium Wa	Czech Rep.	Finland	Germany	Slovakia	Denmark	Sweden
As	20	110	40	65	5	50	30	20	15
Be				15			20		
Cd	2	6	3	10	1	20	5	0.5	1
Co				180	20		50		200
Cr	50		125	450	100	400	250	500	250
Cr(VI)			4.2					20	15
Cu	100	400	110	500	100		100	500	
Hg	2	15	9	2.5	0.5	20	2	1	5
Pb	100	700	195	250	60	400	150	40	300
Mo				50			40	5	
Ni	70	470	150	180	50	140	100	30	150
Sb	2			25	2				
Se							5		
Tl	2							1	
V				340	100		200		200
Zn		1000	230	1500	200		500	500	700

**For historical contaminants only*

From the graph it can be concluded that the highest and lowest values often differ around a factor of one order of magnitude (chromium, cobalt, copper, molybdenum, nickel, antimony, and zinc). No metals show a much lower variability between screening values for significant risk for metals and metalloids than one order of magnitude between the highest and lowest values. A relatively high variability between screening values for significant risk for metals and metalloids is found for arsenic (a factor of 22), cadmium (a factor of 40), mercury (a factor of 15) and lead (a factor of 18), (9 entries for all five metals).
From the graph it also can be concluded that there is no clear trend in regard to screening values for warning risk for metals and metalloids, in terms of relatively high or low values, related to countries.



* *For historical contaminants only*

Figure 4.3. Screening values for warning risk for the metals and metalloids.

Organic contaminants

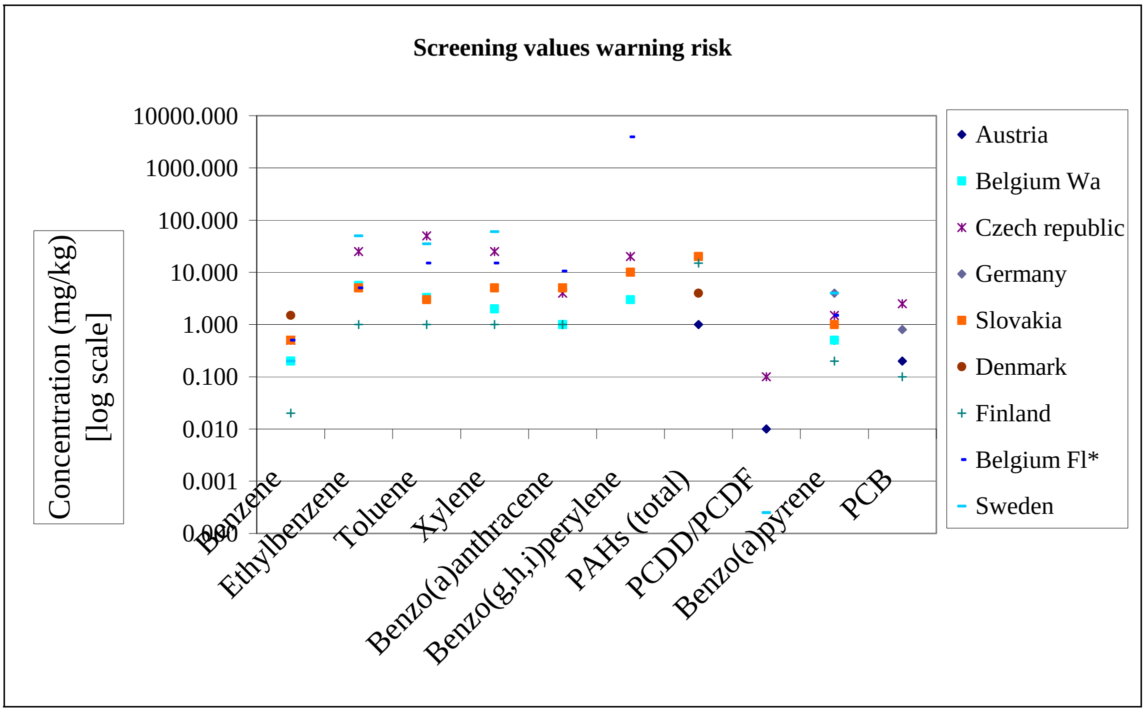
In Table 4.5 all available screening values for warning risk for organic contaminants have been listed. Besides, these values have been plotted in Figure 4.4 for the most relevant organic contaminants. Only contaminants for which at least 3 entries have been given have been included in the graph.

Table 4.5. Screening values for warning risk for the most relevant organic contaminants (residential use) (mg/kg d.w.).

	Austria	**Belgium Fl***	**Belgium Wa**	**Czech rep**	**Finland**	**Germany**	**Slovakia**	**Denmark**	**Sweden**
Benzene		0.5	0.2	0.5	0.02		0.5	1.5	0.2
Ethylbenzene		5	5.6	25			5		50
Toluene		15	3.3	50			3		35
Xylene		15	2	25			5		60
Benzo(a)anthracene		10.5	1	4	1		5		
Benzo(g,h,i)perylene		3920	3	20			10		
PAHs (total)	1				15		20	4	
PCDD/PCDF (in ng I-TEQ TeCdd/g)	10			0.1	0.00001	1,000			0.00025
Benzo(a)pyrene	0.5		0.5	1.5	0.2	4	1		
PCB	0.2			2.5	0.1	0.8			4

**For historical contaminants only*

From the graph it can be concluded that the highest and lowest values often differ around one order of magnitude (benzo(a)pyrene, benzo(a)anthracene, PAH total, PCDD/PCDF), or in between one and two orders of magnitude (benzene, ethylbenzene, xylene, toluene, PCBs). A relatively high variability between screening values for warning risk for organic contaminants is found for benzo(ghi)perylene (a factor of 1300 between the highest and lowest values; 4 entries). From the graph it also can be concluded that the screening values for warning risk for Belgium (Wallonian region) are relatively low for all organic contaminants. Besides, the screening values for warning risk for the Czech Republic and Sweden are relatively high for the organic contaminants.



**For historical contaminants only*

Figure 4.4. Screening values for warning risk for organic contaminants.

4.2.3 Screening values for potentially unacceptable risk (residential soil-use)

Screening values for potentially unacceptable risk (residential soil-use) have been derived in most countries, i.e. Austria, Belgium (Walloon region), Belgium (Flanders), Belgium (Brussels), the Czech Republic, Finland, Italy, Lithuania, the Netherlands, Poland, Slovakia, Sweden, UK, Denmark and Spain.

Metals and metalloids

In Table 4.6 all available screening values for the potentially unacceptable risk (residential soil-use) for metals and metalloids have been listed. Besides, these values have been plotted in Figure 4.5 for the most relevant metals and metalloids. Only contaminants for which at least 3 entries have been given have been included in the graph.

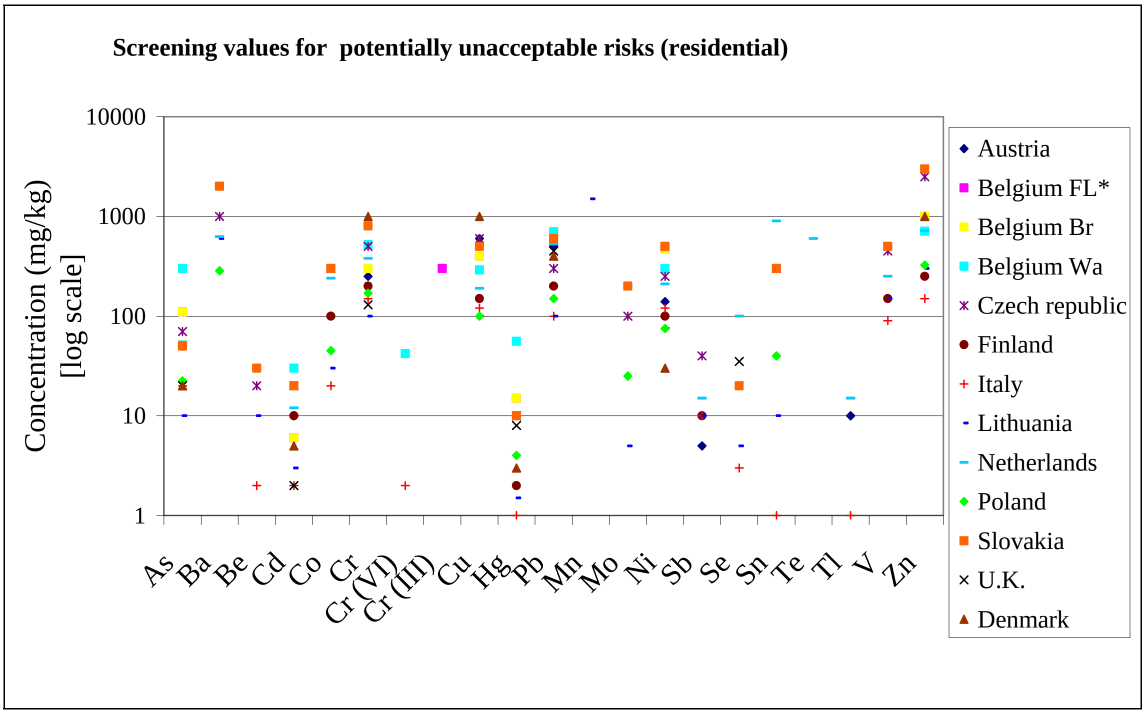
Table 4.6. Screening values for potentially unacceptable risk (residential soil-use) for metals and metalloids (mg/kg d.w.).

Legend: Austria (AUT); Belgium Flanders (BE(F)); Belgium Bruxelles (BE(B)), Belgium Walloon (BE(W)); Czech Republic (CZE); Finland (FIN); Italy (ITA); Lithuania (LTU); Netherlands (NLD); Poland (POL); Slovakia (SVK); United Kingdom (UK); Denmark (DNK)

	AUT	**BE(F)***	**BE(B)**	**BE(W)**	**CZE**	**FIN**	**ITA**	**LTU**	**NLD**	**POL**	**SVK**	**UK**	**DNK**
As	50	110	110	300	70	50	20	10	55	22.5	50	20	20
Ba					1000			600	625	285	2000		
Be					20		2	10	30		30		
Cd	10	6	6	30	20	10	2	3	12	5.5	20	2	5
Co					300	100	20	30	240	45	300		
Cr	250		300	520	500	200	150	100	380	170	800	130	1000
Cu	600	400	400	290	600	150	120	100	190	100	500		1000
Hg	10	15	15	56	10	2	1	1.5	10	4	10	8	3
Pb	500	700	700	700	300	200	100	100	530	150	600	450	400
Mo					100			5	200	25	200		
Ni	140	470	470	300	250	100	120	75	210	75	500		30
Sb	5				40	10	10	10	15				
Se							3	5	100		20	35	
Sn					300		1	10	900	40	300		
Te									600				
Tl	10						1		15				
V					450	150	90	150	250		500		
Zn		1000	1000	710	2500	250	150	300	720	325	3000		1000

**For new contaminants only*

From the graph it can be concluded that the highest and lowest values often differ around a factor of one order of magnitude (antimony, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, vanadium). No metals show a much lower variability between screening values for relevant risk (residential soil-use) for metals and metalloids than one order of magnitude between the highest and lowest values. A relatively high variability between screening values for relevant risk (residential soil-use) for metals and metalloids, in between 1 and 2 order of magnitudes between the highest and lowest values, is found for arsenic, mercury, molybdenum and selenium (5 to 13 entries). For Sn the difference between the highest and lowest value is a factor of 900 (6 entries). From the graph it also can be concluded that there is no clear trend in regard to screening values for potentially unacceptable risk (residential soil-use) for metals and metalloids, in terms of relatively high or low values, related to countries. An exception is Italy, for which the screening values for potentially unacceptable risk (residential soil-use) are relatively low for many metals and metalloids.



*For new contaminants only

Figure 4.5. Screening values for potentially unacceptable risk (residential soil-use) for the metals and metalloids.

Organic contaminants

In Table 4.7 all available screening values for potentially unacceptable risk (residential soil-use) for organic contaminants have been listed. Besides, these values have been plotted in Figure 4.6 for the most relevant organic contaminants. Only contaminants for which at least 3 entries have been given have been included in the graph.
From the graph it can be concluded that the highest and lowest values often differ around two order of magnitudes (benzene, naphthalene, anthracene, PAHs total, dichloromethane, trichloroethylene, tetrachloromethane, MTBE and benzo(a)pyrene). For several contaminants (ethylbenzene, toluene, xylene, benzo(a)anthracene, phenols, cresols, atrazine) differences in screening values for relevant risk (residential soil-use) in between two and four order of magnitudes are found. A relatively low variability between screening values for potentially unacceptable risk for organic contaminants is shown for hexachlorobenzene, 1,1,1-trichloroethane, and chlorobenzenes, but for these organic contaminants only 3 values are available.

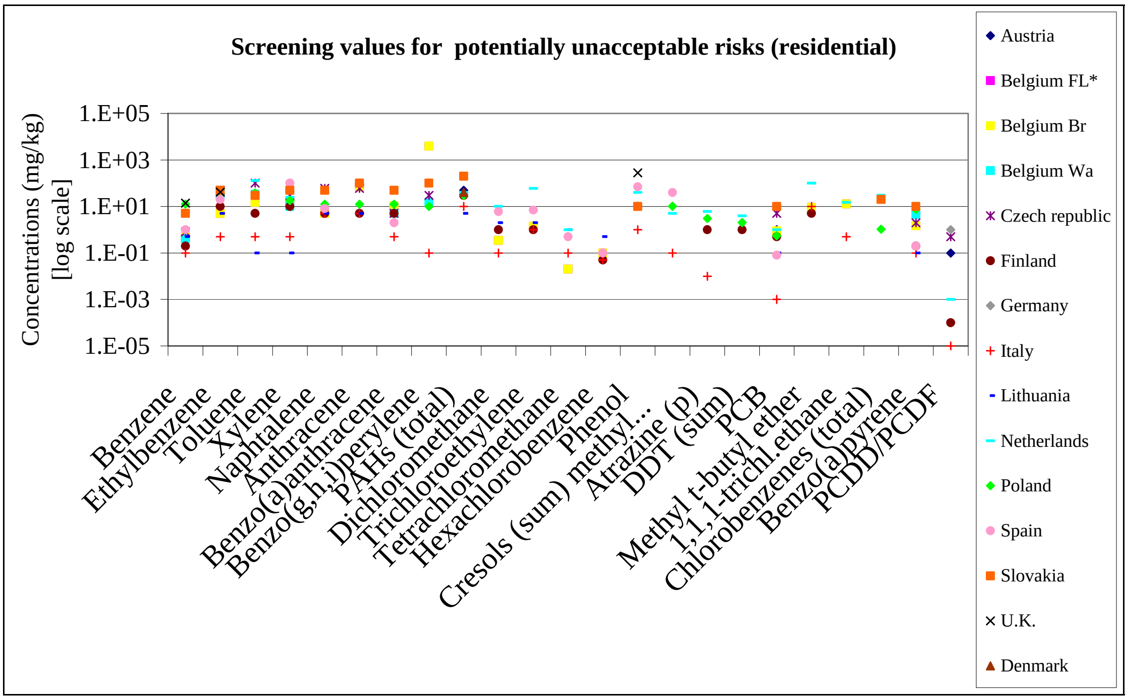
Table 4.7. Screening values for potentially unacceptable risk (residential soil-use) for the most relevant organic contaminants (mg/kg d.w.).

Legend: Austria (AUT); Belgium Flanders (BE(F)); Belgium Bruxelles (BE(B)), Belgium Walloon (BE(W)); Czech Republic (CZE); Finland (FIN); Italy (ITA); Lithuania (LTU); Netherlands (NLD); Poland (POL); Spain (ESP); Slovakia (SVK); Sweden (SWE); United Kingdom (UK) for human health; Denmark (DNK)

	AUT	BE(F)*	BE(B)	BE(W)	CZE	FIN	ITA	LTU	NLD	POL	ESP	UK	DNK
Benzene		0.5	0.5	0.4	0.8	0.2	0.1	0.5	1	12.6	1		
Ethylbenzene		5	5	28	50	10	0.5	5	50	38	20	41	
Toluene		15	15	33	100	5	0.5	0.1	130	38	30		
Xylene		15	15	10	30	10	0.5	0.1	25	18	100		
Naphtalene		5	5		60	5	5	5		12.5	8		
Anthracene		70	70		60	5	5	5		12.5	100		
Benzo(a)anthracene		10.5	10.5	5	5	5	0.5			12.5	2		
Benzo(g,h,i)perylene		3920	3920	15	30		0.1			10			
PAHs (total)	50					30	10	5	40	30			40
Dichloromethane		0.35	0.35			1	0.1	2	10		6		
Trichloroethylene		1.4	1.4			1	1	2	60		7		
Tetrachloromethane		0.02	0.02				0.1	1	1		0.5		
Hexachlorobenzene		0.1	0.1			0.05	0.05	0.5			0.1		
Phenol							1	10	40	10.25	70	280	
Cresols (sum)							0.1		5	10.25	40		
Atrazine (p)						1	0.01		6	3			
DDT (sum DDT, DDE & DDD)						1			4	2.01			
PCB	1		0.9		5	0.5	0	0.1	1	0.55	0.08		
methyl t-butyl ether		9	9			5	10		100				
1,1,1-trichloroethane		13	13				0.5		15				
Chlorobenzenes (total)									30	1.05			
Benzo(a)pyrene	5	1.5	1.5	4.4	2	2	0.1	0.1		7.5	0.2		
PCDD/PCDF (in ng I-TEQ TeCdd/g)	100				0.5	0.0001	1.00E-05		0.001				

**For new contaminants only*

At the other hand a relatively high variability between screening values for potentially unacceptable risk (residential soil-use) for organic contaminants is found for benzo(ghi)perylene and mainly PCDD/PCDF (a factor of 40,000 and 50,000 respectively between the highest and lowest values; 7 and 6 entries, respectively).



*For new contaminants only

Figure 4.6. Screening values for potentially unacceptable risk (residential soil-use) for the most relevant organic contaminants.

From the graph it also can be concluded that the screening values for potentially unacceptable risk (residential soil-use) for Italy are relatively low for many organic contaminants. Besides, the screening values for potentially unacceptable risk (residential soil-use) for the Netherlands and Slovakia are relatively high for many organic contaminants.

4.2.4 Screening values for potentially unacceptable risk (industrial soil-use)

Screening values for potentially unacceptable risk (industrial soil-use) have been derived in Belgium (Flanders), Belgium (Walloon region), Belgium (Brussels), Finland, Italy, Poland and the UK. The same considerations expressed for the residential soil-use apply for the Swedish guideline values.

Metals and metalloids

In Table 4.8 all available screening values for potentially unacceptable risk (industrial soil-use) for metals and metalloids have been listed. Besides, these values have been plotted in Figure 4.7 for the most relevant metals and metalloids.

Table 4.8. Screening values for potentially unacceptable risk (industrial soil-use) for metals and metalloids (mg/kg d.w.)

	Belg.(F)	**Belg.(B)**	**Belg.(W)**	**Finland**	**Italy**	**Poland**	**UK**
As	300	300	300	100	50	62.5	500
Ba						1650	
Be					10		
Cd	30	30	50	20	15	13	1400
Co				250	250	175	
Cr		800	700	300	800	475	5000
Cu	800	800	500	200	600	600	
Hg	30	30	84	5	5	27	480
Pb	2500	2500	1360	750	1000	600	750
Mo						115	
Ni	700	700	500	150	500	285	
Sb				50	30		
Se					15		8000
Sn					10	170	
Tl					350		
V				250	250		
Zn	3000	3000	1300	400	1500	1650	

From the graph it can be concluded that the highest and lowest values often differ around one order of magnitude (copper, lead, nickel and zinc; 6 entries for all metals). For a few metals and metalloids (cobalt, antimony) the screening values for potentially unacceptable risk (industrial soil-use) are similar, but for these contaminants there are only 3 and 2 entries, respectively. The variation in screening values for potentially unacceptable risk (industrial soil-use) for arsenic is around a factor of 30. A relatively high variability between screening values for potentially unacceptable risk (industrial soil-use) for metals and metalloids is found for selenium (a factor of 500; 2 entries only), cadmium and mercury (a factor of 100; 7 entries, for both metals).

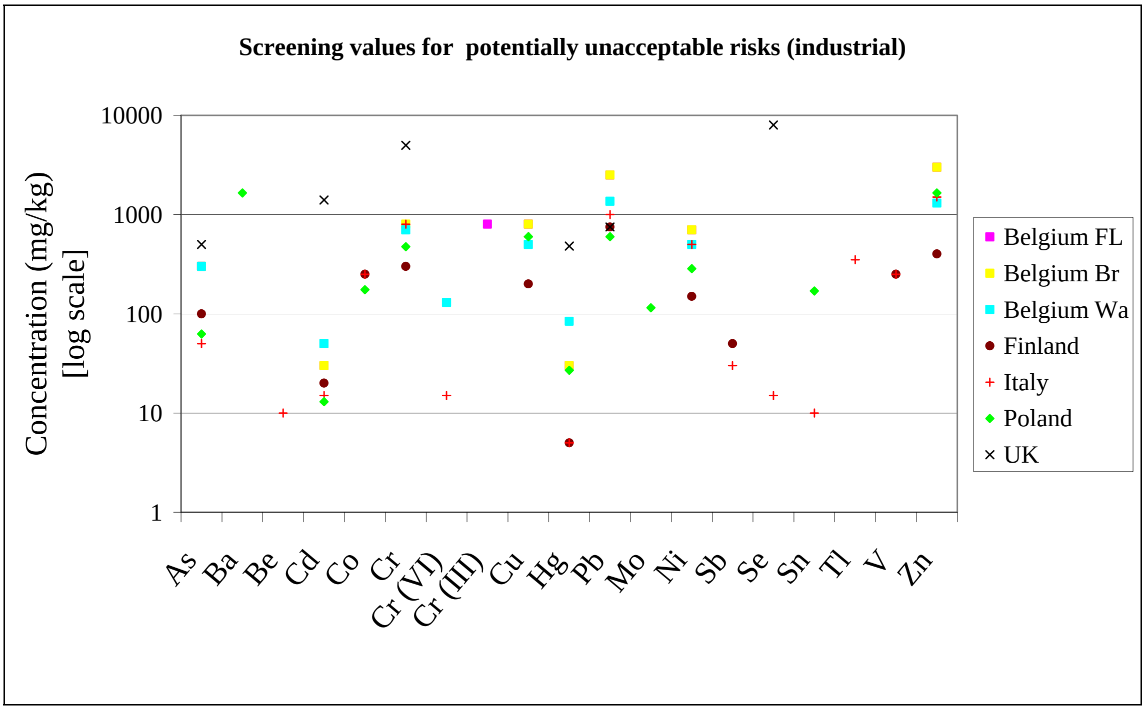


Figure 4.7. Screening values for potentially unacceptable risk (industrial soil-use) for the metals and metalloids.

From the graph it also can be concluded that the screening values for potentially unacceptable risk (industrial soil-use) for Italy are relatively low for many metals. On the other hand, the screening values for potentially unacceptable risk (industrial soil-use) are relatively high for the UK for many metals and metalloids.

Organic contaminants

In Table 4.9 all available screening values for potentially unacceptable risk (industrial soil-use) for organic contaminants have been listed. Besides, these values have been plotted in Figure 4.8 for the most relevant organic contaminants. Only contaminants for which at least 3 entries have been given have been included in the graph.

Table 4.9. Screening values for potentially unacceptable risk (industrial soil-use) for organic contaminants (mg/kg d.w.).

	Belg.(F)	Belg.(B)	Belg.(W)	Finland	Italy	Poland	Spain	UK
Benzene	1	1	0.6	1	2	76.5	10	
Ethylbenzene	70	70	76	50	50	130	100	48000
Toluene	200	200	85	25	50	117.5	100	
Xylene	190	190	20	50	50	77.5	100	
Naphtalene	160	160		15	50	25	10	
Anthracene	4690	4690		15	50	25	100	
Benzo(a)anthracene	30	30	10	15	10	25	20	
Benzo(g,h,i)perylene	4690	4690	100		10	52.5		
PAHs (total)				30	100	110		
Dichloromethane	3.5	3.5		5	5		60	
trichloroethylene	10	10		5	10		70	
Tetrachloromethane	1	1			5		1	
Hexachlorobenzene	55	55		2	5		1	
Phenol					60	51.5	100	78
Cresols (sum) methyl-phenols					25	51.5	100	
Atrazine (p)				2	1	3		
PCB		10.4		5	5	2.75	0.8	
Methyl t-butyl ether	140	140		50	250			
1,1,1-trichloroethane	300	300			50			
Benzo(a)pyrene	3	3	8.8	15	10	22.5	2	

From the graph it can be concluded that for some organic contaminants (phenols, cresols, benzo(a)anthracene, PAH total, tetrachloromethane, 1,1,1-trichloroethane, atrazine, MTBE) the differences between the highest and lowest value for the screening values for potentially unacceptable risk (industrial soil-use) are less than one order of magnitude. However, the number of entries for these contaminants is limited. For many contaminants it can be concluded that the highest and lowest values often differ around one order of magnitude (toluene, xylene, naphthalene, dichloromethane, trichloroethylene, PCB and benzo(a)pyrene; number of entries in between 3 and 6). A relatively high variability between screening values for potentially unacceptable risk (industrial land-use) for organic contaminants, in between 2 and 3 order of magnitudes between the highest and lowest values, is shown for ethylbenzene, anthracene and benzo(ghi)perylene (6 and 5 entries, respectively).
From the graph it also can be concluded that there is no clear trend in regard to screening values for potentially unacceptable risk (industrial soil-use) for organic contaminnats, in terms of relatively high or low values, related to countries.

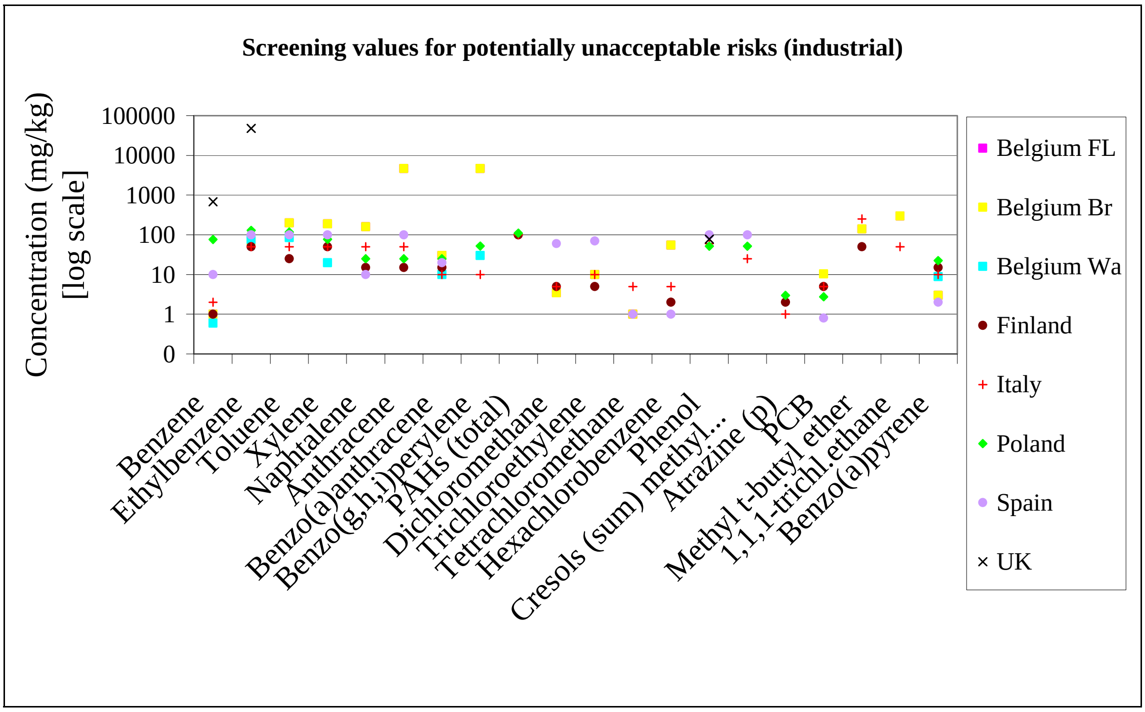


Figure 4.8. Screening values for potentially unacceptable risk (industrial soil-use) for the most relevant organic contaminants.

5

RELATION BETWEEN SOIL AND GROUNDWATER SCREENING VALUES

Marco D'Alessandro, Claudio Carlon

About 50% of the participating countries include the soil leaching pathway in the derivation of contaminants soil SVs (i.e. protection of groundwater resources (e.g. BE-Wal., DK, DE, IT, PL, SE, ES, draft in BE-Fland.). The leaching potential is estimated and compared with groundwater quality criteria. If the groundwater quality criteria are exceeded, the soil SV is adjusted to reduce the potential leaching to acceptable levels. The groundwater protection usually refers to human drinking-water use. Exceptions are the Walloon Region (BE) and Spain. In the Walloon region (BE), both human drinking uses and ecotoxicological effects on aquatic organisms are considered. In Spain, the protection of groundwater resources is considered only in the derivation of ecological risk SVs and in relation to eco-toxicological effects on aquatic organisms.

A completely different approach is followed by Germany, where the soil leaching groundwater pathway is not considered in combination with other exposure pathways, while as an alternative threshold values for leaching tests are provided.

All the participating countries provide groundwater SVs for the assessment of groundwater contamination. In most of the cases, however, groundwater SVs simply refer to toxicological standards for drinking-water use (e.g. standards recommended by WHO). In some cases regional contamination background values are taken into consideration in combination with WHO standards. Other criteria can be the taste and colour. Besides drinking-water use criteria, ecotoxicological criteria are considered in Germany, Denmark and The Netherlands.

The system in The Netherlands implies the derivation of intervention values for groundwater based on the potential leaching associated to soil Intervention Values.

However, the estimated groundwater Intervention Values are eventually adjusted not to exceed drinking quality criteria.
In spite of the poor correlation with soil SVs, groundwater SVs can play a relevant role in the management of contaminated soil. As an example, in Austria industrial areas soil SVs do not apply, while the compliance with groundwater SVs is the only concern.
The weaknesses of current groundwater SVs as indicated in the country reports are the following:

- the lack of groundwater SVs and the use of drinking water objectives instead,
- ecotoxicological criteria are not applied (with the exception of few EU countries), with possible impacts on the aquatic and terrestrial ecosystem,
- the lack of harmonization with SVs of other compartments, in particular with soil,
- the missing distinction between hydrogeological (e.g. permeability) and water use scenarios,
- the missing distinction for point and regional contamination.

However in the near future these weaknesses should be overcome by the implementation of the new European Legislation. In support of the Water Framework Directive, WFD (2000/60/EC), the Commission has proposed [COM(2003)550] the development of a complementary Groundwater Directive (GWD). This Directive would establish criteria for assessing the chemical status of groundwater (nitrates, pesticides and biocides) and would require Member States to identify pollutant threshold values representative of groundwater bodies found to be at risk. In support to the implementation of the future Groundwater Directive, the BRIDGE (Background cRiteria for the IDentification of Groundwater thresholds) project has been funded by the European Commission to provide methodological references for the derivation of groundwater quality criteria. The BRIDGE project is leaded by the Bureau de Recherche Géologiques et Minières (BRGM) in France and is supported by a wide participation of institutes from other European countries.

6

CONCLUSIONS AND OUTLOOK

Claudio Carlon, Frank Swartjes, Marco D'Alessandro

State of the art of SVs derivation methods for soil contaminants in EU

Chapter 3 provides a comprehensive view of derivation methods for soil SVs in a representative group of EU countries. The following conclusions can be drawn:

- in most countries SVs are based on the application of exposure modeling and risk characterization (e.g., in BE, DE, DK, FI, ES, SW, NL, IT, UK). In some countries, mainly new EU Member States, current SVs are based on the review of SVs adopted by other countries (e.g., AT, CZ, SK, PL, LT).
- the main methodological references followed by EU countries are the European Commission Technical Guidance Document on Risk Assessment (ECB, 2003), the procedures developed by RIVM in The Netherlands (RIVM reports), approaches adopted in Unites States (e.g. US-EPA, 1996 and 1998; ASTM, 1998), and the former Soviet Union procedures and values (in central and east European Countries). Some countries developed their own methods (e.g. Belgium). For the ecological risk assessment, the Canadian Guidelines (CCME, 1999) are also considered.
- the derivation of soil SVs is far from being a consolidated and settled process; in fact, the SVs derivation procedures are currently undergoing further implementation or revision in most of the EU countries (AT, CZ, ES, FI, PL, B-Flan. and B-Wal., IT, SE, NL). In many countries the ecological risk SVs have not been adopted (yet), when in some countries ecological risk SVs are still under revision (e.g. UK, B-Flan.).
- the number of soil SVs provided by different countries greatly varies across Europe. Four countries provide less than 20 values (UK, AT, BE-Wal., DE), six countries provide between 40 to 60 soil SVs (CZ, BE-Flan., FI, PL, ES, SE), four countries provide between 60 to 80 soil SVs (NL, SK, DK, LT), and one country generated up to 234 soil SVs (IT).

- the core group of substances for which soil SVs are most commonly generated includes heavy metals and metalloids (As, Cd, Cr, Cu, Hg, Pb, Ni, Zn), aromatic hydrocarbons (e.g., Benzene, Ethylbenzene, Toluene), polycyclic aromatic hydrocarbons (e.g., Naphthalene, Anthracene, Benzo(a)anthracene, Benzo(ghi)perylene, Benzo(a)pyrene), chlorinated aliphatic hydrocarbons (dichloromethane, trichloroethylene, tetrachloromethane), chlorinated aromatic hydrocarbons (chlorobenzene, hexachlorobenzene), pesticides (atrazine, DDT), dioxin and dioxin like PCBs. Whenever the soil SV is not provided, the reference to SVs produced by other countries is usually accepted (in the UK missing SVs are expected to be generated using the CLEA model). The generation of soil SVs for other contaminants is ongoing in some countries, e.g. UK, BE-Wal. Revisions of current soil SVs are ongoing or planned in many countries (BE-Fland, NL, FI, LT).

Weaknesses and needs for implementations have been indicated in the country profiles. First of all, the national legal framework generates some problems:

- the lack of legal recognition of SVs, which is also indicated as the main reason for the weak scientific support (e.g. AT, LT, CZ);
- the conflicting authority on SVs of multiple Ministries, like the environmental, health, agriculture, economic related Ministries (e.g. LT, SK);
- the reference to SVs beyond their significance and intended application (e.g. FI); for example, regulators might be inclined to retain SVs as absolute reference for targeting remediation actions, even when they are intended as thresholds to warn for site-specific assessment; another example is when SVs are applied to excavated soil, while they are derived to assess the soil in place;
- the lack of transparency and documentation of the SVs derivation process (e.g. PL);
- the need for a formal involvement of stakeholders (e.g., FR).

Other problems regard the large uncertainties of risk assessment, in particular for ecological receptors, and the need for further research:

- the adoption of ecological soil SVs is hindered by their conservatism (e.g., BE-Flan., ES, SE, FI),
- the basis of toxicological, ecotoxicological and exposure data should be improved and managed at EU scale (e.g., BE-Fl., BE-Wal., UK, ES, FI)
- transfer and exposure modeling should be validated (e.g., BE-Fl., BE-Wal., UK, FI),
- bioavailability and biodegradability are not (properly) considered (e.g., FI),
- a distinction should be made between top soil and subsoil (e.g., FI),
- soil and groundwater SVs should be harmonized, also with proper inclusion of the soil groundwater-leaching pathway (e.g. FI, SK).

Relation between soil and groundwater screening values

As a general remark, soil SVs and groundwater SVs are often derived separately and not combined. The protection of groundwater resources from contaminants leaching processes is included in the derivation of soil SVs in only about 50% of participating countries. Nevertheless, groundwater SVs play a relevant role in the management of contaminated soil. In some countries the protection of groundwater resources is the main concern and groundwater SVs are the driving factors of contaminated land remediation.

Main weaknesses of current groundwater SVs appear to be the following:

- the lack of adequate criteria for the development of groundwater SVs and the use of drinking-water objectives instead,
- the fact that ecotoxicological criteria are rarely taken into account, therefore possible impacts of groundwater contamination on the aquatic and terrestrial ecosystem are not properly considered,
- the fact that hydrogeological conditions and water use scenarios are not taken into account,
- the lack of methods to consider contribution from several contaminant sources to a single groundwater body,
- the lack of harmonization with SVs of other compartments, in particular with soil,
- the missing distinction between point and regional contamination.

Variability of derivation methods

From the analysis of questionnaire results, it is possible to classify the risk assessment components into four classes:

- Components with **high magnitude** of variation across Europe and **high sensitivity**, therefore **high relevance on the variability** of SVs,
- Components with **high magnitude** of variation across Europe but **limited sensitivity**, therefore with limited relevance on SVs variability,
- Components with **high sensitivity** but **limited magnitude** of variation across Europe, therefore with limited relevance on SVs variability,
- Components with **low sensitivity** and **low magnitude** of variation across Europe, therefore with very limited relevance on SVs variability.

Generally about 30% of the risk assessment components show high magnitude of variation and sensitivity. Therefore this can lead to major variations in SVs across Europe. About 40% of the components are sensitive, but show some uniformity across Europe (low magnitude of variation). About 30% of the components show high variation but their sensitivity is low, or cannot be defined. Very few components show low sensitivity and low magnitude of differences.

Among the components with **high relevance** on the SVs variation, the following conclusions can be drawn:

- many components concern basic choices in the conceptual model, like receptors to be protected and exposure pathways to be included,
- as far the exposure pathways, the "inclusion /exclusion of indoor exposure" and the "consumption of home-grown vegetables" vary across Europe and might have a striking impact,
- in the human health risk assessment, the inclusion/exclusion of exposure sources not-related to soil is also a relevant factor of difference,
- analogously, in the ecological risk assessment, the different ways to account for the average background concentration is a relevant factor,
- as far the acceptable level of incremental risk, a general agreement is observed for the human health risk assessment (e.g., about 10^{-5} for non-threshold carcinogenic substances), while it is still a matter of discussion for the ecological risk assessment (e.g., HC50),
- the reference to different toxicological data sources seems to be a critical factor for both the human health and the ecological risk assessment.

Among the components with wide variability but limited (or not definable) sensitivity, we find legal framework aspects and some technical choices, like the inclusion of less relevant exposure pathways and the SV dependence on the soil type. It is notable that most of the national procedures are under development or revision. This is particularly true for the ecological risk assessment, which for this reason is more demanding for common references at EU level.

Among the components with high sensitivity but limited variability, we find a large range of technical issues for which references are provided by international guidelines or by consolidated practices in most advanced regulatory frameworks. This is particularly true for the ecological risk assessment, which is likely due to the more recent development of national guidelines, with reference to consolidated guidelines and practices like the EC Technical Guidance Document on existing chemicals and the Dutch risk assessment procedure.

Variability of values

The variability of derivation methods is reflected by large variations among soil SVs in the participating countries. For the same contaminant, the difference between the lowest and highest national SVs is often more than one order of magnitude. In general, the differences are higher for organic contaminants than for metals and metalloids and increases up to five orders of magnitude for SVs associated to potentially unacceptable risk of some organic contaminants. The difference is not simply related to higher or lower conservatism adopted by some countries, because trends towards over or under estimations (i.e. when the same country systematically provides relatively low or high SVs for some contaminants) are not, or slightly, evident.

Reasons for differences of derivation methods

Based on the identification of reasons of differences of elements of risk assessment as they are developed in various EU countries, the following conclusions can be drawn:

- in general, differences can be explained by more than one category of factors,
- many differences in elements of risk assessment can be attributed to political reasons,
- scientific differences have also a large impact, in particular for more technical issues,
- environmental and geographical differences throughout Europe have a limited impact on elements of risk assessment.

Differences in the dominance of specific reasons can be noted among general framework issues, human health and ecological risk assessment:

- as for the general framework, reasons of differences are primarily political and regulatory, followed by scientific and, in a few cases, geographical or socio-cultural;
- with regard to the human health risk assessment, political/regulatory reasons are usually combined with scientific reasons. Geographical and socio-cultural reasons play a role in many cases, but rarely are the most relevant reasons;
- in the ecological risk assessment, reasons of differences (or uniformity) are primarily scientific reasons, followed by political/regulatory and in few cases geographical/socio-cultural.

Generally, the systematic analysis of elements of risk assessment has shown a poor correlation between differences in risk assessment practices and geographical/socio-cultural differences across Europe. Also, the variability of environmental conditions within a country is often comparable to the variability among countries, and therefore would support regional differences rather than national differences in risk based estimations.
Reasons of differences are never very clear. It can be argued that many differences have their origin in incidental reasons, like the time in which procedures have been developed and the persons in charge of their development. Some geographical and

socio-cultural factors might be not fully considered due to the non-ideal interaction between decision makers and scientists.
On the other hand, the limits of the performed analysis on reasons of differences should be borne in mind, which are the poor knowledge of the rational behind national procedures and, in particular, the relevant inter-dependence of reasons: e.g., in democratic systems it is expected that political choices well interpret the general will of the community, which in turn is dependent on socio-cultural aspects and environmental factors.

Harmonization perspective

There are significant differences among soil SVs derivation basis in EU countries, which are reflected in large differences in SVs values. In spite of differences in the application of SVs in various countries, it is possible to define criteria for the comparison of assumptions, methods and input values. The comparison performed in the present review outlines possibilities for the alignment of several aspects in derivation methods. Differences among methods are driven by geographical, socio-cultural, regulatory, political or scientific reasons. Moreover, these reasons are different for each specific element of risk assessment. In light of potential benefits of a further alignment of SVs in Europe, for some components reasons for differences seem to be weak or even incidental. Moreover, some components seem to be more sensitive to changes in the resulting SVs. It follows that the alignment of derivation methods for soil SVs should be approached at the level of risk components. Components that are more suitable for approximation are those primarily related to scientific choices. At which extent differences related to political choices can be smoothed should be seen in the light of the objectives of EU soil common policies and is beyond the objective of this report. The contribution of our analysis in this respect can be limited to two resulting considerations: in many cases geographical and socio-cultural differences seem to be marginal reasons for differences; on the contrary, political and scientific reasons in elements of risk assessment, which are usually combined and difficult to separate, are important reasons for differences in SVs.

7

REFERENCES

Aldenberg T, Jaworska JS, Traas TP. 2002. Normal species sensitivity distributions and probabilistic ecological risk assessment. In Posthuma L, Suter GW II, Traas TP, eds, *Species Sensitivity Distributions in Ecotoxicology.* Lewis, Boca Raton, FL, USA, pp 49–102.

ANPA, Agenzia Nazionale per la Protezione Ambientale. 2002. Analisi di rischio ecologico per il risanamento dei siti contaminati. Quadro internazionale e sviluppo di linee guida in ambito nazionale. A cura di F. Quercia, A. Marcomini, A. Critto, C. Carlon. (*in Italian*)

ASTM, American Society for Testing and Materials. 1998. Standard Provisional Guide for Risk-based Corrective Action – RBCA, PS104-98. Philadelphia, USA.

Burton, Jr., G.A., P.M. Chapman, E.P. Smith. 2002a. Weight-of-Evidence approaches for assessing ecosystem impairment. *Human and Ecological Risk Assessment* 8: 1657-1673.

Burton, Jr, G.A., G.E. Batley, P.M. Chapman, V.E. Forbes, E.P. Smith, T. Reynoldson, C.E. Schlekat, P.J. den Besten, A.J. Bailer, A.S. Green, R.L. Dwyer. 2002b. A Weight-of-Evidence framework for assessing sediment (or other) contamination: improving certainty in the decision-making process. *Human and Ecological Risk Assessment* 8: 1675-1696.

Canadian Council of Ministers of the Environment (CCME). 1999. Canadian Council of Ministers of the Environment. Pub.N. 1299. Winnipeg.

Carlon, C., (2005) The development of EU common references of site specific ecological risk assessment for contaminated land within the HERACLES research framework Consoil 2005 9th International Conference on Contaminated Soil, 3-7 Oct 2005 Extended proceedings, pp. 6.

Defra and the Environment Agency (2002) CLR 9 Contaminants in soils; Collation of toxicological data and intake values for humans.

ECETOC, 2001. Exposure Factors Sourcebook for European Populations, with focus on UK Data. Technical Report No.79

ECB, European Chemical Bureau. 2003. European Commission Technical Guidance Document on Risk Assessment. European Commission Joint Research Centre. EUR 20418

Evans, D., Hers, I., Wolters, R.M., Boddington, R.T.B., Hall, D.H., 2002. Vapour Transport of Soil Contaminants. Environment Agency and Institute of Petroleum Research and Development Technical Report P5-018/TR.

Faber, J.H.. 1998. Ecological risk of soil pollution: ecological building blocks for risk assessment. Technical Soil protection Committee, The Hague, The Netherlands, TCB-R07

Ferguson, C., Darmendrail, D., Freier, K., Jensen, B.K., Jensen, J., Kasamas, H., Urzelai, A., and Vegter, J. (eds.). 1998. Risk Assessment for Contaminated Sites in Europe. Volume 1: Scientific Basis. LQM Press, Nottingham.

Ferguson, C.C., and Kasamas, H. (eds.), 1999. Risk Assessment for Contaminated Sites in Europe. Volume 2: Policy Frameworks. LQM Press, Nottingham.

Ferguson, C., Denner, J., 1994. Developing Guideline (Trigger) Values for Contaminants in Soil: Underlying Risk Analysis and Risk Management Concepts. Land Contamination and Reclamation. 2 (3):117-123

Geraghty&Miller International Inc. 2004.NICOLE - Risk assessment comparison study. Report number 916830024, April 2004.

Hersteren, S. van, Leemkule, M.A. van de, Pruiksma, M.A.. 1999. Minimum soil quality: a use-based approach from an ecological perspective. Part 1: metals. Technical Soil Protection Committee, The Hague, The Netherlands, R08.

Leemkule, M.A. van de, Hersteren, S. van, Pruiksma, M.A.. 1999. Minimum soil quality: a use-based approach from an ecological perspective. Part 2: immobile organic micro-pollutants. Technical Soil Protection Committee, The Hague, The Netherlands, R08.

Nathanail, C.P., Earl, N.. 2001. Human Health Risk Assessment: Guideline Values and Magic Numbers Issues in Environmental Science and Technology No. 16 Assessment and Reclamation of Contaminated Land. The Royal Society of Chemistry. pp. 85-101

Provoost, Jeroen, Christa Cornelis, Frank Swartjes. 2006. Comparison of Soil Clean-up Standards for Trace Elements Between Countries: Why do they differ? J Soils Sediments 6(3): 173-181

Quercia, F., Vecchio, A., Falconi, M., Togni, L., Wcislo, E., Dlugosz, J., Korcz, M. 2006. Human health risk assessment: application of the NORISC-HRA and ROME models at two test sites. Proceedings of Second International Symposium and Exhibition on the Redevelopment of Manufactured Gas Plant Sites (MGP 2006), Reading, UK, 4-6 April 2006. Land Contamination &Reclamation, 14 (2) pp. 559-570

Rikken, M.G.J., J.P.A. Lijzen and A.A. Cornelese. 2001. Evaluation of model concepts on human exposure. Proposals for updating the most relevant exposure routes of CSOIL. RIVM report 711701022, RIVM, Bilthoven, The Netherlands.

Rutgers, M., Faber, J.H., Postma, J.F., Eijsackers, H. 2000. Site-specific ecological risk: a basic approach to finction-specific assessment of soil pollution. The Netherlands Integrated Soil Research Programme Report, Vol.28, RIVM, Aquasense, Alterra.

Siegris, R.L..1990. Development and implementation of soil quality and clean-up criteria for contaminated sites. In Contaminated Soil '90. F. Arendt et al. eds. Kluwer, Dordrecht

Sijm D.T.H.M., Wezel, A.P.van, Crommentuijn, T.. 2002. Environmental Risk Limits in the Netherlands. In Posthuma L, Suter GW II, Traas TP, eds, *Species Sensitivity Distributions in Ecotoxicology.* Lewis, Boca Raton, FL, USA, pp 221–253.

Swartjes, F.A. 2002.Variation in calculated human exposure: Comparison of calculations with seven European human exposure models. RIVM report 711701030, March 2001. RIVM, Bilthoven, The Netherlands.

United States Environmental Protection Agency (US-EPA). 1996. Soil Screening Guidance: User's Guide Office of Emergency and Remedial Response EPA/540/R-96/018 Washington, DC 20460

United States Environmental Protection Agency (US-EPA). 1998 Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F. Washington, DC.

Van-Camp. L., Bujarrabal, B., Gentile, A-R., Jones, R.J.A., Montanarella, L., Olazabal, C. and Selvaradjou, S-K. (2004). Reports of the Technical Working Groups Established under the Thematic Strategy for Soil Protection. EUR 21319 EN/4, 872 pp. Office for Official Publications of the European Communities, Luxembourg.

Verdonck, F.A.M., Aldenberg, T., Jaworska, J. Vanrolleghem, P.A. .2003. Limitations of current risk characterization methods in probabilistic environmental risk assessment *Environmental Toxicology and Chemistry*, Vol. 22, No. 9, pp. 2209–2213, 2003

Whittaker, J.J., Buss, S.R., Herbert, A.W. & Fermor, M., 2001. Benchmarking and Guidance on the Comparison of Selected Groundwater Risk Assessment Models. Environment Agency NGWCLC Report NC/00/14.

ANNEXES

ANNEX 1. QUESTIONNAIRE FORM AND RESULTS

1 - Questionnaire form

SOIL SCREENING VALUES			
GENERAL FEATURES			**Comments**
Legal framework	Special law for contaminated sites		
	Soil protection or groundwater protection law		
	Waste management law		
	National law		
	Regional law		
	Other		
Purpose (more than one use is possible)	Target values of negligible risk		
	Trigger values: further investigations,		
	Trigger value: restrictions in land use,		
	Trigger value: site specific risk assessment,		
	Target values: remediation objective		
	Cut off values for urgent remediation		
	Other		
Status	legal,		
	in development		
	Obligatory		
	Advised		
	Other		
Scientific basis	Risk based		
	Background natural concentrations		
	Reference to procedures or values of other countries (specify which)		
	Other (specify if known)		
Level of public domain of methodology	Published methodology for SSV derivation		
	Not published, but accessible		
	Not published and not accessible		
Revision	Continuous revision		
	Periodical revision (every n. years)		
	Occasional revision of some values		
	Revision not planned		
Protected receptors	Human Health		
	Ecosystem		
	Groundwater for drinking uses		
	Groundwater (as a receptor, not solely a pathway)		
	Surface water		

HUMAN HEALTH RECEPTOR - screening human health risk assessment -			Comments
Status	Approved technical guideline,		
	Proposal under approval,		
	In development		
CONCEPTUAL MODEL			
Generic or land-use specific	Generic		
	Residential with garden and allotments (incl. home grown vegetables)		
	Residential with garden (excl. home grown vegetables)		
	Residential with children playing fields		
	Public green areas		
	Nature conservation areas		
	Industrial or commercial		
	Agricultural		
Soil type dependent	Yes		
	No		
Background concentration	Not considered		
	Added		
	Considered instead when above screening value		
	Other		
Mixture effects	Not considered		
	Considered: specify which contaminants and effects considered		
	Effect additivity (TEF) for PAHs		
	Effect additivity (TEF) for dioxins, furans and PBC dioxin-like compounds		

Pathways	Outdoor: soil ingestion		
	Outdoor: dust ingestion		
	Outdoor: dermal exposure to soil		
	Outdoor: inhalation of soil vapours		
	Outdoor: inhalation of soil derived dust		
	Outdoor: inhalation of volatilized irrigation water		
	Indoor: dermal exposure to soil derived dust		
	Indoor: inhalation of soil originated vapours		
	Indoor: inhalation of groundwater vapours		
	Indoor: inhalation of volatilized domestic water		
	Indoor: showering (dermal contact + inhalation of vapours)		
	Resident diet: consumption of groundwater		
	Res. diet: intake of homegrown vegetables		
	Res. diet: Ingestion of soil attached to homegrown vegetables		
	Res. diet: intake of homegrown fruits		
	Res. diet: ingestion of soil attached to homegrown fruits		
	Res. diet: consumption of meat		
	Res. diet: consumption of dairy products		
	Surface water consumption of fish and shellfish		
	dermal contact surface water (swimming)		
	ingestion surface water (swimming		
	ingestion suspended matter (swimming)		

EXPOSURE MODELING			
Exposure averaging period	Differences according to land uses: Y/N		
	Carcinogenic: Adulthood lifetime (specify how long)		
	Carcinogenic: Childhood (specify how long)		
	Carcinogenic: Lifelong (childhood + adulthood) (specify partial durations)		
	Carcinogenic: other		
	Non carcinogenic: Adulthood exp.duration (specify how long)		
	Non carcin.: Childhood (specify how long)		
	Non carcin.: Lifelong (childhood + adulthood) (specify how long)		
	Non carcin.: other		
Exposure parameters (excluded duration)	For the same receptor, differences according to land uses: Y/N		
	Differences according to sex		
	Soil ingestion: deliberate ingestion of soil considered		
	Contribution of home grown vegetable consumption to total vegetable consumption: • 100% rate (specify which one)		
	Inhalation: Activity patterns distinction		
	Inhalation: Body weight related		
	Dermal absorption: Activity pattern related		
	Dermal absorption: Age related		
	Dermal absorption: Body weight-sex related		
Representative exposure	Combined from multiple pathways		
	Most critical exposure pathways		
	Individual pathways		

Intake modeling	Ingestion: substance-specific rate of resorption in the intestinal tract, when available		
	Inhalation: substance-specific absorption coefficient for respirable fraction (<10 µm), when available		
	Dermal uptake: evaporation of volatile contaminants from skin surface		
	Dermal uptake: permeability coefficients based on chemico-physical models		
	Dermal uptake: permeability coefficients only when available		
Inclusion of non-soil sources	No		
	Yes (specify how they are included)		
TOXICOLOGICAL ASSESSMENT			
Data sources	National DB (specify)		
	DB public on the web (specify, e.g. IPCS, US-EPA IRIS, IARC, ATSDR)		
	Peer revisions of national committees		
Toxicity effects	Systemic toxicity (chronic effects)		
	• Carcinogenicity and genotoxicity		
	• Reproductive and developmental effects		
	• Neurobehavioural toxicity		
	Other		
Toxicokinetics studies	Y/N		
Epidemiological studies	Y/N		
Dose-response curve for carcinogens	Yes		
	When possible		
	Threshold mechanism preferred		
	No		

SCREENING VALUE DERIVATION			
Acceptable risk	For carcinogens: incremental risk = 10^{-6}, 10^{-5}, 10^{-4} (specify), other (specify)		
	For not carcinogens: hazard quotient 1, other (specify)		
Deterministic or probabilistic approach	Deterministic		
	Probabilistic (exposure assessment)		
	Probabilistic (exposure + toxicological assessment)		
	If probabilistic, screening value is: 50- 75- 95- 99^{th} percentile? (specify)		
ECOLOGICAL RECEPTORS - Screening ecological risk assessment -			**Comments**
Status	Approved technical guideline,		
	Proposal under approval,		
	In development		
	None		
CONCEPTUAL MODEL			
Generic or land-use specific	Generic		
	Nature conservation areas		
	Residential		
	Industrial or commercial		
	Agricultural		
	Public green areas		
Ecological factors of concern	Ecosystem species		**If they depend upon land uses, differentiate them.**
	Life support functions		
	• Recycling of nutrients		
	• Soil detoxification		
	• Organic matter degradation		
	• Formation of soil structure		
	• Water cycle		
	• Soil ecosystem stability (e.g. biodiversity)		
	• Others		

Considered receptors	Soil microbial processes		
	Soil fauna		
	Plants		
	Wildlife		
	• terrestrial vertebrates		
	• terrestrial invertebrates		
	• others		
	Aquatic organisms		
Considered ecotoxicological endpoints	Survival		
	Growth		
	Reproduction		
	Mobility		
	Microbial mediated processes		
	Enzyme activities		
Soil type dependent	Y/N		
Mixture effects	Not considered		
	Considered (specify)		
Pathways	Bioconcentration in soil organisms and plants		
	Secondary poisoning for all substances. If not, specify which one		
	Bioaccumulation modeling of belowground food web		
	Bioaccumulation modeling of above ground food web		
EXPOSURE MODELING			
Exposure calculation for secondary poisoning	Empirical soil-to-tissue bioaccumulation factors (e.g. BAF)		
	Biomagnification algorithms		
Inclusion of non-soil sources	No		
	Yes, (specify how)		
Inclusion of other types of stress sources	Y/N (specify)		

TOXICOLOGICAL ASSESSMENT			
Data sources	National DB (specify)		
	Available DB on the web (specify e.g. US-EPA ECOTOX, RARs, etc.)		
	Peer reviews of national committees		
Normalisation to standard soil	Normalisation to standard soil (specify which parameters and values of standard soil)		
	Method: empirical reference lines (Dutch method)		
	Method: other (specify)		
Eco-epidemiological studies	Y/N		
Toxicity data extrapolation for one species	If one species, several tox data, same toxicological endpoint		
	If one species, several tox data, different toxicological endpoints		
Toxicity data extrapolation NOEC & LOEC	Specify		
Terrestrial and aquatic organisms tox data	Only terrestrial		
	Terrestrial and/or Aquatic		
	Terrestrial + Aquatic if no statistical differences		
SCREENING VALUE DERIVATION			
Application of Species sensitivity distribution (SSD)	When (specify): • Always • Only if sufficient data (specify criteria) • Never		
	Assumed statistic distribution (specify): • Loglogistic • Lognormal • other		
	Protection level (specify) • HC5 • HC50 • other		

Application of assessment factors	When (specify): • Always • Only if not sufficient data for SSD (specify criteria) • Never		
	Protection level (specify): • EC Technical Guidance Document (TGD) (CEC, 1996) • Modified TGD (specify reference) • EPA method • Modified EPA methods (specify reference) • other		
Background concentration	Not considered		
	Background added to risk based acceptable concentration (only for naturally occurring substances)		
	Other		
Equilibrium partitioning method (to derive soil screening values from screening values in other compartments)	Always adopted		
	Adopted only when (specify criteria)		
	Never adopted		
Harmonisation of derived risk based acceptable concentration for soil with that of other compartments	Performed (specify how, e.g. lower value)		
	Not considered		
Probabilistic modeling	Not adopted		
	Adopted when (specify): • Always • Only when (specify criteria)		

DERIVATION OF SOIL SCREENING VALUES			
Integration of screening risk values for different receptors	Integration with soil screening values derived by human health RA		
	Other (e.g. uncertainty based)		
Economic or social consideration added	No		
	Yes (specify what kind of considerations)		
Harmonisation with other Acts?	No		
	Yes > type		
COMPARISON WITH MEASURED CONCENTRATIONS			
Measured concentration	total concentration		
	site-specific corrections for biavailability		
	operational concentration (reported to standard soil)		
	concentration in contact media (crops, indoor air, soil organisms)		
	Dry soil		
	moist soil		
	sieved soil. Specify size (eg. 2 mm)		
	Top soil		
	Top soil + subsoil		
	Not defined		

2 - Countries, denomination of screening values and authors of the questionnaire

Country	Acronym	Denomination(original language)	Denomination (English translation)	Author
Austria	AUT	Orientierungswerte: Prüfwerte (Pw) & Maßnahmenschwellenwert (Msw)	Screening Values: Trigger Values (= Pw = Cat. 2) & Intervention Threshold Values (= Msw = Cat. 3)	Dietmar Müller
Belgium - Walloon Region	BE(W)	"Valeur Seuil" (Vs)	Trigger Value	Henri Halen
Belgium – Flemish Region	BE(F)	Bodemsaneringsnorm	Soil Clean-Up Standard	Christa Cornelis
Czech Republic	CZE			Milan Sanka
Germany	DEU	Category 1 Vorsorgewerte Category 2 Prüfwerte Category 3 Maßnahmewerte	Category 1 Precaution Values Category 2 Trigger Values Category 3 Action Values	Federal Ministry For The Environment, Nature Conservation And Nuclear Safety
Denmark	DNK	Afskæringskriterie	Cut Off Criteria	Christina Ihlemann And Irene Edelgaard, John Jensen
Spain	ESP	Niveles Genéricos De Referencia	Reference Generic Levels	Vega MM[1], Fernández, MD[2], And Tarazona, JV[2]
Finland	FIN	1) Tavoitearvo 2) Alempi Ohjearvo 3) Ylempi Ohjearvo	1) Target Value 2) Lower Guideline Value 3) Upper Guideline Value	Jaana Sorvari And Jussi Reinikainen
Italy	ITA	Valori Limite Di Concentrazione	Concentration Limit Values	Loredana Musmeci
Lithuania	LTU	Didžiausios Leidžiamos Koncentracijos	Maximum Permitted Concentrations In Soil Of Hazardous Chemical Substances	Gregorauskiene Virgilija
The Netherlands	NDL	1. Streefwaarden; 2. Interventiewaarden	1. Target Values; 2. Intervention Values.	Frank Swartjes, Michiel Rutgers, Leo Posthuma
Poland	POL	Wartości Dopuszczalne Stężeń W Glebie Lub Ziemi (Standardy Jakości Gleby I Ziemi)	Maximum Permissible Concentrations In Soil. Soil Quality Standards	Eleonora Wcislo, Marek Korcz
Sweden	SWE	Riktvärden För Förorenade Områden	Guideline Values For Contaminated Land	Yvonne Österlund, Celia Jones, Mark Elert
United Kingdom	UK	Soil Guideline Values (Sgvs) – Human Health Soil Screening Values (Ssvs) – Ecosystems		Albania Grosso[1], Samantha Fishwick[2] And Graham Merrington

3 - Questionnaire results - regulatory framework and main features

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
		AUT	BE(1)	BE(2)	CZE	DEU	DNK	ESP	FIN	FRA	IRL	ITA	LTU	NLD	POL	SVK	SWE	UK			
Legal framework	Special law for contaminated sites	X	X	X				X	X			X		X				X			1- The Act for the Clean-up of Contaminated Sites primarily aims at establishing structures for the public funding of remediation projects 2- Decree of the Walloon Government 01/04/2004 Not yet in force. 4- Others: Law on agricultural soil protection 5- law on groundwater including contaminated sites/ National law specified in regional laws 8- [1]A governmental decree is pending
	Soil protection or groundwater protection law					X	X		X					X							[2]Environmental Protection Law (incl. Air protection, and management regulations)
	Waste management law				X	X								X							Legal framework is national
	National law					X	X	X	X			X	X	X	X			X			12- Order of Minister of Health of the Republic of Lithuania 2004-03-08, N V-114
	Regional law		X		X	X															16- Generic guideline values are recommendations from the Swedish EPA and are not legally binding.
	Other				X												X				17- Part IIA of the Environmental Protection Act 1990

Purpose (more than one use is possible)	Target values of negligible risk					X			X				X	X							1- Cut-off Criteria or Intervention Values are only given for sensitive uses (e.g. playgrounds, residential areas) when regular oral intake by children has to be assumed.
	Trigger values: further investigations,	X	X	X	X	X	X	X	X				X	X			X	X			2- Eventually; Cut off value for new pollution
	Trigger value: restrictions in land use,		X		X	X	X		X				X	X							5- Values determined in the Soil Protection Ordinance, not in the Soil Protection Act.
	Trigger value: site specific risk assessment,	X	X	X					X					X			X	X			The scales of site-specific risk assessment as well as the target values are decided in a single case.
	Target values: remediation objective												X		X		X				Action values are defined for PCDD/F only
	Cut off values for urgent remediation			X		X						X	X								8- These will be included in governmental decree which is to be issued within 2006
	Other		X																		16- General guideline values have been published as a list. In a simplified site-specific risk assessment site-specific guideline values can be calculated using the same model (available as a spreadsheet tool with user manual) by adjusting the input data to reflect site-specific conditions. (Also other methods and models can be used in site specific risk assessment.)

Status	legal,			X	X	X		X					X	X	X						1- The Soil Screening Values are given by a guideline published by the Austrian Standards Institute 2- Planned to be obligatory Values adopted by the Government
	in development		X		X													X			in first lecture (first project of enforcement decree approved by government on 19th of May 2004).
	Obligatory		X			X	X					X	X		X						4- threshold and negligible risk legal and in development. Threshold for industrial sites advised
	Advised	X			X				X								X	X			8- New values to be issued within 2006
	Other		X																		1- The Screening Values have been established by an expert group taking into account natural background concentrations and considering procedures and values in the Netherlands and Germany
Scientific basis	Risk based		X	X	X	X	X	X	X			X	X	X			X	X			2- Reference to procedures of RIVM (for human health and ecotoxicological aspects) and of CCME (Canadian Council of Minister) for risks of groundwater contamination 4- Risk based-those in preparation Methodical guideline is referred to Dutch A, B, C values 5- A plausibility check is to be undertaken for the values on the basis of background concentration (90. percentile) 8- Methodology used in the Netherlands EU risk assessment of chemicals
	Background natural concentrations	X			X				X			X	X	(x)							11- The SSV can be modified on the basis of background natural concentrations
	Reference to procedures or values of other countries (specify which)	X	X		X				X								X				16- Ecotoxicological risk assessment based on data compilations and assessments of RIVM (Netherlands) and CCME (Canada).
	Other (specify if known)												X	X							

Level of public domain of methodology	Published methodology for SSV derivation				x	x	x		x					x			x	x			2- Technical report on the methodology used to calculate VS can be downloaded at : www.assainissementsoutenablespaque.be (consultation document)
	Not published, but accessible		x	x				x				x									4- Proposals are published (in Czech), legal are not published
	Not published and not accessible	x			x								x		x						5- Exception: Derivation of trigger values pathway soil-groundwater is not published.
Revision	Continuous revision																				1- In average the guidelines of the Austrian Standards Institute should be controlled (and revised) at least every 5 years.
	Periodical revision (every n. years)	x				x								x							2- Is has not been planned yet.
	Occasional revision of some values			x		x	x		x				x		x		x				7- Revision will depend on technical and scientific advances
	Revision not planned		x		x			x				x						x			16- Revision underway

Protected receptors	Human Health	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**			**X**	**X**	**X**	**X**		**X**	**X**			3- ecosystem values are available as draft values, but are not implemented; values based on groundwater as receptor (by reasons of feasibility pragmatic groundwater quality objectives are used) are available as guidance values, but not yet implemented
	Ecosystem	**X**	**X**	±	**X**	**(x)**		**X**	**X**					**X**	**X**		**X**	**X**			5- Ecosystems are only protected by precautionary values derived from ecotoxicological characteristics of substances. Further receptors: pathway soil-useful plants
	Groundwater for drinking uses	**X**	**X**			**X**						**X**		**X**	**X**		**X**				7- Ground water protection has only been taken into account regarding the ecosystem protection (aquatic organisms). In this case, the concentration in the interstitial pore water is considered as the fraction of contaminant that could be expected to migrate and reach both, groundwater and/or adjacent aquatic systems.
	[Groundwater is considered a receptor when Soil Screening Values have to comply with groundwater quality criteria which are not only related to drinking uses]	**X**		±				**X**						**X**			**X**	**?**			There is also a legal provision for informing the River Basin authority on any indication or evidence of groundwater contamination
	Surface water	**x**						**X**						**(x)**			**X**				
	Carcinogenic: other		**X**																		
	Non carcino-					**Y**	**X**		**X**								**X**	**X**			**2-** See above

	genic: Adulthood exp.duration (specify how long)																				3- for non-carcinogens we do not make use of exposure duration; if we would use it, it would be the same as for carcinogens; averaging period would equal exposure duration; we look at child and adult separately for non-carcinogens
	Non carcin.: Childhood (specify how long)					Y			X								X	X			5- chronic (lifelong)
	Non carcin.: Lifelong (childhood + adulthood) (specify how long)		X						X			X		X							childhood 1-8 years
	Non carcin.: other		X																		8- the same of the carcinogenic response
	Adopted when (specify):													(x)							16- Childhood 0-6 years, adult 7-64 years. No averaging period - guideline values calculated from toxicological reference values, eg tolerable daily intake (TDI, mg/kg body weight and day) and reference concentration in air (mg/m^3).
	Always																				
	Only when (specify criteria)																				

DERIVATION OF SOIL SCREENING VALUES																					
Integration of screening risk values for different receptors	Integration with soil screening values derived by human health RA	x	X	+/-	X				X					X			X				2- Soil screening values (trigger values) integrate three kinds of risks : risks for human health (VS_H), risks for ecosystems (VS_E) and risks for groundwater due to dispersion and leaching (VS_N). The final trigger value (VS) is equal to the most stringent value. 3- not decided yet, transparency in values is essential 5- NO integration
	No integration	X				X	X						X					X			8- Lowest value of the two (human risks-based or ecotox.-based) selected for SSL
Economic or social consideration added	No		X	X	x	X	X	X						X	X		X	X			8- SSLs for fractions (3) of petroleum hydrocarbons are "political decisions", not risk-based
	Yes (specify what kind of considerations)								X												
Harmonisation with other Acts?	No		X	X			X	X	X								X				4- Act on feedstuffs 5- Waste, Water, Mining 12- LAND 20 Requirements to sewage sludge, when it is used in agriculture 13- Former guidelines for new formed sediment 14 - Pursuant to Environmental Protection Law; referred to Water Law and Nature Protection laws"
	Yes > type				x	X							X	X	X						17- Not formally but we anticipate the ERA Framework will be flexible and could be used under Habitats Directive; UK Town and Country Planning Regs., etc.

COMPARISON WITH MEASURED CONCENTRATIONS

Measured concentration	total concentration		X	X	x	X	X	X	X				X	X			X	X			1- Bioavailability or the mobilised fraction of metals is measured by the NH4-NO3-extrakt of soil samples. **2-** In the framework of R.A. 3, 8- Bioavailability measured are performed in Tier II 4- For risk elements: aqua regia digestion, ammonium nitrate extraction 6- bioavailability when possible (lead and cadmium)
	site-specific corrections for bioavailability		X				X	X										X			8- Bioavailability, soil properties etc. should be considered in the adoption of the SSLs,
	operational concentration (reported to standard soil)																	X			13- concentration in contact media (crops, indoor air, soil organisms): considered in the stage of site-specific risk assessment only, not in SSVs
	concentration in contact media (crops, indoor air, soil organisms)		X															X			17 – Bioavailability corrections only for ERA
	dry soil	X		X	X	X	X	X					X		X		X	X			1, 4: 2 mm

	moist soil		X																		8- Sieved soil (< 2mm fraction) analysed in the case of metals. Organics are analysed from the whole sample using different extraction methods (described in the standards).
	sieved soil. Specify size (eg. 2 mm)	X			X	X			x				X				X				12- < 1 mm
	top soil	X		X	X	X	X						X					X			**2-** Differentiated in the framework of R.A. 6- In principle, it is applicable to subsoil as well. 12- Whole soil profile down to soil parent material
	top soil + sub-soil		X			X								X	X						16- Possible to derive different guideline values for different soil depth intervals in site specific assessments.
	not defined																x				17- top soil 0-15 cm

4 Questionnaire results: human health risk assessment

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
		AUT	BE(1)	BE(2)	CZE	DEU	DNK	ESP	FIN	FRA	IRL	ITA	LTU	NLD	POL	SVK	SWE	UK			
HUMAN HEALTH RECEPTOR - screening human health risk assessment																					
Status	Approved technical guideline,			x		x	x		x			x	x	x			x	x			1- There is no specific guideline to human health risk assessment and it is also not envisaged to develop one 5- The derivation of trigger values for the pathways soil-human being (direct contact) and soil-useful plants based on human health receptor among others. 7- Criteria are included in regulation. An specific guideline is in development. 8- Guideline on adapting the SSLs
	Proposal under approval,		x		x			x													
	In development																				
CONCEPTUAL MODEL																					
Generic or land-use specific	Generic	?			x								?	x			x				1 -Conceptually the existing soil screening values are related to specific soil functions, demonstrative land-use scenarios and simplified exposure scenarios (i) oral intake by humans (ii) uptake by plants. Just recently it has been scientifically advised to set up a new land-use related system. 3- public green areas are not considered separately, they will fall either under "nature" or under "recreation". Recreation is a separate land-use class for which clean-up values are available 12- Standard is valid in residential, recreational and agricultural areas only **16-** A number of land uses are considered.: 1. Sensitive land use, including residential, schools/nursery, agricultural. Groundwater use as drinking water is included. 2. Less sensitive land use (commercial/industrial). Groundwater use as drinking water is included. 3. Less sensitive land use (commercial/industrial) without use of groundwater. Sensitive land use includes several of the land uses given in the list opposite.
	Residential with garden and allotments (incl. home grown vegetables)		x	x					x						x		x	x			
	Residential with garden (excl. home grown vegetables)					x	x	x				x									
	Residential with children playing fields					x	x					x					x	x			
	Public green areas		x			x	x					x									
	Nature conservation areas		x	x				x							x						
	Industrial or commercial		x	x		x		x	x			x			x		x	x			
	Agricultural		x	x	x	x									x						

	moist soil		X																		8- Sieved soil (< 2mm fraction) analysed in the case of metals. Organics are analysed from the whole sample using different extraction methods (described in the standards).
	sieved soil. Specify size (eg. 2 mm)	X			X	X			x				X				X				12- < 1 mm
	top soil	X		X	X	X	X						X					X			**2-** Differentiated in the framework of R.A. 6- In principle, it is applicable to subsoil as well. 12- Whole soil profile down to soil parent material
	top soil + sub-soil		X			X								X	X						16- Possible to derive different guideline values for different soil depth intervals in site specific assessments.
	not defined																x				17- top soil 0-15 cm

Mixture effects	Not considered	x	x		x		x	x						x							4- considered for trichlorobenzenes, and in the draft values for dioxins and dioxin-like pcb's; was discussed for PAHs but not implemented for feasibility reasons 5- qualitative, not quantitative; trigger value for Benzo[a]pyren is used as a surrogate of the PAH mixture. 8- PAHs (16 EPA), PCBs, chlorinated phenols and benzenes (according to the number of Cl substitutes), xylenes, DDT+DDD+DDE, PCDDs+PCDFs+coplanar PCBs, TBT+TPT Type of effects not studied WHO-TEFs 12- Mn + V 16- Effect additvity is considered within some groups of compounds, eg chlorophenols and chlorobenzenes. PAHs considered as two groups, cancerogenic and non-cancinogenic. 17- At the moment TEFs have been used for dioxins but discussions are ongoing as to whether this is appropriate given information and assessments recently published by EFSA and other UK committees.
	Considered: specify which contaminants and effects considered			x		x			x				x		x						
	Effect additivity (TEF) for PAHs						x		x						x		x				
	Effect additivity (TEF) for dioxins, furans and PBC dioxin-like compounds			x		x			x								x	x			
Pathways	Outdoor: soil ingestion	x	x	x		x	x	x	x			x		x			x	x			4- thresholds derived by Dutch values receptors considered in detailed risk assessment, but US-EPA methodology is considered. 8- In domestic water pathway only diffusion of contaminants through water pipes considered (i.e. migration from soil to groundwater otherwise excluded)
	Outdoor: dust ingestion		x			x	x	x	x			x	x	x			x	x			
	Outdoor: dermal exposure to soil		x	x		x	x	x	x			x	x	x			x	x			
	Outdoor: inhalation of soil vapours		x	x		x	x	x	x			x		x			x	x			
	Outdoor: inhalation of soil derived dust		x	x		x	x		x			x	x	x			x	x			
	Outdoor: inhalation of volatilized irrigation water						x														
	Indoor: dermal exposure to soil derived dust		x	x					x			x					x	x			3 - Indoor: inhalation of soil derived dust; Indoor: dermal contact with groundwater/drinking water from bathing (depending on scenario);

	Indoor: inhalation of soil originated vapours		x	x					x			x		x			x	x			Indoor: ingestion of groundwater or drinking water (depending on scenario)
	Indoor: inhalation of groundwater vapours													x							
	Indoor: inhalation of volatilized domestic water								x					x							
	Indoor: showering (dermal contact + inhalation of vapours)		x	x					x					x							
	Resident diet: consumption of groundwater		x!	x!		x			x!			x		x			x				2- consumption of water contaminated by permeation through service-pipe **3-** meat and dairy products only for agricultural scenario 8- Consumption of drinking water included but not as a drinking water originating from the aquifer on the site (see also note above) Rainsplash excluded 16- Fruit considered together with vegetables 17- Direct ingestion from groundwater is not included in the generic risk assessments for soil contamination. This is due to the fact that groundwater is not usually ingested without treatment. Besides the legislation of the impact to groundwater from soil is specific and refers to other legislation that is more appropriate for the protection of water resources.
	Res. diet: intake of homegrown vegetables		x	x		x			x				x	x			x	x			
	Res. diet: Ingestion of soil attached to homegrown vegetables					x			x					x				x			
	Res. diet: intake of homegrown fruits					x							x				x				
	Res. diet: ingestion of soil attached to homegrown fruits					x															
	Res. diet: consumption of meat			x																	
	Res. diet: consumption of dairy products			x																	
	Surface water consumption of fish and shellfish																x				
	dermal contact surface water (swimming)																				
	ingestion surface water (swimming																				
	ingestion suspended matter (swimming)																				

EXPOSURE MODELING

Exposure averaging period	Differences according to land uses: Y/N	N	Y	Y		Y		N	Y			Y	N	N			Y	Y			16- Exposure times are dependent on land use.
	Carcinogenic: Adulthood lifetime (specify how long)					Y	X		[1]X									X			**2-** Partial durations are only used to convert toxicological threshold levels for inhalation (e.g. *Tolerable Concentration in Air or Carcinogenic Risk for Inhalation*) expressed in mg/m^3 into mg/kg.day. 6child + 64 adult Calculations take into account the time the receptor (child for natural, residential and recreational land-uses ; adult for industrial land-use) spends on the site. Dermal exposure time inside is the total time inside minus the time sleeping. Dermal exposure time outside is equal to the exposure time outside for inhalation. Exposure frequency is equal to 230 days per year for natural and recreational land-uses ; 250 days per year for industrial land-use ; 350 days per year for residential land-use. 3- [6-child/64 adult] for all residential scenarios we assume children 6 years and adults 64 years, averaging takes place as a combination of child and adult over a 70 year period; for industrial scenario we assume 45 years of exposure and averaging over a 70 year period 5- 70 years (adult, lifelong) Higher sensitvity of children to genotoxic carcinogenic substances is considered by a factor of 10 6- 70 years adult 8- [1] 70/40: ED = 64 years (residential) or 40 years industrial [2]:70:ED = 6 years (residential) or 0 a (industrial area) [3]:70/40: EDtotal = 70 years (residential) or 40 (industrial) 11- carcinogenic and non-carc.: 6+64 years for residential use or 30 years for industrial/commercial use 16- Childhood 0-6 years, adult 7-64 years. 17- Adult carcinogenic averaging period is for commercial land use scenario and for 43 years. Childhood averaging period is for 6 years.
	Carcinogenic: Childhood (specify how long)					Y			[2]X									X			
	Carcinogenic: Lifelong (childhood + adulthood) (specify partial durations)		X	x					[3]X			X		X			X				
	Carcinogenic: other		X																		
	Non carcinogenic: Adulthood exp.duration (specify how long)					Y	X		X								X	X			**2-** See above 3- for non-carcinogens we do not make use of exposure duration; if we would use it, it would be the same as for carcinogens; averaging period would equal exposure duration; we look at child
	Non carcin.: Childhood (specify how long)					Y			X								X	X			

	Non carcin.: Lifelong (childhood + adulthood) (specify how long)		X						X			X		X							and adult separately for non-carcinogens 5- chronic (lifelong) childhood 1-8 years 8- the same of the carcinogenic response 16- Childhood 0-6 years, adult 7-64 years.
	Non carcin.: other		X																		
Exposure parameters (excluded duration)	For the same receptor, differences according to land uses: Y/N		Y	Y		Y	Y	X	Y			Y	N	N			N	Y			3 - 25% for residential scenario; 50% for agricultural scenario; inhalation, dermal absorption: only different for child and adult 5- 20 % participation of TDI (tolerable daily intake) by soil ingestion **2-** Dermal absorption is body weight-related (not sex-related) and hence age-related too (child : 4 to 6 years old weighting 15 kg ; adult : 70 kg). 7- Not applicable. The regulation does not include the methodology followed for establishing the human health threshold values for three land uses. Anyway, there is a recommendation for models developed by well recognised institutions, such as the European Chemicals Bureau and the USEPA. 8: deliberate ingestion of soil, but PICA not considered; 10 % is the contribution from homegrown; for inhalation and dermal absorption adults/children (0-6 years) separated (different body weight and skin area) 11- All the exposure parameters are related to the body weight and not to the sex 16- Difference between adult and child - regarding inhalation rates, soil consumptions, consumption of drinking water and vegetables and, dermal exposure. Also differences in body weight for all these pathways. 17- These only refer to the physical differences between children and adult female receptors. Female receptors are the critical receptors used for the derivation of the SGVs. Report CLR10 does contain information for the different sexes in case it is needed for a more site-specific assessment. Assumes 100% of vegetable Consumed are home grown.
	Differences according to sex			N		N	N						N					X			
	Soil ingestion: deliberate ingestion of soil considered			N		Y	Y	x	X			X	N	(x)							
	Contribution of home grown vegetable consumption to total vegetable consumption: • 100% rate (specify which one)		20	25 - 50		X	N		X				N	X			30	100			
	Inhalation: Activity patterns distinction			y		N	N						N					X			
	Inhalation: Body weight related		X	N		X			X			X	N	X			X	X			
	Dermal absorption: Activity pattern related			N									N								
	Dermal absorption: Age related		X	Y					X				N				X				
	Dermal absorption: Body weight-sex related		X	N									N	X							
Representative exposure	Combined from multiple pathways		X	Y		X!		X	X			X	Y	X			X	X			5- qualitative, not quantitative
	Most critical exposure pathways					X	X							(x)							
	Individual pathways													(x)							

Intake modeling	Ingestion: substance-specific rate of resorption in the intestinal tract, when available			**N**		**x**	**x**							**(x)**							**2-** Dermal absorption rate (DAR) taken into account for dermal contact with soil is only age-related. Calculation of exposure through dermal contact with water during showering considers a dermal absorption rate (DARw) depending on some physico-chemical properties of organics (Kow, molecular mass). 3- dermal uptake from soil based on permeability fractions from literature; dermal uptake from water calculated from physico-chemical properties 8- for dermal uptake permeability coefficient, default values included in Risc-Human 3.1. software 16- Not in calculation of general values. Can be included in calculation of site-specific values.; for dermal uptake permeability coefficients, coefficients from MDEP(1994) 17- Uptake modelling is only done on a site specific basis except for the dermal exposure pathway where default absorption factors are used for contaminant types.
	Inhalation: substance-specific absorption coefficient for respirable fraction (<10 μm), when available			**N**		**x**															
	Dermal uptake: evaporation of volatile contaminants from skin surface			**N**																	
	Dermal uptake: permeability coefficients based on chemico-physical models		**x**	**Y**		**x**			**x**									**x**			
	Dermal uptake: permeability coefficients only when available								**x**			**x**									
Inclusion of non-soil sources	No	**x**	**x**						**x**			**x**	**x**	**x**							3- background exposure from food (corrected for part coming from on-site) and air accounted for (corrected for time spent on-site); 5- 80 % from non-soil sources 6- only a fraction of TDI allocated to soil 7- It considered that only a percentage of the overall ADI is allocated to the exposure from the contamin. site. 16- Included for some substances. Non-soil exposure is subtracted from toxicological reference value (eg TDI). 17- Mean daily intakes are included to account for exposure from air, water and food.
	Yes (specify how they are included)			**x**		**x**	**x**	**x**									**x**	**x**			
TOXICOLOGICAL ASSESSMENT																					
Data sources	National DB (specify)					**x**						**x**		**x**							1- WHO-IPCS; US-EPA IRIS; RAIS ; IARC ; ATSDR; INERIS + RIVM (Baars et al., 2001) 4 – US-EPA IRIS 5- TRD (tolerable resorbiente? dose = tolerable adsorbed dose) see International Journal of Toxicology, vol.16, 1997, pages 496-508 "Toxicological risk assessment of soil contaminants" 8- Updates (from 2001) made by the Dutch RIVM 11- DB elaborated on a national scale on the basis of USEPA; IRIS; IPCS; IARC; ATSDR 12- Soil standards of Russian Federation and Environmental Quality Criteria of Swedish Environmental Protection Agency 16- WHO (drinking water and air quality guidelines), USEPA IRIS, IARC. 17- National and international sources are reviewed. Hierarchy of sources with preference for national sources.
	DB public on the web (specify, e.g. IPCS, US-EPA IRIS, IARC, ATSDR)		**x**	**x**	**x**	**x**	**x**		**x**			**x**					**x**	**x**			
	Peer revisions of national committees					**x**			**x**				**x**	**x**				**x**			

Toxicity effects	Systemic toxicity (chronic effects)		**X**	**X**		**X**	**X**		**X**			**X**	**X**	**X**			**X**	**X**			6- acute effects 8- TDIs presented by Baars et al. (2001) and given in IRIS database have been used, the <u>basis of the reference values has not been studied</u>
	• Carcinogenicity and genotoxicity		**X**	**X**	**x**	**X**	**X**		**X**			**X**	**X**	**X**			**X**	**X**			
	• Reproductive and developmental effects			**X**	**X**	**X**	**X**		**X**			**X**	**X**	**X**				**X**			
	• Neurobehavioural toxicity			**X**	**X**	**X**	**X**		**X**			**X**		**X**			**X**	**X**			
	Other						**X**											**X**			17 – skin irritation
Toxicokinetics studies	Y/N		**N**		**N**	**Y**	**Y**	**N**				**N**	**X**	**N**			**N**	**Y**			17- If available
Epidemiological studies	Y/N		**Y**		**Y**	**Y**	**Y**	**N**				**N**	**X**	**N**			**N**	**Y**			**2; 17-** When available
Dose-response curve for carcinogens	Yes			**X**		**X**		**X**	**X**			**X**									3- slope factor or unit risk data used 8- Genotoxic substances If data available
	When possible		**X**		**X**		**X**		**X**								**X**				
	Threshold mechanism preferred													**X**							
	No																	**X**			

SCREENING VALUE DERIVATION																					
Acceptable risk	For carcinogens: incremental risk = 10^{-6}, 10^{-5}, 10^{-4} (specify), other (specify)		**10^{-5}**	**10^{-5}**		**10^{-5}**	**10^{-5}**	**10^{-5}**	**10^{-5}**			**10^{-6}**		**10^{-4}**			**10^{-5}**	**N**			The legal values are derived on background values, the proposals on general toxicological effects and intake of pollutants by plants. NOT CARCINOGENIC EFFECTS? NO substance- specific hazard quotient but combined with recommendations of reduction of contact with soil which is expected to reduce the risk to 10-6. For the hazard quotient, uncertainty factors applied. Chemical group Thresholds: Pesticides 0.05 Organochorinated compounds 0.20 Polycyclic Aromatic Hydrocarbons 0.05 Monocyclic Aromatic Hydrocarbons 0.10 17- The UK has not identified an acceptable risk level.
	For not carcinogens: hazard quotient 1, other (specify)		**1**	**1**	**x**	**x**	**X**	**1**	**X**			**1**		**X**			**X**	**1**			
Deterministic or probabilistic approach	Deterministic		**X**	**X**		**X**	**X**	**X**	**X**			**X**	**X**	**X**			**X**				17- SGVs are derived based on the averaged 95th percentile of exposure for the critical receptor
	Probabilistic (exposure assessment)																	**X**			
	Probabilistic (exposure + toxicological assessment)																				
	If probabilistic, screening value is: 50- 75- 95- 99th percentile? (specify)																	**X**			

5 Questionnaire results: ecological risk assessment

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
		AUT	BE(1)	BE(2)	CZE	DEU	DNK	ESP	FIN	FRA	IRL	ITA	LTU	NLD	POL	SVK	SWE	UK			
ECOLOGICAL RECEPTORS - Screening ecological risk assessment																					
Status	Approved technical guide-line,					X			X					X							1- There is no specific guideline to ecological risk assessment and it is also not envisaged to develop one Tiered Triad approach is proposed 5- Ecological receptors are only considered by pre-cautionary values 7- Criteria are included in regulation. A specific guideline is in development. 16 – Eco SVs issued. Guidelines under development 17- We are currently testing a draft ERA Framework in partnership with UK industries to improve its practicability
	Proposal under approval,		X		X			X										X			
	In development			x								X					X				
	None	X					X					x			?						
CONCEPTUAL MODEL																					
Generic or land-use specific	Generic		X		X	X	X		X					X			X	X			**1-** See above (Human Health Receptor) **2-** Protection levels are land-use dependent. 5- Soil specific precautionary values, independent from land use 16- Two land uses considered for soil, sensitive and less sensitive. Only one "use" considered for aquatic receptors. 17- ERA is not land use specific, although receptors are defined in UK legislation for contaminated land. These receptors are listed in Table A of the Envi-ronmental Protection Act (Part IIA) 1990 and they are designated habitats of conservational value such as National Nature Reserves.
	Nature conservation ar-eas		X	X				X										X			
	Residential		X	X																	
	Industrial or commercial		X	X																	
	Agricultural		X	X	X																
	Public green areas		X	X																	

Ecological factors of concern	Ecosystem species		X	x		X	X	X						X			X	X			**If they depend upon land uses, differentiate them.** 7- The general approach implies enough flexibility to allow the selection of different target receptors, depending on the realistic and specific priorities of protection. 16- All considered indirectly. Considered directly to extent allowed by data availability. Data for soil processes included in species sensitivity distributions. Ecological factors considered are not land use dependent; only degree of effect is land use dependent.
	Life support functions					X								X			X	X			
	• Recycling of nutrients					X								X							
	• Soil detoxification					X								X							
	• Organic matter degradation					X								X							
	• Formation of soil structure					X								X							
	• Water cycle					X								X							
	• Soil ecosystem stability (e.g. biodiversity)					X	X							X							
	• Others																				
Considered receptors	Soil microbial processes		X	X	X	X	X	X	X					X			X	X			**2-** Herbivores only for agricultural land-use. Aquatic organism only when data for terrestrial organisms are not available. 4- Not soil fauna. Generally, soil mic4robial processes for negligible risk (preventive) limits and plant growth for threshold (indicative) limits. 13- Wildlife: for some predators only Aquatic organisms: indirect, i.e. as basis for some terrestrial SSVs 16- All considered indirectly. Use distribution of data to derive species sensitivity distribution curves. Considered directly to extent allowed by data availability 17- We will use aquatic data where terrestrial data is unavailable. Also, we will consider wildlife that spends part of its life on land, e.g. wading birds.
	Soil fauna		X	X		X	X	X	X					X			X	X			
	Plants	X	X	X	x	X	X	X	X					X			X	X			
	Wildlife		X			X		X						(x)			X	X			
	• Terrestrial vertebrates		X			X		X									X	X			
	• Terrestrial invertebrates		X			X											X				
	• others																				
	Aquatic organisms		X					X									X	(x)			
Considered ecotoxicological endpoints	Survival			X		X	X	X	X					X			X	X			**2-** Based on NOEC (No observed effect concentration) on non lethal effects. 4- Not survival! 8- Literature values of ecotoxicological benchmarks (Verbruggen et al. 2001) used in the derivation of SSLs, the endpoints to which they refer have not been studied
	Growth		X	X	x	X	X	X	X					X			X	X			
	Reproduction		X	X			X	X	X					X			X	X			
	Mobility		X						X					X			X				
	Microbial mediated processes		X	X			X	X	X					X			X	X			
	Enzyme activities		X				X		X					X			X	X			

Soil type dependent	Y/N	**N**	**Y**	**N**	**N**	**Y**	**N**	**N**	**N**					**Y**			**N**	**?**			**1-** Advise on site-specific adjustments due to soil type and other factors (e.g. pH, organic content) is given by the existing guideline. **2-** Different soil types were defined depending on the land-use. In addition, further adjustment is planned to be done taking into account site-specific soil properties as a first step of the risk assessment procedure. 8- SSL defined for standard soil (normalization) 17- We are proposing a series of modifications that can be made to a measured concentration (field soil), if appropriate, to account for soil properties. But an ecological risk assessment is not dependent upon soil type as such. The SSVs will be developed using normalised data where available. It is good practice to account for influencing soil properties in the field soils to ensure a like-for-like comparison with normalised SSVs. But an ERA is not dependent on soil type *per se*. We are undertaking further research to road-test the SSVs.
Mixture effects	Not considered		**X**	**X**	**X**	**X**	**X**	**N**									**X**	**X**			8- Equivalent to human health RA 13- Mixture effects: considered in the stage of site-specific risk assessment only, not in SSVs. Exception: for some compound groups for which group-SSVs are used (e.g., PAHs), by concentration additivity within groups of compounds with same Toxic Mode of Action
	Considered (specify)								**X**					**X**							
Pathways	Bioconcentration in soil organisms and plants		**X**	**x**		**X**		**X**	**X**					**X**				**X**			**2-** Only considered for agricultural land-use for heavy metals and organics with log Kow > 5 and molecular mass < 600 g/mole. 3- Bioconcentration is considered in Tier III 8- These have not considered systematically in the derivation of SSLs but used as additional criteria when setting the target values (for few contaminants only) 16- Effects data expressed relative to soil concentrations - bioconcentration taken into account implicitly. Secondary poisoning is only considered when some of the datapoints in the species sensitivity distribution have been derived from studies of bioaccumulation and toxic effect Secondary poisoning is not considered separately. 17- where a substance is likely to bioaccumulate (e.g. logKow is >5).
	Secondary poisoning for all substances. If not, specify which one		**X**	**N**	**X**	**N**		**X**	**X**					**N**			**N**	**X**			
	Bioaccumulation modeling of belowground food web																	**N**			
	Bioaccumulation modeling of above ground food web				**x**			**X**										**N**			

EXPOSURE MODELING

Exposure calculation for secondary poisoning	Empirical soil-to-tissue bioaccumulation factors (e.g. BAF)		**X**	**X**				**X**						**X**				**Y**			
	Biomagnification algorithms							**X**										**N**			
Inclusion of non-soil sources	No		**X**	**N**	**X**	**X**	**X**	**X**	**X**					**X**			**X**	**Y**			
	Yes, (specify how)																				
Inclusion of other types of stress sources	Y/N (specify)		**N**	**N**		**N**	**N**	**N**						**(n)**			**N**	**N**			3- Other stress sources such as acidification might influence the weighing of evidence 8- The median background concentrations in Finnish soil considered (added approach, Dutch methodology) 13- Target value: Indirect by use of safety factor (HC5/100)

TOXICOLOGICAL ASSESSMENT																					
Data sources	National DB (specify)			**X**	**X**	**X**		**X**						**X**				**N**			**2-** RIVM ; ORNL (Oakridge National Laboratory); Danish EPA ; US-EPA ECOTOX 3- For heavy metals specific databases that match Flemish soil types have been compiled 4- System of basal soil monitoring, database of contaminated sites on agricultural soil. US-EPA 6- review of data in open literature in early 90's. 7- BASETOX (IHOBE) ECOTOX, RARs, HSDB, IRIS, RAIS 8- Data collected by the Dutch RIVM, EU risk assessment of chemicals 13- In the past: compound-specific reports; currently: National DB: e-toxBase 16- Use ecotoxicological data compilations from RIVM (Holland) for soil and by CCME (Canada) for freshwater + complementary data from other sources.
	Available DB on the web (specify e.g. US-EPA ECOTOX, RARs, etc.)		**X**	**X**	**X**	**X**	**X**	**X**	**X**					**X**				**Y**			
	Peer reviews of national committees							**X**						**X**				**Y**			
Normalisation to standard soil	Normalisation to standard soil (specify which parameters and values of standard soil)		**X**	**N**				**X**	**X**					**X**			**X**	**Y**			**2-** Normalisation to standard soil properties through the adjustment of solid-liquid partition coefficient. Experimental (literature) $data_{exp}$ have been normalized to the standard soil properties considered ($data_{aj}$) according to : $data_{aj} = data_{exp} \times \frac{Kd_{aj}}{Kd_{exp}}$ 5- classification: soil type clay (clay content >25%) soil type loam (clay content 12-25%, silt content >50%) soil type sand (clay content <12 %, silt content < 50%) 7- Normalization to organic carbon: 0.02 kg C orgánico kg^{-1} suelo. 8- organic carbon content clay content (metals only) 13- correction for clay and organic matter 16- Use of Netherlands data compilation - correction carried out by RIVM. 17- TGD methodology for organic substances. Parameter with the most influence assessed on a case-by-case basis for metals. We also convert field measurements [P]EC to standard soils to ensure a like-for-like comparison with the SSV.
	Method: empirical reference lines (Dutch method)				**X**				**X**					**X**			**X**				
	Method: other (specify)					**X**												**Y**			

Eco-epidemiological studies	Y/N		**N**	**N**	**N**	**N**	**N**	**N**	**N**					**N**			**N**	**N**			
Toxicity data extrapolation for one species	If one species, several tox data, same toxicological endpoint		**X**					**X**	**X**					**X**							**2-** Geometric mean of the available tox data having the same toxicological endpoint concerning that species. Only tox data regarding the most sensitive endpoint is considered for that species. 6- generally used the most sensitive endpoint 8- Geometric mean calculated if sufficient amount of statistical data on same endpoint available
	If one species, several tox data, different toxicological endpoints		**X**	**X**					**X**												
Toxicity data extrapolation NOEC & LOEC	Specify																				**2**- Based on Verbruggen et al., 2001. 1) For each taxonomic group, a geometric mean of the available data is considered 2) When data are available for at least 4 different **terrestrial** taxonomic groups => statistical extrapolation ; 3) When data are available for less than 4 different taxonomic groups - Separated calculation for terrestrial and aquatic tox data - Application of assessment factors to terrestrial tox data - Application of the equilibrium partitioning theory to aquatic tox data - The lowest soil critical concentration for ecosystems is the trigger value (VS_E) **3**- LD_{50} when available, otherwise NOEC, LOEC values 6- EC10 or NOEC 7- NOEC, EC50, LC50
Terrestrial and aquatic organisms tox data	Only terrestrial						**X**														3; 17- Also aquiatic data when only limited soil data are available 8- If number of NOECs representing different taxonomic groups ≥ 4, soil-water partition coefficient used to derive soil NOEC from aquatic NOECs => these compared with available soil NOECs => lowest selected for SSL derivation If number of NOECs representing different tax. groups < 4 => soil-water partition coefficient used to derive soil NOEC from aquatic NOECs
	Terrestrial and/or Aquatic		**X**	**x**		**X**			**X**					**X**				**X**			
	Terrestrial + Aquatic if no statistical differences																				

SCREENING VALUE DERIVATION																					
Application of Species sensitivity distribution (SSD)	When (specify): A. Always B. Only if sufficient data (specify criteria) C. Never		**B**	**B**			**B**	**C**	**B**					**B**			**B**	**B**			**2-** see above 3- At least data on 5 different species are available **2, 13, 17-** Model of Aldenberg and Slob (1993) **2-** HC20 for natural & agricultural land-use HC40 for residential and recreational land-use HC50 for industrial land-use 3- Protection of 20 % of species is considered (CCME Canada methodology) 5- HC 50 6- SSD is used when more than 4-6 data points were available. However, in all cases the assessment factor method is used as well. The lowest of the two was typically chosen 8- application of SSD If ≥ 4 NOECs representing different taxonomic groups available; loglogistic statistic applied; HC5 for definition of target values and HC50 for lower and upper guideline values 13- SSDs only if > 4 data are available for 4 taxonomic groups (if not: assessment factors) Assumed statistic distribution: lognormal (ETX2.0) Protection level: HC5/100 (Target Values); HC50 (Intervention Values) 16- Terrestrial data for effects in soil. Aquatic data may be used if terrestrial data is insufficient. Aquatic data used for aquatic recipients Depends on land use. HC 50 for less sensitive land use. Sensitive land use corresponds to ca HC 25.
	Assumed statistic distribution (specify): A. Loglogistic B. Lognormal C. Other		**B**	**B**			**B**		**A**					**B**			**B**	**B**			
	Protection level (specify) A. HC5 B. HC50 C. Other		**20-40-50**	**20**		**B**	**A**		**A B**					**A B**			**25-50**	**A**			
Application of assessment factors	When (specify): A. Always B. Only if not sufficient data for SSD (specify criteria) C. Never		**B**	**B**		**?**		**A**	**B**					**B**			**B**	**B**			**2-** See above 5- always 7- always 8- Assessment factors between 1 and 1000 have been applied depending on the amount of ecotoxicity data (ECB, 2003, Verbruggen et al., 2001) 13- Application assessment factors: when terrestrial data derived from aquatic data HC5 is level of protection; additional factor of 100 is applied to account for uncertainties, mainly due to combined exposure. Protection level: EC Technical Guidance **2-** Land-use dependent 3- CCME Canada 4- US-EPA method 7; 17- EC Technical Guidance Document (TGD) (EC, 2003) 8- methodology used for Dutch target values, modified EC guidelines

	Protection level (specify): A. EC Technical Guidance Document (TGD) (CEC, 1996) B. Modified TGD (specify reference) C. EPA method D. Modified EPA methods (specify reference) E. Other		**?**	**E**		**?**		**B**	**B**					**B**			**?**	**B**			16- SSD if sufficient data. Assessment factors refer to TGD and RIVM report 711701020 (2001)
Background concentration	Not considered						**X**	**X**										**X**			**2-** Only for the biological inactive fraction of naturally occurring heavy metals. 3- background can be used as reference 5- validation with background concentration 13- Background concentrations for Target Values/ metals only 16- Considered for metals. Background taken into account in calculating acceptable addition to risk based acceptable concentration - this is not addition. 17- Background is considered on a case-by-case basis.
	Background added to risk based acceptable concentration (only for naturally occurring substances)		**X**		**X**				**X**					(x)				**X**			
	Other			**X**		**X**											**X**				
Equilibrium partitioning method (to derive soil screening values from screening values in other compartments)	Always adopted																				**2; 3, 8, 13, 16-** Only when insufficient terrestrial tox data are available (see above) 7 - Regarding the aquatic compartment, the concentration in the interstitial pore water is considered as the fraction of contaminant that could be expected to migrate and reach both, groundwater and also adjacent aquatic systems. For these estimations, the Equilibrium Partitioning Method is used.
	Adopted only when (specify criteria)		**X**	**x**				**X**	**X**					(x)			**X**	**X**			

	Never adopted				X	X	X														
Harmonisation of derived risk based acceptable concentration for soil with that of other compartments	Performed (specify how, e.g. lower value)					X								(x)							13- Harmonisation for Target Values only 16- Site specific guideline values may be adjusted to take into account demands from other legislation, eg. water quality
	Not considered		X	x	x		X										X	X			
Probabilistic modeling	Not adopted		X	x	X	X	X		X					(x)			X	X			7- Probabilistic modeling has not been adopted, although it is not excluded. 13- SSD adopted in the case of sufficient amount of data. Otherwise assessment factors and single observations
	Adopted when (specify): • Always • Only when (specify criteria)													(x)							
	top soil + subsoil		X			X								X	X						
	not defined																x				

ANNEX 2

COUNTRY REPORTS

1 AUSTRIA

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1.1 Soil screening values

Legal framework

In 1984 the principle of integrated environmental protection was established in the Austrian constitution (Federal Legal Gazette no. 491/1984). Since then the following provisions are included to Article 1 of the constitution of the corresponding Federal Act:

(1) The Republic of Austria commits itself to integrated environmental protection.

(2) Integrated environmental protection means protecting the natural environment as basis of human life against detrimental impacts. Integrated environmental protection mainly comprises measures aiming at clean air, clean water and soil as well as preventing noise pollution.

Although the Federal constitution contains provisions for keeping the soil clean, there is no specific national soil conservation act. Up to now, soil conservation has been in the competence of the Provincial authorities which have enacted corresponding laws. These laws, however, aim by history primarily at restoring and maintaining agriculturally used areas and do not deal with soil protection or soil contamination in depth.

Therefore the specific legal framework for contaminated sites is given primarily by the Water Act (see chapter 2.1) and the legislation on waste management. The Waste Management Act (Federal Legal Gazette no. 325/1990) determines when waste collection and treatment is required in the public interest. In order to safeguard public interests and to reduce potential hazards the authorities may impose obligations to dispose of waste and waste-oil and thereby contaminated soil in an environmentally sound way.

The Act for the Clean-up of Contaminated Sites, enacted in 1989 (Federal Legal Gazette no. 299/1989) was primarily meant to be a means of funding clean-up measures. A risk assessment to prove serious risks to human health or the environment is required but the act itself does not define any further criteria which might be used as a basis to define risk assessment procedures or screening values. As for the implementation of the risk assessments on soil contamination, which are prerequisite for the funding of remediation projects for contaminated sites, the Austrian Standard ON S 2088-2 (Contaminated Sites – Risk Assessment for Soil Pollution) is used as technical guideline.

Scientific basis

The soil screening values used for risk assessment of contaminated sites have not been calculated along specific exposure scenarios or the use of models but have been identified by an expert working group established at the Austrian Standards Institute (ON). Until 1999 the working group examined about 15 national or regional lists of soil screening values across Europe. The final decision on the soil screening values included to the Austrian Standard ON S 2088-2 "Contaminated Sites – Risk assessment for polluted soil concerning impacts on surface environment" was taken under consideration of the different methodologies and exposure scenarios which formed the basis to calculate the examined soil screening value lists. The framework of the Austrian Standard ON S 2088-2 aims to set out common criteria for soil contamination and its possible direct effects on humans and plants. As for screening values as the most important part has been seen to provide trigger values for further investigation, which by philosophy are to be set in conservative way. As the general scientific basis was considered as poor "intervention values" have only been established for very sensitive uses (children´s playgrounds, residential areas). Also by purpose no soil screening values for industrial areas have been included as the calculations under human health aspects via oral uptake would end up for a series of contaminants at very high concentrations, which would be a contradiction under consideration of the Austrian waste management legislation. Soil at industrial sites is primarily seen under the aspects to maintain its buffer and storage function and therefore the focus has to be on risk assessments concerning groundwater (see chapter 2.2). Consequently the soil screening values of the Austrian Standard ON S 2088-1 (Contaminated Sites – Risk Assessment for Groundwater) should be used at industrial sites.

Technical approaches

Protected receptors

Conceptually the soil screening values of the Austrian Standard ON S 2088-2 are related to specific soil functions, demonstrative land-use scenarios and two simplified exposure scenarios (i) oral uptake by humans (ii) uptake by plants.

Human health screening values

Although there was no specific exposure scenario used to calculate the screening values (ON S 2088-2, table 1), a simplified and conservative conceptual approach referring to oral uptake by children is assumed.

Ecological screening values

Neither a specific guideline to ecological risk assessment nor ecological screening values exist in Austria. The Austrian Standard ON S 2088-2 provides soil trigger values which indicate that enhanced uptake of contaminants by plants might occur. As further criteria to check the probability of a contaminant uptake soil-specific adjustements due to soil type and other factors (e.g. pH, organic content) are advised by a simplified scheme. Finally a simple test (NH4-NO3-extract) to check bioavailability or the mobilised fraction of metals is suggested and according screening values are provided.

Scientific and practical weaknesses

In first place risk assessment concerning soil contamination lacks a sound legal basis in Austria. Following this situation there are also hardly scientific efforts to establish risk assessment procedures and models or derive soil screening values. Even the Austrian Standard ON S 2088-2, which was set up in a very pragmatic way, and the provided criteria and soil screening values are due to missing legal backup hardly recognized. As risk assessments concerning soil contamination are few there is also some lack of experiences and feedback on practical weaknesses.

Future developments

Just recently it has been scientifically advised to set up a new land-use related system for remediation. To put such a system in place would require specific guidelines on human health risk assessment as well as on ecological risk assessment. However as for the scientific basis national research efforts should avoid a duplication of work and therefore in first place efforts would be needed to make use of international scientific knowledge and practical experiences in Europe.

References

- Austria, Federal Legal Gazette no. 491/1984: Austrian constitution
- Austria, Federal Legal Gazette no. 299/1989 (as amended until 2001): Act for the Clean-up of Contaminated Sites
- Austria, Federal Legal Gazette no. 325/1990 (as amended 2006): Waste Management Act
- Baden-Württemberg (Germany), Legal Gazette no. 33/1993 (amended 1998): Administrative guideline on screening values for contaminated sites and groundwater damages
- ON S 2088-2: Contaminated Sites – Part 2: Risk assessment for polluted soil concerning impacts on surface environments; Austrian Standards Institute, June 2000.
- ON S 2008-3: Contaminates Sites – Part 3: Assessment of risk for public asset air which is to be safeguarded – Austrian Standards Institute, January 2003
- ON L 1075: Principles for the evaluation of the content of selected elements in soils – Austrian Standards Institute, June 2004.
- Eikmann, Th., Kloke, A.: Land-use related screening values on contaminants in soils (2nd revised version) – Rosenkranz (editor): Soil protection, handbook on measures and recommendations how to protect, conserve and remediate soils, landscape and groundwater; Erich Schmidt Verlag, Berlin 1993

1.2 Groundwater screening values

Legal framework

The Austrian Water Act (Federal Legal Gazette no. 215/1959, the Act as amended), which came into force in 1959, is based on the precautionary principle. The overall legal goal of keeping waters clean is specified for groundwater as "maintaining water in its natural condition and as drinking water resource". Since more than 99% of the Austrian drinking water supply is covered by spring water and groundwater abstractions, the protection of groundwater per se is of utmost importance.

As for the implementation of the risk assessments concerning groundwater contamination, which are prerequisite for the funding of remediation projects for contaminated sites, the Austrian Standard ON S 2088-1 is used as technical guideline.

Scientific basis

The groundwater screening values under the Austrian Standard ON S 2088-1 refer in general to the WHO guidelines for drinking-water quality (WHO, 1993).

Technical approaches

Protected receptors

Conceptually the groundwater screening values of the Austrian Standard ON S 2088-1 are primarily related to human use as drinking water. Surface water ecosystems, dependent terrestrial ecosystems or groundwater ecosystems have not been considered.

Relation with soil screening values

The groundwater screening values were established without relation to soil screening values.

Derivation of groundwater screening values

The groundwater intervention values generally have been set equal to drinking water standards or concentrations derived by the simplified scenario (average human at a weight of 70 kg; drinking water consumption 2 l/d; exposure by drinking water max. 10 %), which was used by the World Health Organisation (WHO, 1993). With reference to the Austrian Ordinance on groundwater thresholds the trigger values generally have been established at 60 % of the drinking water standards. The trigger values also have been controlled against recommendations of the German LAWA (LAWA, 1999), which considered humantoxicological data as well as ecotoxicological data.

Scientific and practical weaknesses

The existing groundwater guideline values are generally not relied or checked against ecotoxicological considerations. By this scientific lack it has to be recognized, that possible impacts of groundwater pollution on aquatic or terrestrial ecosystems are not understood.
Furthermore a general practical weakness of groundwater guideline values is discussed. Referring to the variety of geological and hydrogeological situations high contaminant concentrations are more likely to occur in low permeable and less productive strata. In Austria these hydrogeological units are generally of less interest for human uses by water abstractions nor support ecosystems regularly. Therefore even high contaminant concentrations in groundwater which may be some orders above intervention values often are not likely to impair legitimate and possible future uses or the environment.

Future developments

As for the implementation of the European Water Framework Directive (WFD, 2000) and the upcoming common Groundwater Daughter Directive (GWD, common position 2006) no major change for the legal framework in Austria is expected, whereas the technical approaches with regard to balance the impacts of point source and diffuse pollution might undergo some in-depth revisions. Groundwater risk assessment schemes in general will have to be complemented by environmental or ecotoxicological considerations. Consequently the framework for assessing groundwater quality at point sources (local scale) and status assessment for groundwater bodies (regional scale) under the WFD will probably need a revision.
Addressing practical problems specifications to different geological and hydrogeological situations are under discussion. Risk assessments and remediation decisions should not only refer to contaminant concentrations in groundwater but also to the overall contaminant mass flow caused by a point source.

References

- WFD (2000): Water Framework Directive – Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.
- GWD (2006): Groundwater Directive (draft) – (12062/1/2005 – C6-0055/2006 – 2003/0210(COD)): Common position adopted by the Council 23 January 2006 with a view to the adoption of a Directive of the European Parliament and of the Council on the protection of groundwater against pollution.
- Austria, Federal Legal Gazette no. 215/1959 (as amended until 2005): Water Act
- Austria, Federal Legal Gazette no. 502/1991 (amended 1997): Groundwater Threshold Values Ordinance
- Austria, Federal Legal Gazette. Part II, no. 304/2001: Drinking Water Ordinance
- WHO (1993): Guidelines for drinking-water quality. – 2nd ed. Volume 1 Recommendations – World Health Organisation, Geneva, 1993.
- ON S 2088-1: Contaminated Sites – Risk assessment concerning the pollution of groundwater; Austrian Standards Institute, September 2004.
- LAWA (1999): Recommendations of the working group 'Trigger values' of the German Länder Working Association for Water – 1999.
- LAWA (2004): Derivation of significance threshold values for groundwater contamination - German Länder Working Association for Water, Düsseldorf, Dezember 2004.

2 BELGIUM

2.1 FLANDERS

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2.1.1 Soil screening values

Legal framework

In Flanders soil screening values are given in the implementing orders of the Decree on Soil Remediation (in force since 1995).
Two types of soil screening values exist:

- background values;
- soil clean-up standards.

Background values reflect the normal values found in unpolluted soils. They can reflect the influence of soil properties on normal concentrations.
Soil clean-up standards reflect a level of contamination, that, if exceeded, could cause significant harmful effects for human health or the environment. The clean-up standards take account of soil properties and soil function.
Background values serve as remediation goals. However, BATNEEC considerations can be used to deviate from these primary remediation goals. In that case, a gradual approach is followed, in which soil remediation aims at reducing levels below soil remediation standards, or until eliminating serious threat. The last option is to make use of preventive measures or use limitations.
Soil remediation should take place if soil clean-up standards are exceeded in the case of new pollution[1]. In the case of historical pollution, soil clean-up standards form an element in the decision on indications of serious threat. Remediation in the case of historical soil pollution is based on a site-specific risk assessment.

Scientific basis

Background values are derived from levels found in unpolluted soils. For metals and metalloids, background values correspond with the 90-percentile of concentrations measured in Flemish top soils; a linear regression line allows recalculation for measured organic carbon and clay content. For most organic contaminants, the background level equals the limit of detection; except if they show diffuse enrichment. In that case, the 90-percentile of measured values is used.
Soil clean-up standards follow a risk-based approach. Five land-use classes are defined, these land-use classes are characterized by pre-defined exposure scenarios. The land-use classes are: nature, agriculture, residences, recreation and industry.
The information in the following chapters relates to soil clean-up standards. Background values are not discussed further.

[1] new soil pollution: soil pollution that was caused after the Decree became into force
historical soil pollution: soil pollution that was caused before the decree became into force

Technical approaches

Protected receptors

The soil clean-up standards are primarily developed from a human health point of view. Phytotoxicity is included on an ad-hoc basis. The soil remediation standards for nature are set equal to those for agriculture.
A proposal for leaching-based limit values is available, they will be used as guide-line values and will not be taken up in the legally binding framework.

Human health screening values

Conceptual model

The derivation of human health based values follows a land-use dependent approach. The applicable fate and transfer processes and the exposure pathways per land-use are given in table 1. Parameter values depend on land-use.

Table 1. Fate, transfer and exposure pathways per land-use class

	nature agriculture	residences	recreation	industry
Fate and transfer				
leaching to groundwater	X			
volatilization to outdoor air	X	X	X	X
volatilization to indoor air	X	X	X	X
soil resuspension	X	X	X	X
transfer of soil to indoor dust	X	X	X	X
uptake by plants	X	X		
uptake by cattle	X			
transport through drinking water pipes		X	X	X
Exposure				
ingestion of soil/dust particles	X	X	X	X
dermal absorption from soil.dust	X	X	X	X
inhalation of vapours	X	X	X	X
inhalation of particles	X	X	X	X
consumption of vegetables	X	X		
consumption of meat/dairy prod.	X			
intake of groundwater	X			
intake of drinking-water		X	X	X
dermal absorption from water	X	X	X	X

Exposure modeling

Exposure is expressed as an external dose, except for dermal contact in which the absorbed dose is calculated. There are no corrections for differences in relative bioavailability between pathways.
Exposure is calculated for children (assumed age group 0 – 6 years) and for adults, and represents an average daily dose. In the industrial scenario, exposure is only calculated for adults. Averaging takes place over a 1 year period. Doses via the oral and the dermal pathway are summed; doses via the inhalation pathway are summed. In case of threshold contaminants (noncarcinogens and nongenotoxic carcinogens), background exposure is added. A lifetime average is only calculated for nonthreshold contaminants (genotoxic carcinogens).

Toxicological assessment

The toxicological data are taken from existing databases or reports in order of preference: EU, WHO, US-EPA IRIS, RIVM, others. Additional considerations like date of revision or recent scientific evidence can influence the decision on the value taken. Toxicological reference values (TDI, RfD, slope factor) are selected for the oral and the inhalation route separately. If no information for one of the routes is available, the missing value is extrapolated from the available value.

Derivation of screening values

The calculation of the soil clean-up standards uses a step-wise approach. The first condition is that the concentration in soil corresponds with a risk index ≤1. For threshold contaminants the risk index is calculated separately for children and adults according to

$$RI = \frac{D_{oral} + D_{dermal} + D_{oral}^{background}}{TDI_{oral}} + \frac{D_{inhalation} + D_{inhalation}^{background}}{TDI_{inhalation}}$$

For nonthreshold contaminants, the risk index is calculated from lifetime dose, according to

$$RI = \frac{D_{oral} + D_{dermal}}{AD_{oral}} + \frac{D_{inhalation}}{AD_{inhalation}}$$

in which AD corresponds with the dose at an excess lifetime cancer risk of $1/10^5$.
In a second step, a verification takes place on calculated concentrations. These concentrations should not exceed legal or toxicological values, like maximum levels in food for agriculture, maximum levels in ambient or indoor air, drinking water limits.

Modeling tools

The calculations are done with the Vlier-Humaan model. This model is similar to the HESP and C-Soil (the Netherlands) concept, but accounts for the typical Flemish conditions and policy decisions.

Ecological screening values

There are no official ecological soil clean-up standards available. Although a method was developed (based on the Canadian CCME methodology) and values were calculated for heavy metals and some organic contaminants, these values are not used because of the inherent weakness of the methodology and the consequences with regard to remediation if they would be implemented in the legal framework.
Phytotoxicity is taken into account on an ad-hoc basis. Phytotoxicity values are listed and maximum values are decided based upon expert judgement. If sufficient data are available, data depend on land-use. This reflects the idea that sensitive plants and crops should not be inhibited in natural and agricultural areas and in private gardens, whereas in recreational and industrial areas, vegetation can be limited to less sensitive plants.

Derivation of soil screening values

Integration of human health and ecological screening values

The human health based values and the phytotoxicological values – if available – are combined into one set of proposed soil clean-up standards. In addition, comparison is also made with maximum concentrations set in the hazardous waste regulations as to set an absolute limit on concentrations.

Scientific, economic and social factors

About every ten years soil clean-up standards are revised. When important new scientific data become available revision of the relevant soil clean-up standards follows more rapidly.

Before implementation of soil clean-up values representatives of social and economic interest groups are consulted. Because of the risk-based approach and because soil clean-up standards are used for the evaluation of new soil pollution, adaptations for social or economic factors are rare.

Comparison with monitoring concentration

Proposed soil clean-up standards are compared with both background values and analytical limits. In case there are conflicts with either of these, the proposed soil clean-up standard is raised until an acceptable margin.

Scientific and practical weaknesses

The methodology used to develop soil clean-up standards dates from 1995 and needs updating. Choices made on some parameter values are of low transparancy. Others are based on very few data (e.g. amount of soil taken in orally). New reliable experimental data are needed. Validation of the transfer and exposure model with data from biomonitoring would be very useful.
Implementation of ecotoxicological values is hindered by their conservatism and the consequences (remediation) for new soil contamination if these values would be implemented in the legal framework.

Future developments

The model for calculation of soil clean-up standards (and for human health risk assessment) is under revision. This revision relates to model equations and parameter values and will bring the model to a state-of-the-art level.
Soil clean-up standards for heavy metals and arsenic are under revision as well.

References

- OVAM (2004). Guidance for risk assessments – Part 1-H – Method for the calculation of soil remediation values. (in Dutch: Basisinformatie voor risico-evaluaties – Deel 1-H - Werkwijze voor het opstellen van bodemsaneringsnormen), available from: http://www.ovam.be.
- OVAM (2004-2006). Guidance for risk assessments – Part 4-SN – Information on substances for the calculation of clean-up values. (in Dutch: Basisinformatie voor risico-evaluaties – Deel 4-SN – Stofdata normering), available from: http://www.ovam.be.
- VHI (2006). Vlier-Humaan 2.1 – Flemish Instrument for the assessment of risks–human. http://www.risc-site.nl/index.html?riscmainFrame=sw_vlier_nl.htm.

2.1.2 Groundwater screening values

Legal framework

(see 2.1.1)

Scientific basis

Background values are derived from levels found in unpolluted groundwater. For metals and metalloids, background values correspond natural levels. For organic contaminants, the background level equals the limit of detection.
Groundwater clean-up standards follow a risk-based approach.
The information in the following chapters relates to soil clean-up standards for groundwater. Background values are not discussed further.

Technical approaches

Protected receptors

The groundwater clean-up standards aim at protecting human health by the drinking water pathway. There is no connection between the soil clean-up standards and the groundwater clean-up standards. In the proposed leaching-based soil clean-up values, they are connected by the leaching pathway.

Derivation of soil screening values

If EU or Flemish drinking water standards are derived from a toxicological basis, these values are taken for threshold contaminants. If no legal limits are available, the values are calculated according to the methodology of the WHO, assigning a certain fraction of the TDI to drinking-water. In case of non-threshold contaminants, the groundwater clean-up value is based on an excess lifetime cancer risk of $1/10^5$.

Scientific and practical weaknesses

The methodology considers only one receptor, with no differentiation on e.g. type of geological layer, suitability of the layers with regard to water extraction, … Until now it was not evaluated as feasible to introduce these aspects in the standards.

Future developments

Future developments are not planned; they could be initiated by the implementation process of the EU Water Framework Directive.

References

- OVAM (2004). Guidance for risk assessments – Part 1-H – Method for the calculation of soil remediation values. (in Dutch: Basisinformatie voor risico-evaluaties – Deel 1-H - Werkwijze voor het opstellen van bodemsaneringsnormen), available from: http://www.ovam.be.
- OVAM (2004-2006). Guidance for risk assessments – Part 4-SN – Information on substances for the calculation of clean-up values. (in Dutch: Basisinformatie voor risico-evaluaties – Deel 4-SN – Stofdata normering), available from: http://www.ovam.be.
- VHI (2006). Vlier-Humaan 2.1 – Flemish Instrument for the assessment of risks – human. http://www.risc-site.nl/index.html?riscmainFrame=sw_vlier_nl.htm.

2.2 WALLOON REGION

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The Walloon region has developed three kinds of standards for soil and groundwater quality assessment on contaminated sites : "*valeur de référence*" (Reference Value - RV), "*valeur seuil*" (Trigger Value - TV) and "*valeur d'intervention*" (Intervention Value - IV). The reference value is an indicative value of the expected background concentrations in Walloon soils and groundwater. Both trigger value and intervention value are risk-based standards, corresponding to different risk levels.

2.2.1 Soil screening values

Legal framework

The Law of the Walloon government for the cleaning of contaminated sites and rehabilitation of brownfields[2] of April, 1st, 2004 constitutes the legal framework. This Law is not in force yet and the soil values given below (Table 2) are currently still provisional (adopted on the 19th of May 2004 as first project of enforcement decree of the 01/04/2004's Law). The general functioning of the TV and IV is the following : below TV, soil may be managed as being unpolluted. Above TV, an in-depth investigation – generally including a risk assessment – is launched. The cut-off value (IV) corresponds to a higher (theoretical) risk level. Above IV an action is always required. That may consist either in a soil treatment to reduce concentrations, either in a risk management technique, or even, according to the case and the specific risks, in a simple security and/or a follow-up measure. Note that if the contamination is qualified as "new contamination" (generated after 01/01/2003), the way the standards are used is somewhat different : if soils concentrations exceed

[2] Décret du 01/04/2004 relatif à l'assainissement des sols pollués et aux sites d'activités économiques à réhabiliter. Moniteur belge 07.06.2004.

TV, soil clean-up is systematically compulsory and the soil cleaning objective is by default the RV (figure 1).

Scientific basis

Except for the parameter "mineral oil" all the TVs and IVs values have been derived from a methodology based on risks. Risk-based values (TV and IV) are derived considering standardized conditions and by combining human toxicological risk assessment (TV_H and IV_H), ecotoxicological risk assessment (TV_E and IV_E) as well as risk evaluation regarding groundwater contamination (TV_N and VI_N). The final risk-based value for a given pollutant and land use is fixed to the smallest value among $(TV \text{ or } IV)_H$, $(TV \text{ or } IV)_E$ and $(TV \text{ or } IV)_N$ (figure 2).
Equation of the RIVM's CSOIL model (Van den Berg, 1995) have been used as the methodological bases for calculating TV_H and IV_H.

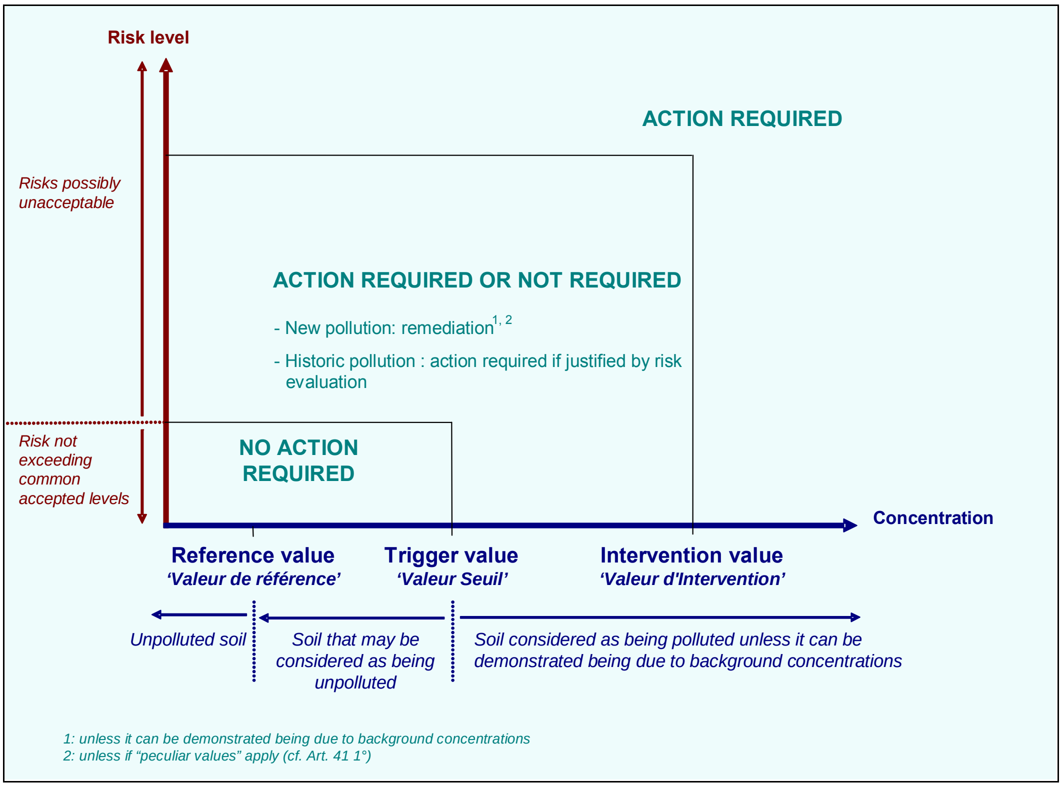

Fig. 1. Soil Quality standards and assessment (adapted from the Interdepartmental Committee for the Redevelopment of Contaminated Land for interpretation of ICRL "trigger concentrations" - http://www.sanaterre.com/guidelines/icrcl.htm) (from Halen et al., 2003)

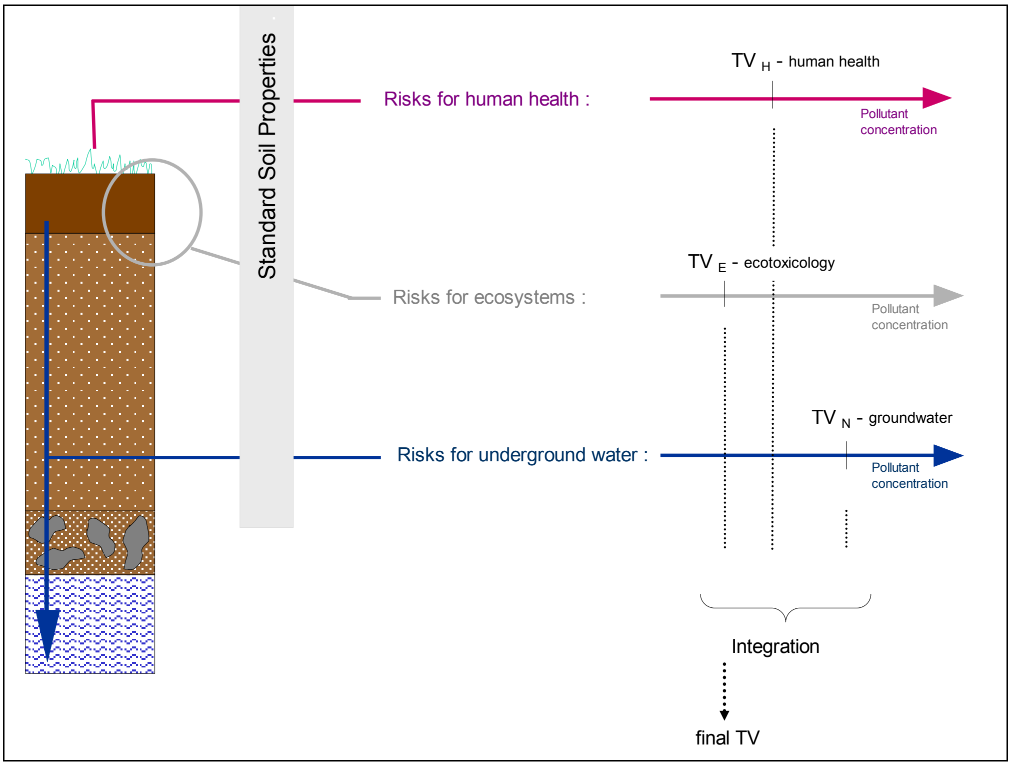

Fig. 2. General procedure for the determination of soil standards (Trigger values – TV - and Intervention values - IV) (from Halen et al., 2003)

In a general way, the TV_H corresponds to a pollutant concentration in soil rendering a Risk Index [3] (RI) of one for non-carcinogens or an excess lifetime cancer risk of 10^{-5} for carcinogens [4]. As suggested by Lijzen *et al.* (2001), calculations were performed using two toxicological threshold levels simultaneously : one for ingestion routes and dermal contact and another for inhalation routes.
For the ecological screening values - TV_E and IV_E - the procedures that have been followed are globally the ones developed by RIVM (Crommentuijn *et al.*, 1994). For TV_N and IV_N the methodology is mainly inspired from the Canadian (CCME, 1996) and American (EPA, 1996) approaches.
All the details about the way the soil standards have been calculated can be found in the technical report (in French) of SPAQuE : Halen *et al.*, 2003 downloadable at www.assainissementsoutenablespaque.be.

Technical approaches

Protected receptors

These are : human receptors (child of adult according to the land use), ecological receptors (soil (micro-) fauna and (micro-) flora, and, in case of agricultural land, also the herbivorous organisms), and groundwater.

[3] Given by the ratio of the exposure dosis to a toxicological threshold level
[4] Excepted for benzene where an excess lifetime cancer risk of 5.10^{-5} was considered.

Human health screening values

Conceptual model

Five land use types of decreasing sensitivity have been defined : natural, agricultural, residential, recreational/commercial and industrial land uses. Except for the agricultural land use type, each of them specifies the specific receptor to protect (child for natural, residential and recreational/commercial land uses ; adult for industrial land use) and the exposure scenario : the exposure routes (see table 1), and the time the receptor spends on the site. Dermal exposure time inside is the total time inside minus the time sleeping. Dermal exposure time outside is equal to the exposure time outside for inhalation. Exposure frequency is equal to 230 days per year for natural and recreational land uses ; 250 days per year for industrial land use ; 350 days per year for residential land use. Note that for natural zones the conceptual model used is the one defined for recreational zones.

Table 1. Exposure routes for natural- (type I), residential- (type III), recreational-/commercial (type IV), and industrial- (type V) land use types

Exposure routes	**Landuse types**			
	I	**III**	**IV**	**V**
(1) Outdoor air Inhalation	X	X	X	X
(2) Indoor air Inhalation	X	X	X	X
(3) Inhalation of soil	X	X	X	X
(4) Inhalation of vapours (shower)	X	X	X	X
(5) Ingestion of soil	X	X	X	X
(6) Ingestion of drinking water	X	X	X	X
(7) Ingestion of vegetables		X		
(8) Dermal contact with soil	X	X	X	X
(9) Dermal contact with water (shower)	X	X	X	X

For agricultural landuse type, the human health screening values have been derived using another methodological approach. This is based on the definition of a maximum permissible concentration in the diet (a fraction of the Tolerable Daily Intake) and by considering that the diary diet of one person is composed of : 0,258 kg (f.w.) potatoes , 0,329 kg (f.w.) vegetables , 0,200 kg (f.w.) milk, 0,268 kg (f.w.) meat, 0,212 kg (f.w.) cereals, 0,041 kg (f.w.) eggs, and 0,644 kg (f.w.) of other products (Halen *et al*., 1998).

Exposure modeling

Equations of the RIVM's CSOIL model (Van den Berg, 1995) have been used as the methodological bases for calculating TV_H and IV_H (See 1.2.).

Toxicological assessment

Toxicological end points have been selected using current data bases such as IPCS, US-EPA IRIS, RAIS, IARC, ATSDR, INERIS and RIVM (Baars *et al.*, 2001).

Derivation of screening values

CSOIL equations have been transformed in order to get algorithms expressing soil values as a function of toxicological endpoints (See 1.2.).

Modeling tools

The so-transformed algorithms have been worked out on Excel format worksheets. The RISC Human software (v. 3.1., Van Hall Instituut) has been used for cross-checks.
For what concerns the exposure dosis calculations for human health risk assessment, the RISC Human software (v. 3.1. & 3.2., Van Hall Instituut) is generally used.

Soil screening values protecting from leaching and groundwater contamination

Conceptual model

TV_N is conceived as the maximum concentration of the pollutant in the soil – assuming a constant concentration from the top of the profile and down to the groundwater table – able to warrant that the quality criteria fixed for groundwater ($TV_{groundwater}$, see section 2) will be respected, even in the long-term, taking into account risks for vertical and lateral transfers (IV_N is defined in an analogous way).

Modeling

TV_N is deduced from $TV_{groundwater}$ through the following equation :

$$TV_N\,(mg/\mathrm{kg}) = TV_{groundwater}\,(\mu g / L) \times FAG(L / kg) \times \frac{1}{1000}$$

where FAG is the global attenuation factor based on a simplified description of the main attenuation mechanisms : partitioning between the liquid-, solid- and gaseous phases, re-distribution in the bosom of the soil profile by sorption, and dilution in the groundwater). For a monitoring well placed at the girth of the polluted zone (downgradient), FAG is given by (CCME, 1996) :

$$FAG(L / kg) = \frac{FD(-)}{F_v(-) \times K_{sw}(kg / L)}$$

where : K_{sw} is the partition factor soil/leachate (assessed through K_{ow} for organics and by statistical pedo-transfer functions for inorganics); F_v the re-distribution factor and FD the dilution factor given as a function of the properties of the aquifer, characteristics of the mixing zone, the leachate flow, and the groundwater flow.

Ecological screening values
They have been calculated using species (or microbial/enzymatic processes) sensitivity distribution assuming loglogistic statistic distribution (Model of Aldenberg and Slob, 1993). Specific rules have been adopted when toxicity (NOEC) data where not available for 4 different taxonomic groups, based on Verbruggen *et al.* (2001). Experimental (literature) $data_{exp}$ have been normalized to the standard soil properties considered ($data_{adj}$) according to :

$$Data_{adj} = data_{exp} \times (Kd_{adj}/Kd_{exp})$$

The protection levels are land-use dependent. For TV_E : HC_{20} for natural & agricultural land-use, HC_{40} for residential and recreational land-use, HC_{50} for industrial land-use. For IV_E : HC_{50} for natural & agricultural land-use whilst for the lesser sensitive land use types other criteria have been adopted (values able to insure a minimal biological activity in soil compatible with the specific usage, based on van Hesteren *et al.* (1998) for heavy metals, an on conventional multiplication factors applied on TV_E for organics).

Scientific and practical weaknesses

For TV_H and IV_H: there is a special weakness for two exposure routes :
(1) plant transfer, in case of heavy metals, where soil conditions are not yet taken into account, when they have a marked incidence ;
(2) indoor air inhalation, which is one of the most sensitive route in case of volatile compounds.
For TV_N and IV_N: the models used could be perceived as an over-simplification of the reality; in practice, a lot of factors can lead to higher risks for groundwater than anticipated : for instance the presence of solvents, for organic pollutants such as polycyclic aromatic hydrocarbons, or the presence of organic complexes or soluble salts, for heavy metals, can lead to a lesser sorption – and higher soil to groundwater transfer -than predicted.
For TV_E and IV_E : the lack of experimental toxicity data (soil data), especially for organics, can lead to screening values with very poor statistical relevance; on the other hand the method used to normalize the literature data to standard soil conditions still lacks for a true validation.

Future developments

Research programmes are on the point of being introduced (Belgian federal research) in order to consolidate some of the most sensitive modules of the models and to get validation data. On another hand, TV and IV should be proximately calculated for the remaining classes of pollutants : e.g. chlorinated solvents, PCB, phenols, cyanides.
Regressions are in preparation for adjusting soil screening values (TV_H, TV_N, TV_E) as a function of general soil properties (e.g organic matter content, clay content) and properties of the aquifer (for TV_N). These will be recommended for use in the framework of the first step of the risk assessment and for the definition of "Risk-Based Corrective Levels" as possible objectives for soil cleaning.

References

- Aldenberg, T. & Slob, W. (1993). Confidence limits for hazardous concentrations based logistically distributed NOEC toxicity data. Ecotoxicology & Environmental Safety, 25, 48-63.
- Baars, A.J., Theelen, R.M.C., Janssen, P.J.C.M., Hesse, J.M., Van Appeldoorn, M.E., Meijerink, M.C.M., Verdam, L. Zeilmaker, M.J. (2001). Re-evaluation of human-toxicological Maximum Permissible Risk levels. RIVM report n° 711701025, Bilthoven, The Netherlands.
- CCME (Canadian Council of Ministers of the Environment) (1996). A protocol for the derivation of environmental and human health soil quality guidelines, CCME-EPC-101E.
- EPA (Environmental Protection Agency) (1996). Soil Screening Guidance : Technical Background Document. Second Edition, EPA/540/R95/128, USA.

- Halen, H, Kreit, J.F. & Vanderheyden, V. (1998). Normes de qualité pour les produits/déchets valorisables sur les terres agricoles dans le cadre d'un plan d'environnement durable. Final report SITEREM to the « Direction Générale de l'Agriculture », Walloon Region, Namur.
- Halen H., Maes, E. & Moutier, M.. (2003) Wallonia facing the challenge to correct vestiges lest from its industrial past – overview of the new decree on contaminated land. *In* : Proceedings of the 8th International FZK/TNO Conference on Contaminated Soil – ConSoil 2003, 12-16 May 2003, Ghent, Belgium).
- Halen H., Maes, E. & Moutier, M. (2004). Procédures de calcul des normes pour le sol : valeur de référence (VR), valeur seuil (VS) et valeur d'intervention (VI). Rapport SPAQuE –Document de Consultation. Mars 2004.
- Lijzen, J.P.A., Baars, A.J., Otte, P.F., Rikken, M.G.J, Swartjes, F.A., Verbruggen, E.M.J. & van Wezel, A.P. (2001). Technical evaluation of the Intervention Values for Soil/Sediment and Groundwater. RIVM report n° 711701023, Bilthoven, The Netherlands.
- Van den Berg. (1995). Blootstelling van de mens aan bodemverontreiniging. Een kwalitatieve en kwantitatieve analyse, leidend tot voorstellen voor humaan toxicologische C-toetsingwaarden. RIVM rapport n° 725201006, Herziene versie, Bilthoven, The Netherlands.
- van Hesteren, S., van de Leemkule, M.A. & Pruiksma, M.A. (1998). Minimum soil quality. A use-based approach from an ecological perspective. Part I: Metals. Technical Soil Protection Committee (TCB). The Hague, The Netherlands.
- Verbruggen, E.M.J., Posthumus, R. & van Wezel, A.P. (2001). Ecotoxicological Serious Risk Concentrations for soil, sediment and (ground)water: updated proposals for first series of compounds. RIVM, report n° 711701020, Bilthoven, The Netherlands.

2.2.2. Groundwater screening values ($TV_{groundwater}$ and $IV_{groundwater}$)

Legal framework

See 2.1.1.

Scientific basis

Trigger values for groundwater ($TV_{groundwater}$) were established considering that groundwater must be drinkable or 'easily made as drinkable'. In establishing $TV_{groundwater}$ different criteria were considered - prioritized differently for heavy metals/metalloïds/inorganics and for organics -

- World Health Organization's water quality guidelines ;
- European parametric values (European Directive 98/83/CE) ;
- regional drinking water quality values ;
- calculated value according to WHO's procedure : for genotoxics, the value was associated to an excess lifetime cancer risk of 10^{-5} (1 additional cancer case per 100.000 of the population ingesting 2 L of water for 70 years) ; for non-carcinogens and carcinogens with convincing evidence to suggest a non genotoxic mechanism, the value was calculated using a tolerable daily intake approach (a fraction of the TDI is allocated to the ingestion of 2L of water by an adult weighting 60 kg)

Additional criteria were considered :

- solubility, olfactory and gustative threshold levels for organic compounds,
- SRC_{eco-gw} (*Serious Risk Concentrations for Groundwater* ensuring protection of 50 % of aquatic species) and MPC_{eco-gw} (*Maximum Permissible Concentrations for Groundwater* ensuring protection of 95% of aquatic species) for heavy metals. (see RIVM reports).

All the details about the way the groundwater standards have been calculated can be found in the technical report (in French) of SPAQuE cited below, downloadable at www.assainissementsoutenablespaque.be.

References

- Halen, H. & Moutier, M. (2005). Procédure de calcul des normes pour les eaux souterraines : valeur de référence ($VR_{\{nappe\}}$), valeur seuil ($VS_{\{nappe\}}$) et valeur d'intervention ($VI_{\{nappe\}}$). Rapport SPAQuE – Document de Consultation. Mars 2005.

3 CZECH REPUBLIC

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3.1 Soil screening values

Legal framework

The competent authority for the soil protection in the Czech Republic is Ministry of Environment. The topic also includes soil pollution.
There are following legislative measures concerning limit values of risk substances in soil in the Czech Republic:

- Decree No. 13/1994 Coll. Regulating some details of agricultural soil fund protection. (Level of trigger values).
- Decree No. 382/2001 Coll. Specifying conditions for sewage sludge application on agricultural soil (Level of precautionary values).
- Decree No. 294/2005 Coll. Specifying conditions on dumping of waste and their utilization on soil surface (Level of precautionary values).
- Guideline of the Ministry of Environment setting criteria for pollution of soil and groundwater. It provides threshold concentration values for three of contaminations, but in an informative way, without strong legislative effect.

Decree No. 13/1994 Coll. was issued to the Act on the protection of agricultural soil fund and Decrees No. 382/2001 Coll. and 294/2001 Coll. were issued to the Act on wastes.

Scientific basis

The precautionary values (Decree No. 382/2001 Coll.) were especially based on the results of two national-wide soil monitoring and inventarization programs:

Soil and atmospheric deposition monitoring program

The program of monitoring on agricultural soil is conducted in the network of 190 representative monitoring plots on arable land, grassland and on special crops since 1992. On selected monitoring plots atmospheric deposition is monitored simultaneously in one-month period. On the special subsystem of 27 monitoring plots, designed in highly polluted areas, parameters of pollution are investigated (level of pollution, sources, translocation in soil profile and transfer in plants). Inorganic pollutants are measured in a six year period, persistent organic pollutants in one year period on a set of 40 plots. (Sáňka et al., 1998).

Register of contaminated sites (for agricultural land)

In the period of 1990 - 1993 the survey of risk element contents (Cd, Pb, Cr, Hg) in agricultural soils in the network of 1 km^2 was implemented. The four elements were successively supplied by analyses of Be, Co, Cu, V, Zn. That survey laid down the database that has been continuously filled by results of supplementary sampling. Geographical co-ordinates and a plot number identify each sample in the database. Affiliated are the results of risk elements contents in soil in 2M nitric acid extract or aqua regia extract. In present, about 40,000 soil samples were analysed and stored in the database. Other risk substances can be analysed in soil samples based on the

requirements of the Ministry of Agriculture. (Sáňka et al., 2001). The inventory is intended preferably for risk elements. Persistent organic pollutants and pesticides are measured only in special cases and in limited network of soil monitoring.
Beside the monitoring campaigns, valid legislative measures from abroad and economy-social aspects were also taken into account in preparation of both precautionary and trigger values.
Although the Decree No. 382/2001 Coll. is issued to the Act on wastes, the precautionary values have already been a part of a new strategy to prepare three levels of limit values: precautionary, trigger (indicative), action. Therefore these values are intended to use in a new strategy as the first level.
The valid maximum permissible limit values for agricultural soil (Decree No. 13/1994 Coll.) represent the level of trigger values. They are focused especially to protect the agricultural production from possible contamination, so the route through food chain is considered. Transport of contaminants as dust, in the vapour phase to the air, in the vapour phase to groundwater and surface water is not considered.

Technical approaches

Precautionary values

Results of the two programs mentioned above, as well as results of some smaller topical researches were statistically evaluated. As main criteria, values of 95% percentiles were used to propose the precautionary limit values. For risk elements, the areas with naturally high contents were excluded from evaluation. The results were also compared with adequate data from abroad.

Trigger values

Values given by Decree No. 13/1994 Coll. can be considered as trigger values from the point of the legislative interpretation. However, they are not "effect based" but based also on statistical processing (95 percentile of background values distribution) and comparison with foreign regulatory limits, in particular from The Netherlands, Germany, Switzerland. The methodology for the calculation of values is not available. Moreover, values derived in 1994 deserve to be updated.
Generally the limit values should protect all receptors, except for groundwater. Groundwater concentration limits are also available, but not in correlation to soil contaminants. However the protected receptors are not strictly specified. Only in Decree No. 13/1994 Coll. is stated that "limit values are maximum acceptable values of some risk substances endangering the existence of living organisms". Limit values given by the guideline are differentiated in categories A – B – C. The A category means the upper level for natural background, or unpolluted soil material (statistically 95 percentile), the category B means approximately the value between A value and limit of pollution. The C category is divided to subcategories according to type of land use: C residential, C recreation, C industrial, C generally (possibly all purpose utilization).
No directly human health or ecological screening values are specified in the legislation. In specific cases, where health or ecosystem risk assessment is recommended, the US EPA methodology is used according the basic formulas:

Ecosystem risk assessment

$$HQ = \frac{PEC}{PNEC}$$

Health risk assessment

non-carcinogenic

$$HQ = \frac{CDI}{RfD_d}$$

carcinogenic

$$ELCR = 1 - e^{(-CDI*CSF)}$$

where:
HQ = hazard quotient
PEC = Predicted environmental concentration
PNEC = Predicted non effect concentration
CDI = Chronical daily intake
RfD = Reference doses
ELCR = Excess lifetime cancer risk
CSF = Cancer slope factor
For the RfD, mostly the values from the US EPA IRIS database are used.

CDI calculation is very important phase of the whole procedure. Specific input values are used according the specific situation.
The whole procedure is based on dose-response relationship for the contaminant – the principle of four steps of risk assessment procedure. Then, different risks are calculated, according to main routes:
A) inhalation (contaminated dust)
B) ingestion (direct ingestion of soil, especially by children)
C) dermal contact
D) oral (through food chain)
The whole procedure is published in detail in guidelines of the Ministry of Environment of the Czech Republic (Guideline of the Ministry of Environment – Risk analysis for contaminated areas and Guideline of the Ministry of Environment Survey of contaminated areas).

Scientific and practical weaknesses

The present valid soil limit values (Decree No.13/1994 Coll.) are not effect based, but only statistically based. The effect-based approach is included only by comparison with limit values in other countries.
The legal force is rather low, except of limit values for sewage sludge application. In this case, the limits must be met; otherwise the sludge must not be applied.
On the legislative basis only limits for agricultural soil are available. The limits for other soils, especially soils of industrial sites were developed only as guideline values (Guideline of the Ministry of Environment setting criteria for pollution of soil and groundwater).
Using the single limit values (maximum permissible values) does not include conditions given by exposition scenarios for different types of land use.

Future developments

An effective tool for the assessment of ecological risks EcoRa was processed. (Holoubek et al., 2002) It comprises a detail methodology of assessment posed by chemicals in the environment. The US EPA procedures are taken into account (US EPA 1989, US EPA 1991a US EPA 1991b, US EPA 1992, U.S. EPA 1998).
New effect based soil limit values for the pathway soil – plant were proposed, but not approved in legislation. They are based on the two extractants – aqua regia and 1M ammonium nitrate. The validity in legislation is proposed as trigger values – in case of exceedance, risk assessment procedure should follow.
Also, the limit values for different exposition scenarios for humans should be proposed, as well as detailed methodical procedure of risk assessment.
In the framework of preparing the new Act on soil protection, also the new attitude for assessment of soil contamination was considered and proposed. There should be three levels of generic soil screening values (precautionary, trigger, action) and differentiation according to land use.
In specific cases the methodology of risk assessment (US EPA) is proposed to use.

References

- Holoubek, I., Dušek, L., Bláha, L., Anděl, P., Maršálek, B. Hofman, J., Šmíd, R., Klimeš, D., Jarkovský, J., Čupr, P., Škarek, M., Kohoutek, J., Holoubková, I., Šnábl, I., Kukleta, P.: Hodnocení ekologických rizik. Manuál pro standardizovanou metodiku. TOCOEN, s.r.o., Brno. TOCOEN REPORT No. 225.Brno, listopad 2002.
- Sáňka, M., Havlíková, Š., Němec, P., Malý, S., Chvátal, V.: Kontrola a monitoring cizorodých látek v půdě a vstupech do půdy. Zpráva za rok 2001. ÚKZÚZ Brno, 2002.
- Sáňka, M., Němec, P., Chvátal, V., Havlíková, Š. (1998): Bazální monitoring zemědělských půd a monitoring atmosférické depozice. Metodické postupy, ÚKZÚZ Brno.
- Sáňka, M., Němeček, J., Podlešáková, E., Vácha, R., Beneš, S (2002).: Setting out the critical limits of risk element contents in soil from the point of plant uptake Final report, Ministry of Environment of the Czech Republic.
- U.S. EPA (1998): Guidelines for Ecological Risk Assessment. /630/R-95/002F, April 1998, Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC.
- US EPA (1989): Risk Assessment Guidance for Superfund, Vol. II, Environmental Evaluation Manual: Interim Final. EPA/540/1-89/001. Office of Emergency and Remedial Response. US EPA, Washington, D. C.
- US EPA (1991a): Summary Report on Issues in Ecological Risk Assessment. EPA/625/3-91/018. US EPA, Washington, D. C.
- US EPA (1991b): Risk Assessment Guidance for Superfund: Vol.I – Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Interim. Publication 928,7-01B. Office of Emergency and Remedial Response, US EPA, Washington, D. C.
- US EPA (1992): Ecological Risk Assessment Projects. Publication 9200.5-325I. BTAG Forum Intermittent Bulletin 2(2). Office of Solid Waste and Emergency Response, US EPA, Washington, D. C.
- Guideline of the Ministry of Environment, Department for Ecological Damages – Procedure to elaborate risk analysis.

- Guideline of the Ministry of Environment, Department for Ecological Damages – Criteria for assessment of soil, soil material and groundwater.
- Guideline of the Ministry of Environment – Risk analysis for contaminated areas. Bulletin of Ministry of Environment, XV, No. 9, September 2005.
- Guideline of the Ministry of Environment – Survey of contaminated areas. Bulletin of Ministry of Environment, XV, No. 9, September 2005.

3.2 Groundwater screening values

Legal framework and future developments
Guideline values are published by the Ministry of Environment (Guideline of the Ministry of Environment, Department for Ecological Damages – Criteria for assessment of soil, soil material and groundwater.)
For the assessment of groundwater as a source of drinking water, limit values for drinking water are used according to Decree No. 252/2004 Coll.
In health risk assessment, the same procedure as in soil is applied

References

- Guideline of the Ministry of Environment, Department for Ecological Damages – Criteria for assessment of soil, soil material and groundwater.
- Decree No. 252/2004 Coll. Setting out the hygienic requirements for drinking water and warm water and range and frequency of inspection of drinking water.

4 DENMARK

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4.1 Soil screening values

Legal framework

The Soil Contamination Act of 1999 last amended in 2006 is the legal framework for management of contaminated soil in Denmark. The Act states:
"This Act shall apply to soil which due to human impact may harm the groundwater, human health, and the general environment."
The Soil Contamination Act covers all contamination in soils, irrespective of the time and place of contamination. However, the act does not apply to soil affected by agricultural spreading of sludge, fertiliser, and pesticides, etc.
As a consequence of the amendment of the act in 2006 the registration system will be changed January 2007. Where all contamination before should be registered, the act in the future will except slightly contaminated soil from registration.
Slightly contaminated soil is defined as soil contaminated with 7 specified low-mobile substances e.g. lead, cadmium, and PAH in low concentrations (1-10 times the preventive level). Slightly contaminated soil is primarily found in the central parts of cities.
The cities will be subject to a general classification. The general classification does not rule out that areas with contaminated soil in the cities can be registered if the contaminated soil is more than "slightly contaminated".

Registration of contaminated sites

(Potentially) contaminated sites are registered in the land registry. Registration takes place at two levels. A site is registered at level 1, if actual knowledge has been obtained of activities on the site or activities on other sites that may have been sources of contamination at the site. A site is registered at level 2 where documentation is obtained, which renders it highly probable that the site contains soil contamination of some type, and concentration that may have a harmful impact on humans and the environment. The registration of a contaminated site is followed by restrictions on the use of the sites, on changes of land use and on soil removal. In addition, investigations and remediation may be required as well as monitoring of pollution levels and acceptance of subsequent monitoring of pollution levels.
In Denmark, contaminated sites are registered at the preventive level unless the contaminants are low-mobile. The preventive level is also used as an action criterion for remediation when it comes to mobile substances that may evaporate to the indoor climate or be leached to the ground water.

General classification of city areas

The municipalities should make a general classification of larger areas primary in the city where the concentrations of low-mobile substances in the soil are expected to exceed the prevention level but to be below the cut off values. In the classified areas people will be informed about possible measures to reduce contact with the slightly contaminated soil. Before moving excavated soil from a property in a classified area notice should be given to the municipality to ensure the soil is handled safely and not give rise to problems at a new location.

Prioritisation

The registered sites are prioritised according to the need for remediation. Sites used for residential purposes, kindergardens and public playgrounds and sites that pose a risk for groundwater that could be used for drinking water purposes is given priority in the program for public financed investigations and remediations. Generally, lower priority is given to surface water.
Usually, risk assessments are based on contaminant concentrations, comparing them with the relevant criteria at either the preventive level (mobile substances) or the cut off value (low-mobile substances). If the concentration of a specific contaminant is found to exceed the relevant criterion, the site is considered to present a certain risk to humans and/or the environment. This will result either in further field investigations to improve the initial risk estimate, or in remedial action.
In November 1998 a guideline on Remediation of Contaminated Sites (http://www.mem.dk/love/htmlfiler/98v30047.htm) was issued. It provides a detailed description of the management of contaminated sites including field survey methods, collection of samples, site characterisation, conducting risk assessments and implementation and control of remedial actions.

Scientific basis

The scientific foundation for drawing up the criteria generally rests on the same international evaluations and internationally published investigations and methods for hazard evaluation and characterization.

Technical approaches

Generic guideline values are calculated as separate values for soil (toxicological quality criteria and ecotoxicological quality criteria). The toxicological quality criteria are derived to protect against harmful effects from direct exposure to soil. In parallel to this, air quality criteria are derived to account for the evaporation of volatile contaminants into indoor air, and ground water/ drinking water quality criteria are used in connection with assessment of leaching and contamination of the groundwater. Ecotoxicological soil criteria are only seldom used in connection with risk assessment of contaminated sites.
The contamination is judged tolerable if none of the relevant media oriented quality criteria is exceeded. If for example a contamination is at or below the level of the soil quality criteria, then the area can be used for most sensitive uses. If, at the same time, the contamination level in groundwater is exceeding the ground water quality criteria, then the contamination is considered unacceptable in relation to protection of the groundwater. Thus, compliance to the soil quality criteria does not automatically secure the contamination of the other media i.e. the degree of evaporation to indoor air or the wash out into the groundwater. Criteria values have been published in the guideline on Remediation of Contaminated Sites (DEPA 1998) and in an updated version at Danish EPA’s homepage (www.mst.dk).
The level of protection is primarily determined by guidelines for risk assessment and by use of health based quality criteria. The purpose is to prevent any health hazard in the human population caused by chemicals as pollutants.
If the concentration level of a specific contaminant is found to exceed the relevant criterion, the contamination of the site is considered unacceptably high. This will result, either in further field investigations to improve the initial risk estimate, in restrictions on landuse, or in remedial action.

Assessing the risk of soil ingest, skin contact and inhalation of dust particles is based on the landuse and the accessibility of the contaminated soil to human exposure (e.g. is the contaminated soil accessible or covered by clean soil, grass, pavement etc.).
Humans are especially exposed to injurious substances on lands used for sensitive purposes like playgrounds, day-care centres and residential gardens including household gardens. When assessing risk for sensitive purposes the relevant criteria (cut-off value for low-mobile substances and toxicological soil quality criteria for all other substances) should be fullfilled in the top soil (0,5 m).

Protected receptors

The main objective of the act on contaminated soil is to protect groundwater that can be used for drinking water purpose and to prevent health problems connected to use of contaminated areas.
Since nearly all drinking water in Denmark derives from groundwater, groundwater protection has a very high priority. Quality criteria for groundwater shall thus ensure that the water, when it reaches the consumer, complies with the drinking water quality criteria. Generally, lower priority is given to surface water.
Soil quality criteria are derived with respect to the most sensitive uses of the soil i.e. use for domestic gardens, kindergartens or playgrounds. The intention is to protect small children, as children are considered to be the most heavily exposed group (ingestion of soil, hand - mouth contact), but also because children for several chemical pollutants may be more biological susceptible than adults.

Human health screening values

Conceptual model

For the guidance of public authorities the Danish EPA has laid down provisions as to the quality of soil, air and water. For the protection of human health, the quality criterias for chemical pollutants are set at a level at which exposure to the media is not considered to have any adverse effect on human health. That means that the level of the quality criteria is considered to represent a safety level. Thus, when a quality criteria is exceeded to a minor extent it does not mean that a danger level is reached, rather it should be interpreted as an undesirable reduction of the safety level.

Exposure modelling

When establishing quality criteria, consideration is – whenever possible – taken of the fact that exposure to the substance may occur from several sources. When there are multiple sources of exposure, 10% is allocated to the media in question. In practice however, adjustments are made with regard to drinking water and background exposure.
When 10% of the TDI is allocated to soil the calculation of the soil quality criteria is based on a standard scenario consisting of a child weighing 13 kg who ingests 0,1 g soil per day as an average (corresponds to median exposure). For acutely toxic substances, isolated ingestion of 10 g of soil is considered.
When a majority of the TDI (or more) is allocated to soil the calculation of the soil quality criteria is based on a standard scenario consisting of a child weighing 13 kg who ingests 0,2 g soil per day as an average (corresponds to 95-percentil). For acutely toxic substances, isolated ingestion of 10 g of soil is considered.
Average skin contact is set to 1g soil to consider substances with high skin permeability.

Toxicological assessment

The use of uncertainty factors when extrapolation is made from a zero-effect level in animal testing to a "tolerable exposure" to humans follow the general recommendations given by WHO. This means that consideration is made for the variation between animals and humans and the biological variation in humans as well as to the uncertainty caused by the quality and relevance of the data foundation. In practice, the size of the uncertainty factor may deviate due to differences in the subjective estimation. Generally, a combined uncertainty factor of above 10,000 is not accepted.
In Denmark, an increased lifetime risk of one out of one million (10^{-6}) is tolerated for carcinogenic substances without limit value in all media (soil, air and water).

Derivation of screening values

The principles for calculating soil quality criterias as described above are the principles used for calculating all type of criteria for prevention in Denmark. The exposure scenarios for air and water are as for soil based on covering the whole population including the most sensitive individuals.
Often both risk assessment of e.g. land use and groundwater will be relevant. There does not exist combined screening values to cover situations where more than one risk should be assessed but all relevant criteria should be fulfilled.
Areas with contaminated soil that exceed the preventive level described above will be registered as a contaminated site in the Land Registry.
For 7 low-mobile substances there has been elaborated so-called cut off values. The cut off indicate that if contamination is below that value, remediation is not necessary because exposure can be reduced to an acceptable level by reducing the contact with soil, e.g. not eating home-grown vegetables or replacing bare soil by a lawn. From January 2007 the cut-off values will be used as criteria for registration of contaminated soil with low-mobile substances.

Ecological screening values

A set of ecotoxicological based soil quality criteria exist in Denmark. These were derived by the National Environmental Research Institute on request from the Danish Environmental Protection Agency in the early 90'ies (Table 1). Below a short presentation of the procedure used more than a decade ago and the practical use of these criteria can be found.

Procedure to derive Danish Eco SQC

The procedure used in Denmark to determine ecotoxicological soil quality criteria for anthropogenic compounds have previous been described in detail in Jensen & Folker-Hansen (1995) and Scott-Fordsmand and Jensen (2002). The evaluation is based on studies published in reports or reviews and articles in scientific journals. An exhaustive review of all the available literature was neither possible nor intended within the limits of the procedure. The approach uses No Observed Effects Concentrations (NOEC) or Effect Concentrations (EC_x) or LOEC (Lowest Observed Effect Concentration)) for soil dwelling organisms, including invertebrates, plants, microorganisms and microbial processes.
The ecological effects on vertebrate species living in and on the soil, e.g. mice, birds, cows and humans was not considered in this project, neither as a direct consequent of soil exposure or as secondary poisoning through e.g. ingesting of soil living invertebrates or plants. The protection of groundwater resources is another important environmental issue, which was not dealt with by these soil quality crite-

ria. The objectives of ecotoxicological based SQC are to protect the function and structure of the ecosystems involved against effects caused by pollutants. Ideally, adequate data for the effects of a compound should be obtained, alone and in combination with other compounds, on the ecosystem of interest - that is effects on the structure as well as the function of the ecosystem. As not all organisms and functions in an ecosystem can be tested against all possible compounds and combinations of these, extrapolation from simple laboratory tests to the ecosystems was attempted. The extrapolation models used for establishing SQC in Denmark was a simple factorial application method and a species sensitivity distribution based extrapolation method. Neither of the two methods was considered superior. Therefore in the few cases where enough data was available, both methods were conducted and the lowest out-put used.

The values calculated by the two methods should only be considered as estimates of a no effect concentration. The final soil quality criteria were always proposed after an expertise evaluation of the proposed PNECs in combination with information about the chemical fate and background level of the compound in question.

In cases where the assumptions for none of the extrapolation methods are fulfilled, a direct evaluation of the obtained data was carried out with the aim of estimating a no-effect level for the ecosystem. For metals several problems prevents the use of any known extrapolation method in finding a PNEC for an ecosystem. The fact that metals are natural occurring in a vary levels and are essential for organisms to a different degree may result in an overlap of essentiality and toxicity between species. Furthermore, a number of other considerations led to the conclusion that the two extrapolation methods were not applied to heavy metals in Denmark, e.g.

- the common practise to use soluble salts in experiments followed by immediate exposure of test organisms
- the complex binding of metals in soils
- the different routes of exposure
- the ability of some organisms to regulate metal uptake and excretion
- the ability of some organisms to adapt to increased soil concentrations

Instead the soil quality criteria was based on a direct evaluation of the lowest no-effect and effect-values reported for individual species, taking the fate, bioavailability, level of essentiality and background concentration of the metal in question into consideration before the recommendation of a soil quality criterion.

Practical use of Eco SQC in Denmark.

Practical use of Eco SQC has been limited in Denmark. Very little, if any, practical experience of the use of Eco SQC in connection to contaminated sites can be found. Risks to humans and groundwater are the main target of protection when evaluating the risk at contaminated sites. As a consequence of this no national accepted framework for assessing ecological risk of soil contamination is available, and hence in practical terms no site-specific assessment of ecological risk is performed. However, the municipalities often uses the Eco SQC when deciding whether or not excavated soil from contaminated sites or from soil remediation companies can be applied to agricultural land or other sensitive land uses. Furthermore, to some extend a few of the criteria was part of the data used for evaluating cut-off criteria for hazardous substances in sludge and intervention values for remediation of contaminated sites. The intervention values for remediation of contaminated sites will as a consequence of an amendment of the Act on Contaminated Soil be used as basis for decision of the mapping of Contaminated Sites according to the act.

Future developments

The human health based soil quality criteria has often been criticised to overestimate the bioavailability of the substances in soil. Danish EPA has in 2004 and 2005 financed the development of test methods. The general conclusion is that correction of soil cadmium and lead concentrations for relative bioaccessibility in evaluation of compliance with soil quality criteria and cleanup levels based upon reduced bioavailability/bioaccessibility of the contaminants may be recommended in site-specific risk approach. Conversely, the data available at present do not allow for general regulation of soil quality criteria and cleanup levels for specific contaminants, soil types or sources. One test can, with modifications, be used for measuring cadmium, lead and nickel bioaccessibility, and another, but similar, test for PAH. However for nickel and PAH, the bioaccessibilities can currently only be used for estimates of the relative risk associated with different soils.
Danish EPA will follow the international development in this field – but will as a consequence of the results above recommend that the methods only be used in special situations, for example where results from traditional methods are close to limit values.

References:

- Scott-Fordsmand, J.J. & Jensen, J. 2002: Ecotoxicological Soil Quality Criteria in Denmark. In: Posthuma, L., Suter, II, G.W. & Traas, T.P. (eds.): Species Sensitivity Distributions in Ecotoxicology. Lewis Publishers. pp. 275-282.
- Jensen, J., Kristensen, H.L., Scott-Fordsmand, J.J. & Bruus Pedersen, M. 1997: Soil Quality Criteria for Selected Compounds. Danish Environmental Protection Agency. - Working Report 83, 134 pp. Download from www.mst.dk.
- Jensen, John; Folker-Hansen, Pernille. 1995. Soil quality criteria for selected organic compounds. Danish Environmental Protection Agency. Working Report 47, 156 pp. Download from www.mst.dk.
- Scott-Fordsmand, Janeck J.; Pedersen, Marianne Bruus. 1995. Soil quality criteria for selected inorganic compounds. Danish Environmental Protection Agency. Working Report 48, 200 pp. Download from www.mst.dk.
- Principles for setting quality criteria for chemical substances in soil, air and drinking water to protect human health. Guideline No.5 (In Danish), Danish EPA, 2006

4.2 Groundwater screening values

Risk assessment of contaminated soil in relation to groundwater is integrated in the management of contaminated sites.

Assessing the risk of ground water contamination is based on calculations of contaminant transport by infiltration. The most significant factors in the calculations are as follows:

- The contamination scenario, i.e. type of substance (mobility/ degradability and other substance characteristics) as well as the contaminant concentration and area.
- Geology and hydrogeology, i.e. types of sediment (clay/sand/lime, organic content, hydraulic conductivity, effective porosity), net precipitation/ groundwater formation, groundwater gradient, pressure gradient between the secondary and the primary aquifer, as well as redox conditions.

The risk assessment is based on the principle that the groundwater zone containing the highest concentration must comply with the drinking water/ groundwater quality criteria.

Standards for groundwater that is or may be used for drinking water are based on drinking water standards.

There exist a tool (PC-based spreadsheet "JAGG") to carry out the calculations included in a risk assessment.

5 FINLAND

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5.1 Soil screening values

Legal framework

So far in Finland, the guideline values for soil issued in 1994 have been applied in the determination of the need for remediation and in the setting of remediation targets. These values were originally meant to be advisory only and not to act straightforwardly as remediation targets. The guideline values of some key contaminants (the most predominant at Finnish contaminated sites) were updated in 1997. In 1998 the preparation of a governmental decree was started based on these updated guideline values. The decree has been pending since this and the guideline values (SSLs) have been renewed during the process. The final version of the decree was released for comments on the 2nd of February 2006 and the finalized regulations are expected to be issued within 2006. The decree is based on the regulations given in the Environmental Protection Act which states that the Government can "by decree stipulate maximum permitted content of harmful substances in the soil…and on the maximum concentrations of harmful substances for the purpose of assessing level of contamination and need for treatment".
There are three categories of SSLs introduced in the forthcoming decree; a threshold value and a lower and an upper guideline value. According to the decree, the assessment of contamination and remediation need should be based on site-specific risk assessment, in which the lower and upper guideline values can be applied. In general, soil is considered as contaminated and risk reduction measures are required if the lower guideline value is exceeded. In the case of industrial or similar insensitive sites, the upper guideline value is applied. The threshold value is used as a trigger value. When the threshold value is exceeded, a site-specific assessment of contamination and remediation need has to be carried out. When all the measured concentrations are below threshold values, no further actions are required. The threshold value is also used as a criterion for relocation and reuse of excavated soil.

Scientific basis

The new SSLs are based on risk limits considering both the risks to human health and ecological risks. Risk limits have been derived using the Dutch methodology described in the latest publications of RIVM (e.g., Lijzen et al. 2001, Traas et al. 2001, Verbruggen et al. 2001), and the methodology of EU technical guidance documents on risk assessment of chemicals (ECB 2003). Risk limits have also been derived from the Finnish guideline values for drinking water and from the leaching limit values issued in the Council Decision 14473/02 by using equilibrium partitioning. Based on the calculated risk limits the lowest SSL (the threshold value) has been set to a concentration level, in which risks to humans and ecosystems can be considered negligible. Additionally, certain socio-economic values were taken into account in defining the threshold values. For naturally occurring substances the regional background concentrations are to be used as threshold values. The lower and upper guideline values are based on significant risks to human health or soil ecosystem (HC[5]50 values for microbial processes or terrestrial species). In the derivation of guideline values for metals, the median background concentration in Finnish moraine has been added to the HC50 values, when the guideline value is based on ecological risks. These background concentrations refer to mineral soil and data collected by the Geological Survey of Finland. The methodology to derive the threshold values and guideline values is presented in Fig. 1.

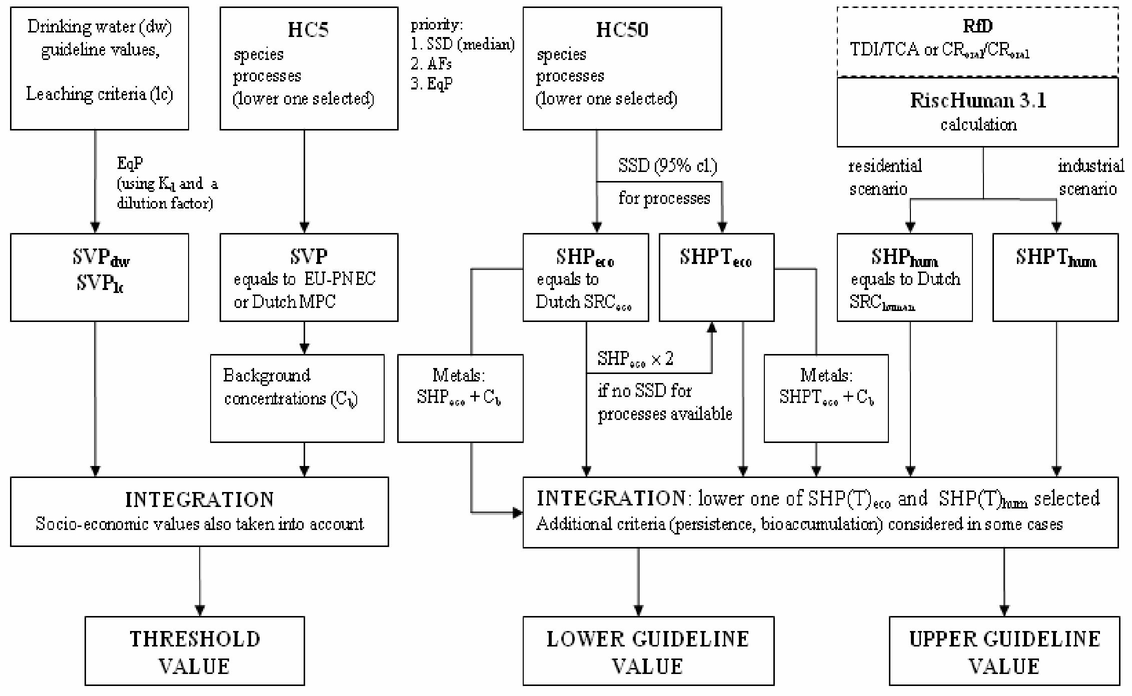

Figure 1. Scientific basis of the derivation of Finnish threshold values and lower and upper guideline values. SVP = Suurin Vaikutukseton Pitoisuus; maximum no-effect concentration, SHP(T) = Suurin Hyväksyttävä Pitoisuus (Teollisuusalueella); maximum acceptable concentration (in industrial area).

Technical approaches

Protected receptors

Protected receptors include humans and soil organisms (processes, species). Here in the scenario "residential area" (refers to the lower guideline values) associated with health risks both children (0-6 years) and adults have been considered. On the contrary, in the scenario "industrial area" (refers to the upper guideline values) only adults have been considered.

[5] HC = Hazardous Concentration, HC5/HC50 = Concentration which is expected to be safe for 95%/50% of all soil species and microbiological processes

Human health screening values

Conceptual model

The land use scenarios considered in the derivation of SSLs included the following:

- residential area (including cultivation of vegetables)
- industrial/commercial area

Following pathways of contaminants are included in the derivation of SSLs associated with human health risks:

- volatilization from soil
- dispersion of particles in air
- transfer from soil to plants (root intake, deposition)
- diffusion of contaminants from soil to domestic water through water pipes
- volatilization from domestic water

Migration of contaminants outside the contaminated site is excluded.
In the derivation of SSLs for residential areas (lower guideline values) following exposure routes were considered:

- soil ingestion
- inhalation (indoors and outdoors) of volatiles (from soil and contaminated domestic water) and particles (air dust)
- dermal exposure (indoors and outdoors)
- consumption of homegrown vegetables.

In the derivation of SSLs for industrial areas (upper guideline values) consumption of homegrown vegetables and use of domestic water were excluded as exposure routes. Furthermore, in both land use scenarios, following factors were excluded

- intake of contaminated groundwater located on the contaminated area
- background exposure associated with other sources
- sensitive receptors (e.g., children, women in child-bearing age)
- exposure related to recreational use of the surface water within the contaminated area (swimming, fishing etc.)
- exposure associated with agricultural activities, i.e., large-scale farming and breeding of cattle.

Exposure modeling

The software Risc-Human version 3.1. was used to derive SSLs for the land uses considered. Here, only the CSOIL model included in the software was applied. Modeling was complemented with separate soil-plant intake modeling using models described in EUSES and in the updated CSOIL model (Trapp and Matthies 1995).
The input parameters used in the calculations were selected so that they would present the average conditions at Finnish contaminated sites. Hence, particularly the northern climate and soil properties were considered.
In the case of a residential area, the exposure time was set to 70 years while in an industrial area 40 years was used as a default value. In both cases 70 years was used as the averaging period.

Toxicological assessment

No separate toxicological assessment was carried out. In the definition of risk estimates, both carcinogenic and non-carcinogenic effects were considered. The definition of non-carcinogenic risks was based on comparison of calculated daily doses with the TDI values described in Baars et al. (2001). The foundations of these benchmarks were not studied. In the case of carcinogenic response, comparison was made between the daily doses and CR (cancer risk) values, which refer to acceptable daily doses associated with 10^{-5} excess life-time cancer risk. CR values

were collected from Baars et al. (2001) or calculated from the SFs (slope factor) and URs (unit risk) given in the IRIS database.
Mixture effects were considered only in the case of known additivity i.e., in the case of PAHs (16), PCDDs+PCDFs+coplanar PCBs, DDT and it's degradation products (DDD, DDE), TBT+TPT, xylenes, isomers of chlorinated benzenes and phenols (based on the number of chlorine substituents) and PCBs (congeners 28, 52, 101, 118, 138, 153, 180).

Derivation of screening values

In the derivation of SSLs, HQ = 1 was used as an acceptable risk level. Hence, the SSLs corresponding this risk level were calculated using the exposure model described in chapter 1.3.2.2.

Ecological screening values

Conceptual model

The ecological SSLs are based on the same land use scenarios than SSLs referring to the risks to human health i.e., residential and industrial land use. Additionally, threshold values have been defined, which are based on expected negligible ecological risks. The receptors considered include soil processes (microbes), soil fauna, and plants. For certain contaminants bioaccumulation and biomagnifications in terrestrial fauna were used as additional criteria. No exposure modeling was performed to derive the SSLs.

Derivation of screening values

The ecological SSLs are based on HC5 values (threshold value) and HC50 values (lower and upper guideline values) derived using the Dutch methodology (Traas 2001) and toxicity data (NOECs) collected mainly by the Dutch RIVM (Crommentuijn et al. 1997a;1997b, Van de Plassche et al. 1992;1994, Verbruggen et al. 2001).
Data for soil species and microbial processes were treated separately. Toxicity data referring to aquatic species were used when toxicity data for terrestrial organisms were insufficient. Depending on the amount of data, different assessment factors have been used (based on ECB, 2003 and Verbruggen et al. 2001). In the case of metals, the added risk approach based on median Finnish background concentrations in moraine was used to derive ecological SSLs. To do this, the HC50 values based on risks to soil biota were added to the background concentrations. Threshold values for metals and certain organics (e.g., PAHs) are based on the upper estimate of the Finnish background concentrations (of natural and anthropogenic origin). The lower guideline value (residential areas) is equivalent to the median concentration in the SSD[6] curve (HC50) based on toxicity to soil species or microbiological processes. The upper guideline value (industrial areas) is based on the concentration equivalent to the upper confidence limit (95%) of the median in the SSD curve (HC50) representing toxicity to microbiological processes. When the derivation of a lower guideline value was based on the calculation of geometric mean of L(E)50 or NOEC values and the use of assessment factors (i.e., in the case insufficient toxicity data for statistical analysis), then the upper guideline value was set to HC50 x 2.

[6] SSD = Species Sensitivity Distribution

Integration of human health and ecological screening values

The lowest value (i.e., human health risk based limit value or HC50 based on ecological risks) was selected for each contaminant- or group-specific SSL (lower and upper guideline value). Additional criteria in the derivation of the combined SSLs included environmental fate of the contaminant (e.g., persistence and bioaccumulation). In the case of threshold values, the background concentrations and the risk limits derived from the guideline values for drinking water and from the leaching limit values were also taken into account. The consideration of additional criteria was based mainly on expert judgement, hence no systematic methodology was used.

Scientific, economic and social factors

In defining the threshold values, besides scientific evaluation (i.e. calculated risk limits), socio-economic factors were also considered. This was found as necessary since the threshold values are also to be used as criteria for relocation and reuse of excavated soil. Therefore the values should be both scientifically valid and practical (e.g., very low HC5-based values could impair present remediation practices and hinder the reuse of slightly contaminated soil).
Additionally, the definition of SSLs for 3 fractions (based on the number of carbon atoms: C5 – C10 , >C10 – C21 , >C21 – C40) of petroleum derived hydrocarbons did not follow the risk assessment procedure described above. Instead these SSLs are based on political decision on what is acceptable taking into account economic and environmental factors.

Comparison with monitoring concentration

All SSLs refer to "total" concentrations determined using concentrated acid (*aq regia* or HNO_3). For analysis of metals, samples have to be sieved (< 2 mm).

Scientific and practical weaknesses

The most important scientific and practical weaknesses associated with the SSLs include the following:

- Excluding the groundwater pathway for the lower and upper guideline values (migration and exposure);
- The limited toxicity data available, in particular the data on toxicity to terrestrial organisms; consequently, high safety factors and aquatic toxicity had to be used in order to derive the SSLs;
- The applicability of toxicity data to Finnish conditions was not studied;
- Different soil layers (top soil, deeper soil) were not separated, hence the SSLs refer to concentrations at any depth despite the different extent of exposure owing to the depth of contamination or existence of a surface cover (e.g. asphalt);
- In the selection of values for physico-chemical parameters, Finnish conditions have not been considered in detail;
- Bioavailability and biodegradability were not considered in the calculation of SSLs, also, the difference in the bioavailability of a substance originating from anthropogenic sources and occurring naturally (background) was not considered. Since the bioavailability was not taken into account in the calculation of risk levels, SSLs overestimate actual risks;
- Originally, the SSLs were not meant to be used as remediation targets. However, in practice in decision making, clear guidelines (= numeric values) to set these are expected;

- Excluding the threshold values, the SSLs are not meant to be used in the evaluation of the quality of excavated soil (i.e., the treatment and disposal options). In practice it is highly probable that they will be used for this purpose (based on the experience of the use of previous guideline and limit values). Hence, the link between the SSLs and the "waste character" should be clarified.

Future developments

It has been planned that the SSLs will be updated in the future, however, no specific dates have been set.

References

- Baars A., Theelen R., Janssen, P., Hesse, J., van Apeldoorn, Meijerink, M., Verdam, L. and Zeilmaker, M. (2001). *Re-evaluation of human-toxicological maximum permissible risk levels*. Report no. 711701025. National Institute of Public Health and the Environment (RIVM), Bilthoven, the Netherlands. 297p.
- Crommentuijn T, Polder MD, Van de Plassche EJ. 1997a. Maximum Permissible Concentrations and Negligible Concentrations for metals. Taking Background Concentrations into account. Bilthoven, National Institute of Public Health and the Environment (RIVM). Report no. 601501 001.
- Crommentuijn T, Kalf DF, Polder MD, Posthumus R, Van de Plassche EJ. 1997b. Maximum
- Permissible Concentrations and Negligible Concentrations for pesticides. Bilthoven,
- The Netherlands: National Institute of Public Health and the Environment (RIVM).
- Report no. 601501 002.
- ECB (2003). *Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC on Risk Assessment for new notified substances and Commission Regulation (EC) No 1488/94 on Risk Assessment for existing substances. Part II*. Office for official publications of the European communities, L – 2985, Luxembourg. 328p.
- Lijzen, J.P.A., Baars, A.J., Otte,P.F., Rikken, M.G.J., Swartjes, F.A., Verbruggeen, E.M.J. and van Wezel, A.P. 2001. *Technical Evaluation of the Intervention Values for Soil/sediment and Groundwater. Human and ecotoxicological risk assessment and derivation of risk limits for soil, aquatic sediment and groundwater*. Report no 711701 023. The National Institute of Public Health and the Environment (RIVM), Bilthoven. 147p.
- Traas, T. (2001). *Guidance document on deriving environmental risk limits*. Report no. 601501012. The National Institute of Public Health and the Environment (RIVM), Bilthoven, the Netherlands. 117p.
- Van de Plassche EJ, Polder MD, Canton JH. 1992. Maximum Permissible Concentrations for
- water, soil and sediment for nine trace metals. Bilthoven, The Netherlands: National
- Institute of Public Health and the Environment (RIVM). Report no. 679101 002.
- Van de Plassche EJ. 1994. Towards integrated environmental quality objectives for several
- compounds with a potential for secondary poisoning. Bilthoven, The Netherlands:

- National Institute of Public Health and the Environment (RIVM). Report no. 679101
- 012.
- Verbruggen, E., Posthumus, R. and van Wezel, A. (2001). *Ecotoxicological serious risk concentrations for soil, sediment and (Ground)water: updated proposals for first series of compounds*. Report no. 71170120. National Institute of Public Health and the Environment (RIVM), Bilthoven, the Netherlands. 263p.

5.2 Groundwater screening values

In Finland, no screening values exist for groundwater. In the case of groundwater pollution at contaminated sites, the quality standards for domestic water have usually been used in the assessment of the level of contamination and in setting the remediation targets. These standards are based on the guidelines issued by the World Health Organization (WHO). Sometimes, the background concentrations have been used for the same purpose. This has been the practice even if the groundwater has not been used for domestic water intake. Due to the implementation of the forthcoming Water Framework Directive, screening values will be developed. In this context, Finland is participating in the work of BRIDGE[7], which is focused on the creation of the methodology and producing data for the definition of priority contaminants and risk-based threshold values for groundwater.

[7] BRIDGE = Background cRiteria for the IDentification of Groundwater thrEsholds

6 FRANCE

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6.1 Soil screening values

Legal framework

The legal framework for the management of contaminated sites in France is mainly the 1976 Law on Classified Installations (Installations Classées pour la Protection de l'Environnement, ICPE: industrial or semi-industrial facilities listed in a national classification). For contaminated sites which are not related with Classified Installations, the 1975 Law on waste is also used.
The official procedures and tools for the assessment and the management of contaminated sites in France were developed in the frame of the regulation for Classified Installations. But they define a "state of the art" or a "state of good practices" which is also used as a reference outside of the regulation for Classified Installations.
Thus, in the frame of the regulation for Classified Installations, a "national policy" was introduced in 1993 (MFE, 1993). It included an inventory of the contaminated sites, and guidelines for the site investigation. Concerning the assessment of the site, it introduces a two-gear system for the use of the administration (MATE, 2000-2002):

1. Simplified risk assessment (*Evaluation Simplifiée des Risques*, ESR): through a scoring system, the ESR allows the ranking of the site in one of three categories: "to be considered as banal" ("*banalisable*"), "needing monitoring" ("*à surveiller*"), or "needing further assessment" ("*nécessitant des investigations approfondies"*).
2. Detailed risk assessment (*Evaluation Détaillées des Risques*, EDR): the EDR should provide a clear and precise knowledge of the site contamination and of the resulting risks for human health, water resource, and when relevant the ecosystems.

An "Instruction" from the Ministry in charge of the Environment to the local authorities (Circulaire, MATE, 1999) gives the principles for the elaboration of remediation goals for contaminated sites: This elaboration should be based on the estimate of the actual risks, obtained through the detailed risk assessment, and also on the technical and financial possibilities and the respective impacts of the different management alternatives. This principle is now accepted by the jurisprudence (TA Amiens, 2002). In that instruction, the excess risk of cancer due to the site generally accepted is 10^{-5}, but lower levels should be looked for, and higher levels, up to 10^{-4}, may be allowed when there is no technically feasible alternative at a bearable cost. For the threshold effects, the exposure due to the site plus the environment[8] should not reach the reference dose or concentration.
The simplified risk assessment (ESR) does not pretend to inform on the actual risks on the site: The scoring system does not allow such an information. Besides, some pathways, such as the inhalation of dust and vapour, and some types of sources, such as the groundwater sources, are not taken into account. The simplified risk assessment does not either directly determine the future management of a given

[8] In the praxis, the exposure due to the environment is very seldom taken into account. One reason is that the environmental exposure alone may be above the used reference dose or concentration for some compounds, for example cadmium or naphtalene, deending on the toxicological reference used.

site considered individually: it only brings a hierarchisation between the many contaminated sites, thus helping the authorities to set up their priorities and their demands. For example, the authorities can prescribe a detailed risk assessment even for a site ranked as "to be considered as banal" ("*banalisable*") in a ESR, if they consider that an estimate of the actual risks is needed (e.g. for a change of the site use towrds a sensitive use), or when the conceptual model taken into account in the ESR is not representative for the case. When there is no demand from the authorities, not an ESR is recommended, but the detailed risk assessment.

The methodology for the detailed risk assessment is described in a guideline of the French Ministry in charge of the Environment (MATE, 2000). No recommendation are made on which models should be used: there is no standard model in France, each actor chooses its own tools according to its needs and possibilities. Some guideline is provided by the reports and training sessions of the public Institute INERIS on transfers, models and software (e.g. INERIS 2002, INERIS 2005). The models used in the praxis are mainly US and Dutch models and/or software (RBCA, RISC, Johnson & Ettinger, CSOIL, VOLASOIL,…), often re-programmed on Excel-files, and sometimes with some developments (e.g. Hazebrouck *et al*., 2005).

The relevance of an ecological risk assessment is decided by the site manager or by the local authority (*Préfecture*, with the technical support of the DRIRE: *Direction Régionale pour l'Industrie, la Recherche et l'Environnement*), on a case by case basis, depending of the perceived interest/value of the local ecosystem. An important –but not exclusive- criteria for this appreciation can be the inclusion of the site in a registered natural area of interest for the ecology, the fauna and the flora (Zone *Naturelle d'Intérêt Écologique, Faunistique et Floristique*, ZNIEFF, being incorporated in the Natura 2000 areas).

In the simplified risk assessment (*Evaluation Simplifiée des Risques*, ESR), generic soil concentrations are used to set a score for the soil source ("*Valeurs de Définition de Source Sol*": VDSS: "soil source definition value") and a score for the impact on the surface soil ("*Valeurs de Constat d'impact*": VCI: "impact statement value"). The VCI are divided in values for a sensitive site use (playground, garden, …) and values for a non-sensitive use (industrial and commercial use, offices,…). It is explicitly specified (MATE, 2000, 200-2002) that the VDSS and VCI should not be used outside that scoring system of the ESR, and particularly not as screening values for the assessment of the actual risks or as remediation goals.

Thus this framework does not propose any soil screening value for the assessment of the actual risks or as remediation goals. Generic soil concentrations are used only in the frame of a scoring system which helps hierarchise the contaminated sites, but des not decide of the future of a site taken individually.

The model which was analysed by Frank Swartjes for CLARINET (France 2000, no name) is still in use at INERIS. It combines different modules taken from one or the other models (mainly US and Dutch). It is not diffused outside INERIS. Each consultant uses its own model or self-developed excel table, on a quite similar basis.

Scientific basis

At the beginning (1997), the priority was to get some values quickly for the ESR: values were taken from Dutch, Swedish, German lists. Afterwards, some French values were developed replacing or completing the foreign values.

The French values are based on a generic risk assessment with an adapted version of the Dutch CSOIL model (INERIS, 2001). The modelling choices were decided by a working group of the French Ministry of the Environment for the specific goal of the ESR, and not solely on scientific considerations.

The last values (MATE, 2002) are set as follows:

- VCI, sensitive use (in order of priority):
    - French values (residential scenario);
    - German "*Prüfwerte*" for a residential scenario
    - Dutch Intervention values of 1994
- VCI, non sensitive use (in order of priority):
    - French values, then German "*Prüfwerte*" (residential scenario)
    - Dutch Intervention values of 1994, multiplied by 5 for the trace elements, by 2 for the other compounds.
- VDSS: half the VCI for sensitive use.

Technical approaches

We present here only the French "own" VDSS and VCI. For the Dutch and German values, please refer to the documents of the respective countries.

Protected receptor

The protected receptor is the human being, adult for the industrial scenario, adult and child (< 6 years) for the residential scenario.

Human health screening values

Conceptual model

The source considered for the elaboration of the VCI is the contaminated upper soil layer (0-30 cm). Other environmental background exposure or pollution sources (e.g. contaminated groundwater) are not taken into account.
The following pathways are taken into account:

	Soil and dust ingestion	**Ingestion of own grown produce**	**Dermal absorption from soil and dust**
Residential scenario	X	X	X
Industrial scenario	X		X

Exposure modelling

The following exposure parameters are used:

		Unit	**Industrial scenario**	**Residential scenario**		
			Adults	**Adults**	**Children**	**Source**
Mean exposure time	Indoor	h/d	4, 220 d/y	14,3	19,5	Working group
	Outdoor		4, 220 d/y	3,3	4,5	
Exposure duration		years	40	24	6	Working group
Soil and dust ingestion rate		mg/d	50	50	150	HESP 2.1a confirmed with US EPA
Mean consumption of own grown produce		g/d fresh weight	-	135 (30,2%)	69,3 (29,1%)	French studies
Exposed skin area	Indoor	m^2	0,13	0,27	0,085	Working group, specific areas from HESP 2.1a
	Outdoor		0,21	0,27	0,085 [2]	

Toxicological assessment

The dose-response relationship is selected from different toxicological sources and-databases, including IRIS of the US EPA, HSDB, RIVM, ATSDR, UBA, WHO. The selection is based on the relevance and the quality of the values.
For the dermal absorption, an equivalent dose-response relationship is derived from the oral dose-response relationship using the respective absorption rates for ingestion and dermal contact.

Derivation of scoring values

The VCI are derived for each scenario and each compound independently (no addition of scenarios). The pathways considered are cumulated through the addition of the calculated hazard indexes on one hand and of the calculated excess risks of cancers on the other hand. The risk objectives are set at 1 for the hazard index and at 10^{-5} for the excess risk of cancer due to the site.

Modelling tools

The modelling tool is the HESP 2.1a model. The model was modified so as to use substance-specific dermal absorption rates and an own selection of bioconcentration factors, when available.
The soil type was set to a silt, defined as in HESP 2.1a, but with more organic matter (foc =3%). The soil type is involved in the modelling of the soil-to-plant transfer.

Ecological screening values

Not relevant: there are no ecological screening values.

Derivation of soil screening values

The French own VDSS and VCI are directly derived from the risk calculation. No correction with scientific, economic and social factors, or with monitoring concentrations, takes place.

Scientific and practical weaknesses

If the meaning of each individual value can be tracked back to its origin, as a whole the French VDSS and VCI have no signification outside the ranking process of the ESR:

- They are not related to a homogeneous risk assessment: major differences appear between the French "own" VCI, the "German" VCI" and the "Dutch" VCI, on the exposure scenario and modelling, and on the toxicological values. For example, vapour inhalation is considered only in the Dutch values, dust inhalation only in the Dutch and German values, the German soil ingestion rate for children is three times over the French and Dutch ones, the Dutch and German values are based exclusively on country-specific toxicological values.
- They are not related to a background level. The VDSS is defined as the half of a risk based value. Therefore, despite its name, it is not supposed to define a pollution source in a site characterization. This is illustrated with such

values as 2500 mg/kg for the total hydrocarbons (too high), or with 19 mg/kg for arsenic (too low for many places[9]).

The heterogeneity in the French scoring values does not allow a homogeneous rating of the sites: it introduces uncontrolled bias in the site hierarchisation. But the importance of the VDSS and VCI in the ranking, and of the ranking in the site management, is limited: the practical impact of this weakness in site management in France is thus also limited.

A much greater impact of this construction of the VDSS and VCI is linked to the absence of screening values for site assessment (outside the peculiar frame of the ESR) and for remediation goal setting: facing this void, the VDSS and VCI have often been misused in such a fonction, since they appeared in 1997, in spite of all the opposite warnings in the official guidelines. For example:

1. VDSS used to define a pollution source in a site characterization and to decide to launch a detailed risk assessment[10] or to do nothing (total hydrocarbons);
2. VDSS or VCI used as remediation goals, by site managers or also by local authorities;
3. VDSS or VCI used as acceptance criteria for soils in waste landfills;
4. More insidious effects occur, such as the reporting on maps or tables, exclusively of the concentrations above the VDSS or the VCI.

This leads to strong bias in site management, because the VDSS and VCI are not consistent with the detailed risk assessment: the French "own" VCI do not take into account the vapour pathways nor the background exposure, the German and Dutch toxicological values would not always be selected for a French HRA, the final risk objective for carcimogens is 10 times less conservative in the French and Dutch VCI than in remediation goal setting, etc.

A more systematic critic of the appliance of generic values in general has recently been developed (INERIS, 2004) and is generally accepted in France:

Impact of the variability in the use of generic risk based screening values:

1. If they are supposed to be protective of human health for all places over a country, generic screening values have to be elaborated through a conservative risk assessment taking into account the most conservatory parameter values relevant for the country, e.g.:
   - population parameters, such as the part of food consumption produced in the local garden: some families live mostly on their own production;
   - soil parameters, such as air permeability;
   - transfer parameters, such as bioconcentration factors (BCF).
2. For some pathways, even taken individually, this leads to unrealistic generic screening value: for example, for a farm scenario, an INERIS simulation based on a literature review of soil-plant bioconcentration factors, lead to health based generic screening values of 2.10^{-3} mg/kg arsenic and 3.10^{-2} mg/kg cadmium in soil, which is much lower than usual background concentrations in France. Other examples, although less striking, are obtained for other pathways and scenarios.
3. Therefore, operational generic screening values cannot pretend *per se* being protective of human health over a country. The alternatives are:

[9] The 2002-2002 guideline, appendix 5, specifies that the VDSS actually used in the ESR should be above the local backgound level, at least 5 times for the ubiquitious compounds and 2 times for the other compounds.

[10] In one case this was observed without any sign of contamination, due to one concentration (among 20) of one parameter (arsenic) above the VDSS.

a. To issue generic screening values high enough to be operational, with unlimited use, and accept that in some cases they will not be protective: this is the case e.g. with the intervention values in the Dutch and Flemish policies;
b. To issue worst-case generic screening values for different scenarios, sometimes too low to be operational, and to refer to specific site assessment for higher , more operational values;
c. To issue no generic screening values at all, and to refer to specific site assessment. This is the current French policy;
d. To issue generic screening values high enough to be operational, but linked to restrictions on the site scenario and parameters: before using them, one would have to check that the effective site conditions comply with the generic scenario. This could be an operational and scientifically sound compromise.

Impact of uncertainties in the use of generic risk based screening values:

Current transfer models still present major uncertainties, estimated for example at two orders of magnitude for soil-air to indoor air models, for soil-plant bioconcentration factors or for dermal transfer. Consequences are not always drawn in term of security factors. It is often said that current models are over conservative. But this is not established. The same was also said in the 1990s, when the CSOIL model (van den Berg, 1994) was used for the vapour transfer, until it was realised that one major vapour transfer phenomenon (convection transport) was not taken into account in that model, and the model was consequently updated (Waitz *et al.*, 1996). In an intensive verification experiment, Hulot *et al*. (2003) also got a direct indication that current vapour models are not always conservative, in a field experiment with soil-air to indoor air transfer.

Deciding more or less protective approaches:

The technical experts are not legitimate for choosing between more or less protective approaches of generic screening values when facing the variability and the uncertainties: an important part of political decision is unavoidable, which should include all stakeholders. This stakeholders' involvement is seldom seen currently: with current generic systems in Europe, some "unacceptable risk" is statistically accepted for some populations on contaminated sites without their knowledge. The stakeholders' involvement requires a comprehensive understanding, and then explanation, of the tools that are used in the site assessment, including of the rationale and the limits of the different available alternatives. This represents a major work. For more efficiency , this work could be shared at an European level. Therefore, it is recommended to:

- gather and develop further, at an European level, the knowledge and the tools for site assessment;
- harmonise the practices at an European level (for more consistency and equity);
- develop stakeholders' involvement in the decisions for contaminated sites.

Developing the stakeholders' involvement may be helped by guidelines and concertation tools. Several R&D projects are currently running in France in that view, involving public institutes such as InVS, INERIS, ADEME, IRSN.

Future developments

In April 2004, the French Ministry for the environment communicated its decision to suppress soon those values, because of the wide misunderstanding of their use in the country. The suppression has not been effective yet, but a working group is currently elaborating a new alternative system, which will redefine the whole set of procedures and tools for contaminated site management. A draft of the overview document was put on consultation on the 30th June 2006 (MEDD, 2006). That system will propose a standard human exposure model (from the exposure media to the human being) including values for human exposure parameters, but no transfer model (from one medium to the other) nor soil screening values.

References

- Hazebrouck B., Hulot C., Gay G. Vapour emissions from contaminated soils into buildings: developments of the volasoil model for a multilayer soil. Consoil 2005 (poster) : proceedings of the 9th international FZK/TNO conference on soil-water systems, 3-7 october 2005, Bordeaux, France. Karlsruhe : Forschungszentrum Karlsruhe, 2005. Also on www.ineris.fr.
- Hulot C., Hazebrouck B., Gay G., Malherbe L., Pokryszka Z., 2003. Vapour emissions from contaminated soils into buildings: comparison between predictions from transport models and field measurements. Consoil 2003. Updated Version 14 mai 2003. www.ineris.fr.
- INERIS, 2001. Méthode de calcul des Valeurs de Constat d'Impact dans les sols. MATE. INERIS DRC-01-25587/DESP-R01. R. Bonnard, C. Hulot, S. Lévèque. Novembre 2001. http://www.ineris.fr
- INERIS, 2002. Evaluation Détaillée des Risques pour la santé. Fiches techniques de présentation des modèles d'exposition aux sols pollués. HESP (Human Exposure to Soil Pollutants). Ministère de l'Ecologie et du Développement Durable. G. HEUZÉ. Octobre 2002. INERIS-DRC-02-41200/DESP-R30a. www.ineris.fr.
- INERIS, 2004. Retour d'expérience sur la gestion des sites pollués (et des Installations Classées) en France. Réflexion sur les VDSS et les VCI-sols, et les outils d'évaluation des sites pollués: Evaluation et besoins. Rapport projet. Ministère de l'Ecologie et du Développement Durable. Benoît Hazebrouck. INERIS DRC-04-57278-DESP/R04a. 19 août 2004. Powerpoint presentation on www.ineris.fr.
- INERIS, 2005. Etude des modèles d'évaluation de l'exposition et des risques liés aux sols pollués. Transfer de vapeur du sous-sol ou du vide sanitaire vers l'air intérieur. B. Hazebrouck. N° INERIS DRC-05-57278-DESP/R03a. 15/04/2005. www.ineris.fr. (concerns the vapour transfer from a basement into the indoor air).
- MATE, 1993: Ministère Français de l'Environnement: circulaire du 3/12/1993 relative à la "politique de réhabilitation et de traitement des sites et sols pollués".
- MATE, 1999. Circulaire du Ministère de l'Aménagement du Territoire et de l'Environnement portant sur les principes de fixation des objectifs de réhabilitation pour les sites et sols pollués, datée du 10 décembre 1999
- MATE, 2000. Ministère Français de l'Environnement. Gestion des sites pollués : Diagnostic approfondi – Evaluation détaillée des risques. Version 0. BRGM Editions. Juin 2000.
- MATE, 2000-2002: Ministère Français de l'Environnement. Gestion des sites (potentiellement) contaminés. La visite préliminaire - Le Diagnostic initial – L'évaluation simplifiée des risques. Version 2. BRGM Editions. Mars 2000. Annexe 5 de décembre 2002.

- MEDD, 2006. Consultation letter: "Politique nationale en matière de sols pollués". DPPPR. Ref. BPSR/2006-186/DG. The documents on consultation can be found on the internet site of the Ministry in charge of the Environment: www.sites-pollues.ecologie.gouv.fr
- TA Amiens, 2002. Tribunal Administratif d'Amiens Affaire N° 96450. Société Prosign C/ Préfet de l'Oise. 22 janvier 2002.
- van den Berg R. (1994) Human exposure to soil contamination : a qualitative and quantitative analysis towards proposals for human toxicological intervention values (partly revised edition). National Institute of Public Health and Environmental Protection (Rijkinstituut Voor Volksgezonheid en milieu), Bilthoven, The Netherlands. Report 755201011. April 1991/January 1994
- Waitz *et al.*, 1996. The VOLASOIL risk assessment model based on CSOIL for soils contaminated with volatile compounds. M.F.W. Waitz; J.I. Freijer; F.A. Swartjes. May 1996. RIVM. Report n° 75810014. http://www.rivm.nl/bibliotheek/rapporten/715810014.pdf

6.2 Groundwater screening values

Legal framework

In the frame of the Simplified Risk Assessment (ESR, see § 0), as for soil, some groundwater generic concentrations, "*Valeurs de Constat d'impact*" (VCI) are used to rank the impact of the soil contamination on the groundwater.
Besides, the use of the French regulatory limits for drinking water (*Décret* 2001, now[11] *Code de la Santé Publique, Livre III, titre II, section 1*) is considered by the Ministry for the Environment as an adequate groundwater reference for acceptable concentrations. This practice was officially advised in a "Circular" by the Ministry in charge of the Environment (MEDD, 2004). But this circular has not a fully legal or regulatory status. No document with fully legal or regulatory status recommends any screening values for groundwater.
In the praxis, when there is no French regulatory limits for drinking water, the values from the Drinking Water of the World Health Organisation (WHO, 1993-1998), are also accepted by the local authorities.

Scientific basis and technical approach

The "*Valeurs de Constat d'Impact*" (VCI) for the groundwater are set as follows (MATE, 2000-2002):

- For sensitive groundwater use (in order of priority):
  - French regulatory limits for drinking water (*Décret* 2001);
  - Drinking Water Guidelines of the World Health Organisation (WHO, 1993-1998).
- For non sensitive groundwater use: Values for sensitive groundwater use, multiplied by 5 for the trace elements, by 2 for the other compounds.

Thus the VCI for sensitive groundwater use, applicable in the restricted frame of the ESR on the one hand, and the drinking water limits used as screening values in broader contexts on the other hand, are fully consistent.

[11] Only the value for baryum has been changed, through the *Décret* 2004-802 of the 29th July 2004 (art.8).

The *Décret* 2001 is the French transcription of the Drinking Water Quality EU Directive 98/83/EC (INERIS, 2006). The values of that Directive 98/83/EC were set by the European Commission, taking into account, among others:

- Former EU regulatory limits for drinking water (Directive 80/778);
- Drinking Water Guidelines of the World Health Organisation (WHO, 1993-1998).
- The opinion of the Scientific Committee on Health and Environmental Risks: this consultative Committee attached to the European Commission takes into account the available scientific knowledge, the precaution principle, the technical capacities regarding water treatment and analysis, and social and economic considerations.

The WHO Guidelines for drinking water are based on human risk assessment (HRA) and also on questions of taste and color, for the use as drinking water solely (WHO, 1993-1998). For the HRA, a source contribution factor (often 10% or 20%, for example 20% for Barium) is often considered in the value for non carcinogen effects. This accounts for other pathways for the component considered. A goal of an incremental risk 10^{-5} is used for carcinogens (for drinking water, *i.e*. with a source contribution factor of 100%). A all-source hazard quotient of 1 is considered for non carcinogen effects.

Scientific and practical weaknesses

For some compounds, such as arsenic, the WHO Guidelines for drinking water could not be based on human risk assessment due to analytical limits: the value was set up to the current analytical detection limit.

It has not been demonstrated that the regulatory limits for drinking water indicate negligible risk for other scenarios than water ingestion, for example vapour transfer or transfer to produce through watering. But:

- The modelling of those other pathways is quite uncertain (especially transfer to produce);
- Modelling results on some compounds have confirmed the assumption for vapour transfer. The assumption of negligible risk seems reasonable for transfer to produce through watering, where lot of contaminant dilution (in the soil) takes place;
- On a practical point of view, it seems consequent to accept the exposure to groundwater at a contamination level which is allowed for tap water (in case of a site contamination: this is not a right to pollute).

Future developments

No specific future developments are planned.

References

- Décret no 2001-1220 du 20 décembre 2001 relatif aux eaux destinées à la consommation humaine, à l'exclusion des eaux minérales naturelles. Annexe I-1. Limites de qualité des eaux destinées à la consommation humaine.
- INERIS, 2006. Synthèse des valeurs réglementaires pour les substances chimiques, en vigueur dans l'eau, l'air et les denrées alimentaires en France au 1er mars 2006. INERIS-DRC-06-75999 /DESP-R2a. Adeline Barnaud. June 2006.
- MEDD, 2004. Circulaire du 25 octobre 2004 sur le Plan National Santé-Environnement (PNSE). Ministère de l'Ecologie et du Développement Durable.
- WHO, 1993-1998. Guidelines for drinking water quality. Second Edition. Volume 1. Recommendations et Addendum to Volume 1. WHO.

7 GERMANY

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7.1 Soil values

Legal Background: The Federal Soil Protection Act

Scope of the Federal Soil Protection Act

The Federal Soil Protection Act came into force in March 1998, the accompanying sublegal regulations in July 1999.
The act integrates both aspects of soil protection: the prevention and the remediation.
The basic idea of the act is the protection from harmful changes of the soil. Such harmful changes are given

- if the soil functions are impaired <u>and</u>
- if this leads to danger, to considerable drawbacks or nuisance for individual persons or for the general public.

The soil has functions as

- living basis and living space for human beings, animals, plants and soil organisms,
- component of the ecosystem with its water and nutrient cycles,
- media of decomposition, compensation and composition particularly in regard to the protection of groundwater,
- archives of the natural and cultural history,
- reservoir of raw materials,
- area for settlement and recreation,
- site for agricultural and silvicultural use,
- site for other economic and public uses, traffic, supply and disposal.

The act is to aim at

- maintaining the soil in its functional variety,
- taking preventive action against harmful changes,
- warding off damaging changes of the soil,
- preventing that damages, which have already occurred, have any effects on people and the environment and
- eliminating or reducing these damages.

Theses aims shall be reached by the following duties:

- Everyone has to act in such a way that harmful changes of the soil do not occur.
- Site owners are obliged to take measures to avert harmful changes of the soil.
- Existing harmful changes of the soil as well as groundwater pollution which is caused by harmful changes of the soil must be repaired as far as possible and reasonable. This duty applies to the polluter as well as to the site owner. The remediation has to be carried out so far that for a long time the remaining substances will cause no hazards. If a remediation is not possible or reasonable, al least the effects of the harmful changes to human beings or to the environment have to be prevented or reduced.
- Preventive action has to be taken if future harmful changes are suspected.

With the two terms „harmful changes of the soil‟ and „contaminated sites‟ the act on soil protection covers all burdens of the soil, which cause hazards for human beings and the environment.
Contaminated sites are

- abandoned waste disposal sites (closed-down waste disposal plants or other estates on which wastes have been treated, stored or disposed) and
- abandoned industrial sites (estates of closed-down plants or other estates on which environmentally hazardous substances have been handled),

which cause harmful changes of the soil or other hazards for the individual or for the general public.
Contaminated sites impose particular dangers. Therefore additional stipulations are provided for this field:

- If it is necessary, the authorities may require a remediation plan by those responsible if a site is recognized as contaminated. This plan has to cover the results of the risk assessment and the prospective remedial actions.
- Acceptance of remediation projects will be increased by information of the public about the remediation plans.

Assessment Criteria

The act on soil protection provides three categories of assessment criteria in form of soil levels:

- "action levels‟ indicating as a rule a hazard which has to be warded off; further investigations to ascertain the hazard are usually not necessary;
- "trigger levels‟ triggering further investigations to ascertain (verify/falsify) whether the pollution of the soil implies a hazard;
- "precaution levels‟ indicating a certain chance of future soil problems which need to be addressed in order to avert upcoming damages.

The action levels and the trigger levels are related to the use of the respective site. The decision whether the soil contamination implies a hazard (or does not) has to take into account how the site is actually used and what future use can reasonably be expected.
The action levels and the trigger levels are risk-based. Assessing the risks of all theoretically thinkable exposure pathways produces increasing uncertainties and therefore the probability of artificial results. On these grounds it is most likely that the generation of soil levels has to narrow down full scale exposure assessment to selected, characteristic and simplified exposure scenarios, such as the exposure by oral uptake of children playing outdoors.
Soil levels focusing on public health and on ecotoxicological risks are not compiled in a single level. As soil levels differ depending on what kind of risk is considered, integrated soil levels seem most likely to under- or overestimate the actual risk a contamination may pose to a use.
Whenever feasible, action levels should rely on bioavailable soil concentrations in order to figure out a realistic worst case of exposure.
Concentrations of hazardous substances in the ground

- which exceed the action levels usually lead to a remedial action; "usually‟ means that in some cases another conclusion could be justified, if for example the derivation of the levels is based on assumptions that are wrong in the specific case,
- which exceed the trigger levels lead to an examination with a final conclusion by the competent authority, whether a remediation is necessary or is not; the examination has then to take into account the type of soil, the mobility of the hazardous substances and other specific circumstances;
- which are below the trigger levels, relief the site of the suspicion to be hazardous.

Methods for sampling and analyzing are defined together with the soil levels.

Derivation methods of Soil Trigger Levels for the Protection of Human Health

Soil Trigger Levels:

Levels triggering further investigation in order to verify whether there is a contaminated site (whether there is a dangerous concentration of hazardous substances).

<u>Note:</u> Trigger levels are <u>not</u> fill-up levels and <u>not</u> hazard indicating levels.
If a trigger level is exceeded, an investigation is necessary whether the unfavorable circumstances, which were used to derive the levels, are given in that special case.

Two pathways are taken into consideration:

- the uptake of contaminated soil by playing children and
- the inhalation of soil particles.

The evaluation of hazards has to take into account

- the hazardous substances coming from the soil and
- the exposition to hazardous substances coming from other media (food, water).

Proceeding

toxicological data
↓
exposure factors (unfavorable circumstances)
↓
calculating
↓
plausibility check
↓
recommendation of trigger levels

Toxicological Basis

- For carcinogenic substances an additional lifetime cancer risk of 10^{-5} is regarded as tolerable (in accordance with WHO).
- Substance specific toxicological data defining a tolerable body dose (D_{tb}) are used.

D_{tb} levels are equivalent to a "no observed adverse effect level" in sensitive human subpopulations (like NOAEL). The D_{tb} level was usually derived from the LOAEL (lowest observed adverse effect level) from animal tests by using specific uncertainty factors (1 to 10 depending on the level of uncertainty).
The trigger levels are defined as related to risk. Therefore a risk level was needed lying between the D_{tb} level (no risk) and the LOAEL level (damage). This level was found by multiplying the D_{tb} with a risk connecting factor (f_{rc}), i.e. the square root of the previously used uncertainty factors.

← lower level											higher level →

D_{tb} (NOAEL)← ← ← ← ← factors ← ← ← ← LOAEL

D_{tb} → → $f_{rc} = \sqrt{factors}$ → → risk level

For carcinogens a risk connecting factor f_{rc} = 5 was chosen.
It is assumed that already a rate of 80 % of the tolerable ingestion of non carcinogenic hazardous substances comes through other pathways (food, drinking water). The dose connected with risk is therefore:

$D_{tb} * f_{rc} – D_{tb} * 0.8 = D_{tb} * (f_{rc} – 0.8)$ (oral pathway)

$D_{tb} * f_{rc}$ (inhalative pathway)

with $f_{rc} = \sqrt{factors}$

D_{tb} -Levels and Risk Connecting Factors

substance	oral uptake				inhalative uptake			
	D_{tb} level [ng/kg*d]		f_{rc}		D_{tb} level [ng/m^3]		f_{rc}	
	non carc.	carc.	non carc.	Carc.	Non carc.	carc.	non carc.	carc.
Aldrin	80	0.59	10	5	200	1.2	3.2	5
arsenic	300	5.60	1.7	5	33	0.514	10	5
B(a)P		1.40		5		0.04		5
lead	2,000		2					
cadmium	500		1.4		10	0.229	10	5
chromium	5,000		10		14	0.229	3.2	5
DDT	1,000	33	10	5		30		5
HCB	30	6	5.5	5		6.3		5
HCH (tot.)	20	6	10	5	5	5.7	10	5
nickel	1,333		10		2.86	11.4	10	5
PCB (6)	15	1.30	5.5	5		2.37		5
mercury (a)	214		4.5		37.5		7.1	
mercury (o)	50		3.9					
PCDD/F	$1*10^{-3}$	$6,7*10^{-5}$	3.2	5		$6*10^{-5}$		5

Exposure Factors

- For children's playgrounds, residential areas and parks the exposure scenarios "soil ingestion" and „dust inhalation" are used.
- For industrial sites the exposure scenario "soil/dust inhalation" is used.

Carcinogens:

The risk of 10^{-5} is connected with a lifetime exposure (70 years). It is assumed that the time for the uptake of soil is only 8 years. Therefore a factor of 8.75 (70a/8a) is used.

Daily Intake Rates:

- children's playgrounds: 10 kg body weight
  0.5 g/d soil ingestion
  0.625 m^3/h respiration
  frequency: 240 d/year (2 h/d)
  ➔ daily ingestion rate : 33 mg/ kg BW * d
  ➔ daily inhalation rate: 0.082 mg/ kg BW * d

- residential areas: ➔ daily ingestion rate : 16.5 mg/ kg * d
  (factor 1/2) ➔ daily inhalation rate: 0.041 mg/ kg BW * d

- parks and recreation: ➔ daily ingestion rate : 6.6 mg/ kg * d
  (factor 1/5) ➔ daily inhalation rate: 0.016 mg/ kg BW * d

- industrial areas: working time: 8 h/d, 5 d/w, 45 w/y, 40a
  reduction through wetness, factor: 1/3

Accumulation Factor (AF):

It is assumed that hazardous substances are accumulated in the dust with a factor 5 (for inorganic substances) and a factor 10 (for organic substances).

Calculation for Playgrounds, Residential Areas and Parks

Formulae for Calculating Trigger Levels (TL)

1. oral ingestion, non carcinogens

$$TL = \frac{D_{tb} * (f_{rc} - 0.8)}{\text{daily ingestion rate of soil}}$$

2. oral ingestion, carcinogens

$$TL = \frac{D_{tb} * f_{rc} * 8.75}{\text{daily ingestion rate of soil}}$$

3. inhalation, non carcinogens

$$TL = \frac{D_{tb} * f_{rc}}{\text{daily inhalation rate of dust * AF}}$$

4. inhalation, carcinogens

$$TL = \frac{D_{tb} * f_{rc} * 8.75}{\text{daily inhalation rate of dust * AF}}$$

Calculation for Industrial Areas

$$TL = \frac{D_{tb} * f_{rc} * Z}{DC * AF}$$

with DC (dust concentration in the air) = 0.325 mg/m^3

$$Z = \frac{365\ d/a * 24\ h/d}{45\ w/a * 5\ d/w * 8\ h/d * 1/3} = 14.6 \quad \text{(for non carcinogens)}$$

$$Z = \frac{70\ a * 365\ d/a * 24\ h/d}{40\ a * 45\ w/a * 5\ d/w * 8\ h/d * 1/3} = 25.6 \quad \text{(for carcinogens)}$$

Scientific and practical weaknesses

Although in some cases the trigger levels are mixed with the consequences of the action levels or are taken as remediation targets, the general acceptance of the concept and the levels is high in practice.

Future developments

The Federal Soil Protection Ordinance will be revised in 2007.
The methodology of derivation for the pathway: soil - human beings (direct contact) will not be changed, the list of relevant substances however might change.

7.2 Groundwater Values

Legal framework

Insignificance thresholds

Groundwater can be classified as uncontaminated or "changed in its chemical status to only an insignificant extent" (uncontaminated in a legal sense) according to the Groundwater Ordinance if, despite an increase in substance concentration compared to regional background values,

- no relevant ecotoxicological effects occur and if, in addition,
- the demands of the Drinking Water Ordinance or values derived accordingly are met.

To describe concentration values that meet these conditions, the term "insignificance threshold" is used. With insignificance thresholds it is not intended to set a quality goal for groundwater, but rather that a groundwater status be maintained that is largely unaffected by human activity.
Where regional geogenic background values in groundwater transgress insignificance thresholds, the authorities responsible for these regions can lay down values in exceptional cases that, at most, may correspond with such regional concentrations.

Scientific basis

The derivation of these Insignificance Thresholds is based on toxicological (drinking water) and ecotoxicological standards and takes into account background concentrations.

Technical approaches

The Insignificance Thresholds are primarily used to assess the groundwater quality. They can also be the basis for the assessment of waste recycling and the use of products.

Scientific and practical weaknesses

Future developments

The next step is the harmonisation of the Groundwater Insignificance Thresholds with the values in other environmental areas (waste, soil), which might have influence on the groundwater quality.

8 ITALY

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8.1 Soil screening values

Legal Framework

A Ministerial Decree concerning soil contamination has been in force in Italy since 1999.
As a matter of fact, specific regulations and/or guidelines had been issued in some Italian Regions since the early nineties. These regulations/guidelines were defined on the base of the "threshold value" criterion. These threshold values, in turn, made reference to the regulations of other European countries (Holland, for instance)
The issue on February 5th 1997 of Legislative Decree no. 22, concerning waste management, laid the basis for discussion about assessment criteria, on a national scale, for the management of contaminated soils as well as for the adoption of technical and administrative procedures for remedial actions. In fact, a specific article of the Decree (art. 17) states that *"A site must be considered polluted when the concentration of contaminants exceeds the limit values"*. Therefore the definition of contaminated soils arises from the adoption of the criterion of "threshold value/concentration limit value". As a result, a subsequent Ministerial Decree was entrusted with the fixing of concentration limit values.
This regulation was issued in 1999, on October 25th, through D.M. no. 471 consisting of 18 articles and 5 enclosures. The aims of the regulation are as follows:

- to provide the definitions of polluted site, potentially polluted site, safety measures in case of emergency, remediation, remediation with safety measures, environmental recovery, permanent safety measures and widespread pollution;
- to establish criteria and administrative procedures for undertaking remedial actions and define the monitoring operations that have to be carried out by both private and public bodies;
- to set the acceptability limits for contamination of soils, surface waters and ground waters; to define the protocols for chemical analyses of soil and water samples; to provide strategies for remedial actions for soil and ground water by bioremediation approaches;
- to define guidelines for risk analysis.

In May 2006 a new regulatory provision was issued on contaminated sites that partly amends the D.M. no. 471. This new regulatory provision was not definitely approved at the time of writing this chapter, and therefore only mentioned but not fully considered in the following text.
As previously mentioned, the basic concept of defining the "contaminated site" refers to the exceeding of the concentration limit in two environmental compartments: soil and groundwater.
If just one of the pollutants considered exceeds its limit value in soils and/or ground waters, the site is "polluted" and the landowner must carry out remedial action (a 10% tolerance-standard deviation is accepted).
If the pollutant concentration in the soil around the site exceeds the limit concentration reported in enclosure 1, the site tenant must carry out remedial action to achieve the concentration of the natural background.

Limit values have not been defined for surface waters. In this case a set of criteria were adopted to assess possible contamination, such as:

- comparison between upstream and downstream concentrations in waters;
- if one or more pollutants are found only in the downstream waters, the acceptable limit value is that reported in the law in force regulating the quality of surface waters; this is intended to assure proper use of the water;
- if the contamination concerns very persistent and bioaccumulating substances, the load in the receptor body has to be assessed;
- in order to validate the cumulative effects, "Extended Biotic Index" analyses also have to be made and the sediments in contact with the contaminated surface waters must also be sampled and analysed.

The "concentration limits" should also be regarded as remediation targets. When they cannot be achieved either by applying the best available technologies at reasonable costs, remedial interventions and environmental recovery with safety measures may be authorized. The residual acceptable concentration values are determined by site-specific risk analysis methodology. This, nevertheless, must follow the guidelines given in the decree. If the safety measures require temporary or permanent limitations, or special conditions to use the area (i.e. survey, monitoring, etc.) these conditions or limitations have to be reported on cadastral and planning documents.

Scientific basis

The concentration limit values for 100 substances listed in the decree have been derived on the basis of health protection criteria. The most toxic, persistent and bioaccumulable substances have been selected from among the more recurrent substances present in contaminated soils due to different causes such as pouring, waste disposal, accidents, etc.

In order to identify the concentration limit value according to the soil use (house/public park use and commercial/industrial use), the "worst case" method has been chosen : the "target", i.e. man, is assumed to be exposed to the specific substance, through all exposure routes (inhalation, ingestion, skin contact) for the longest allowable exposure time. In order to assess the acceptability of the risk as calculated above, the following reference criteria were used:

- an incremental carcinogenic risk of 1×10^{-6} was considered acceptable;
- for non-carcinogenic substances the Hazard Index, expressed as the ratio between the dose introduced into the environment and the reference dose, was considered. This Hazard Index must be < 1.

Technical approaches

Protected receptors

With regard to human receptors, special attention was paid to children; with regard to the environment, waters were considered as a valuable resource to be preserved.

Human health screening values

Conceptual model

To obtain the screening value (Regulatory limits in Italian Decree no. 471/1999) a General Conceptual Model was utilized, taking into account the following premises:

- topsoil, subsoil and groundwater were considered as contamination sources;
- a generic soil with organic carbon 1% and clay 10 %;
- a multiple exposure scenario (for the soil: vapour and dust inhalation, ingestion and skin contact; for the groundwater: ingestion, skin contact and vapour inhalation);
- the risk of leaching into the groundwater was also considered.

Exposure modelling

As mentioned above, in order to determine the concentration limit values given in the Decree, a multiple exposure scenario (inhalation, ingestion, skin contact for the soil and groundwater), was used.
Specific standards were also used: A.S.T.M. E 1739 – PS 104 standards, apply the so-called "RBCA, Risk – Based Corrective Action" procedure.

Toxicological assessment

The following toxicological characteristics were considered:

- European Substance Classification or U.S.E.P.A. or I.A.R.C. classification;
- For non-threshold contaminants, Slope Factor, for inhalation, ingestion, skin contact;
- For threshold contaminants, Reference Doses (RfD), for inhalation, ingestion, skin contact;
- NOAEL, only when RfD are not available.

Derivation of screening values

The screening values determined as mentioned in para. 1.2. are both "intervention" values, and "remediation target" values. Therefore, if only one parameter exceeds the limits, the remediation action is compulsory in order to bring the contaminant concentration in soil to below the limit values.
If toxic substances for which no limit concentrations are provided by the decree are present, a concentration limit can be determined *ad hoc* by relying on the "toxicological affinity" criterion. Assessment will then be done referring to the substance on the list having toxicological properties and environmental behaviour similar to those of the contaminant concerned.
This assessment was carried out by the National Health Institute, a national health research organization, and limit concentrations for 163 substances, in addition to the list of 94 chemicals already included in the Decree, have been determined. Nevertheless, these limit values are not in force yet, since specific national regulations have not been issued. Therefore these values are only a "reference limit concentration".

Derivation of soil screening values

Integration of human health and ecological screening values

The screening values worked out on a national scale were determined by taking into account only the human health protection concept, omitting any consideration of ecological risk.

Scientific, economic and social factors

The Italian soil screening values so defined are very conservative, therefore they are restrictive and protective for the human health. The achievement of these values as a remediation target can be rather heavy for the landowner who must engage in cleaning up the site. Only in this case will it be possible to resort to the site-specific risk assessment, in order to evaluate the acceptability of a possible residual contaminant concentration when this exceeds the soil screening values established in the Decree. In this case, the soil uses have to be restricted and monitoring activities are enforced. However, this arrangement is considered too onerous by Italian firms.

Comparison with monitoring concentration

The decree also indicates how to carry out the site characterization. The soil chemical analysis is carried out on the fine fraction (ø < 2 mm), the value is related to the dry soil and expressed in mg/Kg. Correction regarding the soil contents of organic substances is not considered.

Scientific and practical weaknesses

Six years after the issue and enforcement of the Decree, it can be criticized both scientifically and practically, because it lacks flexibility and does not take sufficient account of regional and local specificities.

Future developments

In Italy at present other Decrees on environmental matters are being drawn up, mainly concerning soil pollution and soil clean-up. These future regulations will resort more to site-specific risk analysis. Soil screening values will be reported and, where they are exceeded, a more in-depth study of the site will be made, as well as a risk analysis evaluation. So, the "remediation target concentration values" will be determined in order to evaluate the advisability of intervention with clean-up: this necessity must be evaluated through a site-specific risk analysis.

References

- Italian Ministry of Environment, 1999. Technical Regulation on Cleanup and Environmental Recovery of Contaminated Sites according to art. 17 of Law No. 22/97. Italian Ministerial Decree No. 471/1999, Italian Official Bulletin No. 293, December 15 (in Italian).

8.2 Groundwater screening values

Legal framework and scientific basis

In the aforementioned Italian Decree, the groundwater screening values have been determined in accordance with the European Water Framework Directive concerning protection of water from pollution (Directive 2000/60/EC) where the multifunction of the water compartment, potable use included, is a goal to reach. Therefore, this is the reference concept, since the potable use is more restrictive. The groundwater screening values have been set with reference to the European Council Directive 98/83/EC on water quality for human consumption and the United States decree for drinking water was used as a reference for missing parameters.

Technical approaches

Protected receptors

"Groundwater" has been considered as a valuable resource, so groundwater screening values are very restrictive and do not differ according to the type of bodies of water and/or its use.

Relation with the soil human health screening values

Based on the analysis of modelling applied for their derivation, it was considered that soil screening values should be protective for groundwater, i.e. should avoid groundwater exceeding the screening values associated with leaching processes.

Scientific and practical weaknesses

The groundwater screening values have been criticized, both scientifically and practically, because they are applied to every type of groundwater body, regardless of their use and purposes.

Future developments

Similar to soil screening values, a forthcoming Decree provides a greater use of risk analysis for the protection and remediation of contaminated groundwater.

References

- ASTM – American Society for Testing and Materials 1998. Standard Provisional Guide for Risk-Based Corrective Action. PS 104-98
- Italian Ministry of Environment 1999. Technical Regulation on Cleanup and Environmental Recovery of Contaminated Sites according to art. 17 of Law No. 22/97. Italian Ministerial Decree No. 471/1999, Italian Official Gazette No. 293, December 15 (in Italian).

9 LITHUANIA

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9.1 Soil screening values

Legal framework

The valid soil limit values in Lithuania are documented by:

- Decree No. V-114 of Minister of Health of the Republic of Lithuania of 8th March 2004 "On the Hygiene Standard HN 60:2004 "Maximum permissible concentrations of hazardous chemical substances in soil" (Valstybės žinios, 2004, No. 41-1357);
- Decree No. V-412 of Minister of Health of the Republic of Lithuania of 3rd June 2004 "On the Hygiene Standard HN 97:2004 "Maximum permissible concentrations of pesticides (products of plant protection) active chemical substances in environment" (Valstybės žinios, 2004, No. 94-3442)

Object of these standards are obligatory limit values for the soil (whole soil layer from surface till soil parent material) of residential, recreational and agricultural areas. Subject of soil standards are all natural and juridical persons and companies activity of which is related to direct use or indirect impact to soil.

Scientific basis

Lithuanian soil standard HN 60:2004 was derived on the statistical extrapolation of data on soil geochemical mapping of urban areas and medical statistical data of morbidity in the differently contaminated areas.

Technical approaches

The documents are published only in national language and could be found in the official Government newspaper "Valstybės žinios" of 03.17.2004 and 2004 06 15, and on internet,

(http://www3.lrs.lt/pls/inter2/dokpaieska.showdoc_e?p_id=228693&p_query=&p_tr2=;

http://www3.lrs.lt/pls/inter2/dokpaieska.showdoc_e?p_id=235263&p_query=&p_tr2=)

Risk values are derived for the protection of human health and environment.
Soil screening values are risk based, in that they are derived using designated exposure scenarios that relate to different contamination. Different levels of integrate contamination by heavy metals of soil were related using statistical methods to the common parameters of health of persons these live, work or spend particular time in areas with various contamination.
Integrated soil risk values were copied from soil standards of Soviet times (Methodical order on assessment of soil contamination level by chemical substances = Методические указания по оценке степени опасности загрязнения почвы химическими веществами. Москва, МИНЗДРАВ СССР, 1987) and modified according national soil baseline values and taking into consideration EU legislation (86/278/EEC Directive, first of all) and soil standards valid in neighbouring countries. According to the soil standard derivation method adopted by the former Soviet Union, still in use by the Russian Federation, the obligatory maximum permissible concentrations (MPC) is related to background values and derived for water soluble F, bioavailable Cu, Ni, Zn, Co, Cr and F, and total Sb, Mn, V, As, Hg, Pb,

Pb+Hg, Cu, Ni and Zn in all soil. The synergy of contaminants is taken into account in lower MPC for lead and attendant mercury. Different types of MPC are derived: the "translocation MPC" intends to protect spread of soil pollution by the pathway soil-to-plant; the "migration MPC" for the pathway soil-to-water; "the sanitary MPC" for soil ecology and protection pathway soil-to-soil microorganisms. Besides, the soil total contamination index Z_s is used for estimation of soil contamination level in Russian soil guidelines. Z_s index is calculated by formula:

$$Z_s=\Sigma K_{ki}-(n-1),$$

where $K_{ki}=C_i/C_b$,
C_i – measured content of *i* element-pollutant in soil sample (mg/kg),
C_b – background value of i element-pollutant (mg/kg),
n – number of elements-pollutants,

The index is based on the significant quantity of coherent geochemical, medical and agricultural data. In residential and industrial areas the total contamination index Zs is used for estimation of soil contamination level and required actions.
Moreover, in the Russian Federation recommendatory optional permissible concentrations (total contents) were derived in 1995 for the three groups of soil according to soil texture and pH combination
Soil sanitary standard of Lithuania is of complex structure in the same way as Russian. The maximum permissible concentrations (MPC) related to the background values and reference values for sand and sandy loam soil as well as for loam and clay are given in the standard. The synergy of contaminants again is taken into account in lower MPC for manganese and attendant vanadium. The reference values are necessary in calculation of total contamination index Z_s and estimation of soil contamination level in residential, recreational and agricultural areas. The risk index K_0 also is used for estimation of soil contamination level, and calculated by formula:

$$K_0=C/MPL,$$

where C – content of particular element in soil sample (mg/kg),
MPC – maximum permissible concentration of the same element (mg/kg).

Scientific and practical weaknesses

Future developments

References

- Lietuvos higienos norma HN 60:2004. Kenksmingų cheminių medžiagų didžiausios leidžiamos koncentracijos dirvožemyje. (Valstybės žinios, 2004, No. 41-1357)
- Lietuvos higienos norma HN 97:2004. "Pesticidų (augalų apsaugos produktų) veikliųjų medžiagų didžiausios leistinos koncentracijos aplinkoje. (Valstybės žinios, 2004, No. 94-3442)
- Методические указания по оценке степени опасности загрязнения почвы химическими веществами. Москва, МИНЗДРАВ СССР, 1987.

9.2 Groundwater screening values

Legal framework

Legal frameworks are presented by Environment protection law and several environment protection legislative acts (ministerial orders). They are: (1) Order on requirements for clean-up of soil and groundwater contaminated by petroleum hydrocarbons, LAND 9-2002 and (2) Order of the Director of Geological Survey regarding collection of information and inventory of discharge of dangerous substances into groundwater.

The only normative document of the Ministry of Environment is "Order on requirements for clean-up of soil and groundwater contaminated by petroleum hydrocarbons, LAND 9-2002" establishes maximum allowable concentrations (MAC) for petroleum hydrocarbons after reaching of which clean-up actions have to be started or other measures taken.

This document also requires clean-up petroleum hydrocarbons from the groundwater when a free phase oil layer is detected above the groundwater table.

Order of the Director of Geological Survey regarding collection of information and inventory of discharge of dangerous substances into groundwater, 3 February, 2003 No. 1-06. includes the list of substances described in the EC directives 80/68/EEC and 2000/60/EC Annexes VIII and X are transformed into the Order of GSL. The document directly not requires clean-up, but risk assessment procedure should be taken if MAC is exceeded.

Decision for clean-up or other activity is responsibility of Departments of the Ministry of Environment which are situated in regions and Geological Survey of Lithuania (responsible for groundwater protection). However difficulties arise when decision should be made for historically contaminated lands.

Ministry of Health legislated act regulating MAC of pesticides in groundwater intended for water consumption, recreation and agriculture (hygienic norm HN 97:2004). However this legislative document sets quite high allowable concentrations of pesticides and planed to be revised when new directive on the protection of groundwater against pollution will be in force.

Scientific basis

The development of screening values, named in Order of the Director of Geological Survey regarding collection of information and inventory of discharge of dangerous substances into groundwater, mainly based on scientific knowledge and legislation of other countries taking into account national background concentrations (Table 1). The clean-up values for hydrocarbons (LAND 9-2002) in soil and groundwater developed using data of geological investigations of contaminated sites in different geological media and taking into account existing technological potential and economical situation in the country (Table 2).

Technical approaches

Protected receptors

Different clean-up values for hydrocarbon contamination are based on current/future land use. The land use is divided to five categories according sensitivity of environment from very sensitive areas (drinking and surface water protection areas, etc.) to non sensitive (industrial sites, rail way, etc.). The LAND 9-2002 foresee two actions related to environment protection: (1) if floating oil present – in all cases to remove it; (2) after action (1) – groundwater monitoring to prove that

plume of dissolved hydrocarbons not expanding and not present risk to water uses or ecosystems. Main protected receptor is groundwater resources as potential for drinking water supply and as media discharging to surface waters.
The Order of the Director of Geological Survey regarding collection of information and inventory of discharge of dangerous substances into groundwater sets screening values for wide range of substances regulated by the directive 80/68/EEC and 2000/60/EC. Main protected receptor is groundwater resources as potential for drinking water supply and as media discharging to surface waters. If concentration of dangerous substance exceeds MAC, the human health and environment risk assessment procedure should be carried out.

Relation with soil human health screening values

Because screening values for dangerous substances listed in the Order of the Director of Geological Survey regarding collection of information and inventory of discharge of dangerous substances into groundwater derived using published data of other countries and have indirect relation with soil human health values applied in Sweden, Canada, Flanders, etc.
Values for oil hydrocarbons indicated in LAND 9-2002 derived empirically and not have relation with soil human health screening values.

Relation with soil ecological screening values

Values for oil hydrocarbons indicated in LAND 9-2002 has relation with soil ecological screening values. It sets different MAC in top soil and in deeper geological layers (Table 3, 4).

Scientific and practical weaknesses

The legislation of clean-up of contaminated sites, especially related to historical sites, not fully developed. Weakness of legislative base lead to low application of local scientific potential and knowledge. From other hand, legislative gaps not intensify development of groundwater screening values, requirements for remediation investigations and clean-up activity. Because two ministries, ministry of Health and ministry of Environment, participating in development of legislative acts related to environment pollution, there is discrepancy between them. Various legal acts of the Ministry of Environment regulate groundwater protection at some specific economical units: fuel stations, domestic wastewater filtration fields, territories polluted by oil products that are only ecological screening values for industrial sites. Ministry of health sets requirements for MAC of substances which can not be exceeded to protect human health in living, recreational or agricultural areas.

Future developments

In the program of the Government of the Republic of Lithuania for 2004-2008 inventory of potential environment pollution sites and sources and risk evaluation are foreseen. This will follow by preparation of requirements concerning soil and groundwater sampling, methods of analysis and quality assurance during the remedial investigations. Fulfilling of the program and risk evaluation of [potentially contaminated sites require revision of existing screening values. It should be done by preparing united legislative act which include soil and groundwater contaminants values based on possible environmental and human health impacts.

10 POLAND

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10.1 Soil screening values

Legal framework

On 27 April 2001, Parliament adopted the Act on Environmental Protection Law (EPA). The Act was published in the official Journal of Laws of the Republic of Poland No. 62, item 627, and came into force on 1 October 2001.
The EPA is the main Polish legal regulation referring to contaminated land. Pursuant to this Act, any holder of land on which soil contamination or damage of natural land's lay-out exist, is liable for its reclamation. Under the EPA (Article 103), remediation of soil means bringing it back to conditions which meet soil quality standards. Pursuant to Article 105 of EPA, the Ordinance of the Ministry of Environment on Soil Quality Standards (OSQS) was issued on 9 September 2002.
According to this ordinance, land is regarded as contaminated when concentration of at least one substance exceeds the soil quality standards.
The soil quality standards were established for three categories of land:

- Group A – land located in protected areas pursuant to the Water Protection Act and the Nature Protection laws. The regulations provide that unless the contamination constitutes a threat to human health or to the environment, no special action is required. Such land will however also fall under Group B or C and will be subject to the provisions thereof;
- Group B – agricultural land except land under water in ponds and ditches, forest land and tree-covered or shrub-covered, wasteland, and developed and urbanised land except industrial land, mining land and land used for transportation;
- Group C – industrial, mining and transportation land.

Scientific basis

Scientific basis of OSQS is not specified.
While establishing the soil quality standards the guideline values for remediation purposes issued by the State Inspectorate for Environmental Protection in 1995 were partly adopted (IEP 1995). However, the scientific basis for derivation of these guideline values is not specified, either. In the IEP publication it is only mentioned that the guideline values do not result from detailed research and analytical studies, but that they are based on legal regulations applied in the world as well as a many years' experience of Polish scientists and engineers. The guideline values are close to the solutions applied in EU countries in nineties. A list of guideline values do not include all dangerous substances, but only these which are considered in the EU Directives and standards of some European countries. For the purpose of comparison two documents were included in the IEP publication: the A, B, C - Dutch List and the Berlin List, i.e. standards enforced in many European countries in the nineties and also the Directive of Economic European Community on the protection of groundwater against pollution caused by certain dangerous substances (80/68/EEC 17 of December 1979).

Technical approaches

The soil quality standards (QSQS 2002) can be defined as "cut off values", which means that corrective actions are needed wherever values are exceeded. If soil quality standards are exceeded as a result of naturally occurring substances, it is considered that standards are not exceeded.
The soil quality standards are established for three groups of lands (A, B, C Groups described above) including specific land use patterns. However, it is not simply specified which receptors, i.e., human, ecological or both were taken into account in each established land group.
All soil quality standards refer to dry soil.
The standards within B and C Groups of land are established for three and two soil depths, respectively. They amount to 0-30 cm, 30 cm -15 m and > 15 m for B Group, and 0-2 m and 2-15 m for C Group.
Additionally, soil quality standards for soil depths of 30 cm -15 m and > 15 m (B Group), and 0-2 m and 2-15 m (C Group) depend on values of hydraulic conductivity of soils, i.e., up to and below $1*10^{-7}$.
Hydraulic conductivity of soils is the only soil parameter considered in Polish soil quality standards.

Scientific and practical weaknesses

Scientific and practical weakness of the OSQS is that scientific basis and procedure employed for establishing soil quality standards have not been published; therefore they are not fully transparent.
Moreover, according to the OSQS the assessment of contaminated sites was designed as three-phase process but in fact this process is not described in the regulation.
Categorization of land use patterns seem to be too complicated. Soil quality standards should be established for land use categories based on clearly defined criteria, e.g., health and/or ecological risk. The OSQS does not specify which sampling strategy and analytical methods are approved and how to interpret monitoring concentrations (e.g., whether exceeding one standard in one sampling point means that the whole site should be considered as contaminated; there is a lack of information on soil volume considered when comparing soil contamination level with soil quality standards).
To facilitate making decision on scope, frequency and costs of investigations Technical Guidance on Delimitation of Areas Where Soil Quality Standards Are Exceeded were issued by the Inspectorate for Environmental Protection (IEP 2004) which includes recommendations on soil sampling strategy and analytical methods. However, its status is not obligatory but only recommended.

Future developments

New soil quality standards are under development.

References

- EPA (Environmental Protection Act) 2001. Ustawa z dnia 27 kwietnia 2001 r. Prawo ochrony środowiska, Dziennik Ustaw Rzeczypospolitej Polskiej, Nr 62, poz. 627, 20 czerwca 2001 (Environmental Protection Act dated 27 April 2001, Journal of Laws of the Republic of Poland No. 62, item 627, 20 June 2001).
- IEP (Inspectorate for Environmental Protection) 1995. Kościelniak S., Adamski A., Bil J., Hac B., Sobczyk W., Ulman-Bortnowska M. Wskazówki metodyczne do oceny stopnia zanieczyszczenia gruntów i wód podziemnych produktami ropopochodnymi i innymi substancjami chemicznymi w procesach rekultywacji. Państwowa Inspekcja Ochrony Środowiska, Warszawa (Methodological Guidelines for Assessment of Soil and Groundwater Contamination of Petroleum Products and Other Chemical Substances in Remediation Processes. State Inspectorate for Environmental Protection, Warsaw).
- OSQS (Ordinance on Soil Quality Standards) 2002. Rozporządzenie Ministra Środowiska z dnia 9 września 2002 r. w sprawie standardów jakości gleby oraz standardów jakości ziemi. Dziennik Ustaw Nr 165, poz. 1359 z dnia 4 października 2002 r. (Ordinance of the Ministry of Environment of 9 September 2002 on Soil Quality Standards of Soil, Journal of Laws of the Republic of Poland No. 165, item 1359, 4 October 2002).
- IEP (Inspectorate for Environmental Protection) 2004. Stuczyński T., Siebielec G., Maliszewska-Kordybach B., Smreczak B., Gawrysiak L. Wyznaczanie obszarów, na których przekroczone są standardy jakości gleb. Poradnik metodyczny dla administracji. Inspekcja Ochrony Środowiska. Biblioteka Monitoringu Środowiska, Warszawa (Delimitation of Areas Where Soil Quality Standards Are Exceeded. Technical Guidance for Administration. Inspectorate for Environmental Protection, Warsaw).

10.2 Groundwater screening values

Legal framework

On 18 July 2001, Parliament adopted the Act on Water Law (WA). The Act was published in the official Journal of Laws of the Republic of Poland No. 115, item 1229 from 11 October 2001, with further amendments.
Pursuant to WA (2001) the Ordinance of the Ministry of Environment including limit values for groundwater quality indicators in groundwater classes was issued on 11 February 2004 (OGQS 2004).

According to this ordinance, classification of groundwater (5 classes) was introduced for presenting groundwater status:

Class I - very good quality:

a) groundwater quality indicator values result only from natural processes occurring in a water-bearing horizon,
b) none of groundwater quality indicators exceeds permissible values for drinking water;

Class II - good quality:

a) groundwater quality indicator values do not indicate anthropogenic impacts,
b) groundwater quality indicators do not exceed permissible values for drinking water, except iron and manganese;

Class III - satisfactory quality:

a) groundwater quality indicator values are raised as a result of natural processes or weak anthropogenic impact,
b) small number of groundwater quality indicators exceeds permissible values for drinking water;

Class IV - unsatisfactory quality:

a) groundwater quality indicator values are raised as a result of natural processes or weak anthropogenic impact,
b) most of groundwater quality indicators exceed permissible values for drinking water;

Class V - bad quality:

a) groundwater quality indicator values prove anthropogenic impacts,
b) groundwater does not comply with requirements established for drinking water.

However this ordinance expired on 1 January 2005.
On 3 June 2005, Parliament adopted the Amendments to Water Law and Some Other Acts (WA-Amendments 2005). According to this Act the competent ministers for water management and the environment are obliged to established criteria and a method for assessing groundwater status. Currently, a draft of a new Ordinance of the Ministry of Environment including a new limit values for groundwater quality indicators has been prepared for consultation. The current status of the draft is - after intrasectoral and before intersectoral agreements.

Scientific basis

Not specified.

Technical approaches

Protected receptors

Groundwater limit values are not directly related to protected receptors though requirements for drinking water are partly incorporated into them.

Relation with soil human health screening values

Groundwater limit values are not related to soil quality values.

Relation with soil ecological screening values

Groundwater limit values are not related to soil quality values.

Derivation of groundwater screening values

Not specified.

Scientific and practical weaknesses

The expired ordinance including limit values for groundwater quality indicators (OGQS 2004) did not fulfill all requirements specified in the proposal of a Groundwater Daughter Directive (GDD 2003), e.g., concerning identification of trends in pollutants and standards for TCE and PCE.

Future developments

A draft of a new Ordinance of the Ministry of Environment including a new limit values for groundwater quality indicators has been prepared for consultation (its current status - after intrasectoral and before intersectoral agreements). The new ordinance will be adjusted to the requirements of Framework Groundwater Directive (FGD 2000) and the proposal of a Groundwater Daughter Directive (GDD 2003).

References

- FGD (Framework Groundwater Directive) 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Official Journal of the European Communities, 22.12.2000.
- GDD (Groundwater Daughter Directive) 2003. Proposal for a Directive of the European Parliament and of the Council on the protection of groundwater against pollution. COM (2003) 550.
- OGQS (Ordinance on Groundwater Quality Standards) 2004. Rozporządzenie Ministra Środowiska z dnia 11 lutego 2004 r. w sprawie klasyfikacji dla prezentowania stanu wód powierzchniowych i podziemnych, sposobu prowadzenia monitoringu oraz sposobu interpretacji wyników i prezentacji stanu tych wód. Dziennik Ustaw Nr 32, poz. 2840. (Ordinance of the Ministry of Environment of 11 February 2004 on Classification for Presenting a State of Surface- and Groundwater, Monitoring Principles, Interpretation of Results and Presenting the Status of These Waters. Journal of Laws No. 32, item 2840).
- WA (Water Act). 2001. Ustawa z dnia 18 lipca 2001 r. Prawo wodne. Dziennik Ustaw Nr 115, poz. 1229, 11 października 2001 (Act of 18 July 2001. Water Law. Journal of Laws, No. 115, item 1229, 11 October 2001).
- WA-Amendments 2005. Ustawa z dnia 3 czerwca 2005 r. O zmianie ustawy – Prawo wodne oraz niektórych innych ustaw. Dziennik Ustaw, Nr 130, poz. 1087 (Act of 3 June 2005. Amendments to Water Law and Some Other Acts. Journal of Laws. No. 130, item 1087).

11 SLOVAK REPUBLIC

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11.1 Soil screening values

Legal framework

At the beginning of nineties of the 20th century the limit values and methods for analyses of non-acceptable contents of potentially toxic elements were appointed. Due to absence of national target values or permissible levels for risk elements in soils of Slovakia, the former Dutch ABC-list was adapted in 1994 (LVRC, 1994). However the list (Table 2a, 2b) was supplemented with Slovakian A_1 value (for the extracts with 2M HNO_3).
Since the 1st of May 2004 a new Soil Protection Law (ASP, 2004) has come into legislation. The purpose of this act is merely to protect agricultural soils. In contrast with three categories (A,B,C) of threshold values defined in LVRC (1994), this norm determines only one category of limit values (Tables 1a, 1c), which represent soil contamination limits. In the Act also limits for soil-plant pathway are determined (Table 1b), which are related to ammonium nitrate (1M NH_4NO_3) extractable contents of elements.

Scientific basis

Slovakia is the country with occurrence of three types of increased contents of xenobiotics in the environment. The first type is represented by geochemical anomalies, which are of natural origin. The second type includes regions affected by loads from mining activities (so called old ecological loads). These are in some extent eliminated by natural processes. Full extent and intensity of this type of contamination (deterioration) is difficult to determine because they are often a part of recent forest ecosystems. The third type is caused by recent industry. But generally it can be noticed that most of Slovakian soils did not have character of contaminated soils.
Determination of threshold values looked very important from the beginning of soil research. That is why various approaches were applied in soil contaminant research.
The beginning of the research comes back to the seventies of the 20th century. In Slovakia this research starts with the investigation of micronutrients in soils. Method according to Rinkis was applied, so called “hard” extraction agent. But the results had only limited applicability for their original purpose – assessment of the need of fertilization. Attempts for improvement of existing method was not successful.
In the late seventies and early eighties the interest was reoriented to so called “soft” extraction agents – DTPA Lindsay-Norvell extraction for Cu, Mn, Zn and Fe (Lindsay, Norvell, 1978), Berger-Truog method for B (Berger, Truog, 1939), and Grigg method for Mo (Grigg, 1953). In Slovakia the first cycle of agrochemical evaluation of Slovakian soils was made by the above-mentioned methods. Assessment of the contents of micronutrients should serve also for determination of “high” contents of metals and limit values, which indicate normal values of element contents in soils.

From the previous research experience an information on trace element contents in 2M HNO_3 extracts was considered in the 1994, when the Dutch ABC-list was accepted and supplemented with the A' limit value for the trace element extracts in 2M HNO_3.
In the new Soil Protection Law (ASP, 2004) contamination limits were implemented. The contamination limits for risk elements are comparable to the German precaution values (BboDSchV, 1999) and for organic substances to the data of Tebaay et al. (1993) and to the Czech proposal (Podlešáková, Němeček, 1995). Trigger values were adopted only for soil-plant pathway for six elements (Tab. 1b) in ASP (2004). These trigger values were adopted from German ordinance (BboDSchV, 1999) without further research.
Several research and scientific institutions are participating on soil survey of Slovak Republic at present, in particular Soil Science and Conservation Institute in Bratislava, Comenius University in Bratislava, Slovak University of Agriculture in Nitra, and Technical University in Zvolen.

Technical approaches

The existing limit values are supposed to support the decision making process of the local authorities but higher-level intervention limit values are not assigned. The limit values in the Soil Protection Law (ASP, 2004) are considered as precaution values (Table 1a, 1c) for agricultural soils. Trigger values (Table 1b) are specified only for As, Cu, Ni, Zn, Cd, Pb and F for soil-plant pathway. The methods for determination of trigger or action values for other pathways and receptors are not given in the Act 220/2004 although it is required when the limit (precaution) values are exceeded.
As the result the limit values from 2004 (ASP, 2004) are used parallely to older limits (LVRC, 1994) based on the Dutch ABC-list. From this decree, the B values (Table 2b) are usually applied as remediation targets. In groundwater protection areas, however, A values (Table 2a) should be applied as remediation targets. The C values (Table 2b) are used as intervention values.

Scientific and practical weaknesses

The main scientific weakness in the existing soil limits lies in disregarding of an existing research results and experience on trace element contents and availability in soils of Slovakia.
The Dutch limit values were adopted without taking into account some specific features of Slovakian soils. For example soil pH or redox conditions are not considered in the LVRC (1994). At least differences between calcareous and non-calcareous soils should be implemented.
The soil pH is partly considered in the ASP (2004). But only in the case of values used as soil contamination (precaution) limits.
For any foreign limit values adopted, their re-evaluation under Slovak soil conditions should be performed.
Practical weakness embodies the fact that the Slovak environmental policy is not clustered in themes (acidification, eutrophication etc.) but rather in target groups (agriculture, transport, industry etc.) and environmental constituent groups (air, water, soil, food chain). This clustering has caused some competence problems. E.g. the Ministry of Agriculture is responsible for soil protection, while the Ministry of Environment guides other environmental constituent groups (air and water).

Future developments

From discussions being in progress on national level it is clear that process of implementation of limit values in Slovakia is not closed. As follows from the assessments performed in the frame soil monitoring projects, the precaution values in the ASP (2004) are not fully suitable for soils of Slovakia. There is also a need to determine limits for some contaminants specific for Slovakian soils (e.g. antimony). In any case it will be necessary to define conceptual models, methods and trigger or action values for other receptors and pathways.

References

- ASP (2004) Act No. 220/2004 Coll. on the Protection and Use of the Agricultural Soil. Ministry of Agriculture of the Slovak Republic.
- BBodSchV (1999) Federal Soil Protection and Contaminated Sites Ordinance. 12 July 1999, Germany.
- Berger, K.C., Truog, E. (1939) Boron determination in soils and plants. Industrial and Engineering Chemistry 11: 540-545.
- Grigg, J.L. (1953) Determination of the available molybdenum in soils. New Zealand Journal of Science and Technology 34: 405–415.
- Lindsay, W.L., Norvell, W.A. (1978) Development of a diethylene-triamine-pentacetic acid soil test for zinc,iron, manganese, and copper. Soil Science Society of America Journal 42:421-428.
- LVRC (1994) Decree of the Ministry of Agriculture of the Slovak Republic No. 531/1994-540.
- Podlešáková, E., Němeček, J. (1995): Contamination and pollution of soils in the Czech Republic. Proceedings, SFRI, Bratislava, 301-306.
- Tebaay, R.H., Welp, G., Brümmer, G.W. (1993): Gehalte an polycyklishen aromatischen Kohlenwasserstoffen (PAK) und deren Verteilungsmuster in unterschiedlich belasteten Böden. Z. Pflanzenernähr. Bodenk. 156: 1-10.

11.2 Groundwater screening values

Legal framework

For groundwater the threshold (trigger) values are not directly assigned at present. Limit values for drinking water are used most frequently for groundwater evaluation (Table 3). At this time the „Decree of the Ministry of Health of the Slovak Republic from the 26th of January 2004 on demands for drinking water and control of drinking water quality" (DWQ, 2004). Another norm, which is sometimes used, is "Decree of the Ministry for Administration and Privatization of National Property of the Slovak Republic and Ministry of Environment of the Slovak Republic" (DMAP, 1997). New Law on Water Protection (LWP, 2004) is fully harmonized with the Council Directive 80/68/EEC on the protection of ground water against pollution with specified dangerous substances and the Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (the so-called Nitrate Directive).

Scientific basis

Research has not been performed in Slovakia on the determination of limit values for groundwater as limit values for drinking water were adopted for this purpose (Table 3). It can be stated that introduction of the European legislation in the Slo-

vak Republic poses no problem since the emphasis on quality criteria according to international standards has had a long tradition, and starting the year 1983 a modern technical norm on drinking water observing worldwide trends has been introduced.
In Slovakia, systematic monitoring of groundwater quality has been carried out, concentrated into important water management areas since 1982. Altogether, the monitoring network consisted of more than 300 monitoring stations with once-a-year monitoring frequency. The Žitný ostrov area belongs to one of the largest groundwater resources areas in the Central European region. For this reason, groundwater quality in this important water management area is monitored more closely as it represents a separate part of the groundwater monitoring network in Slovakia. Groundwater quality is monitored altogether at 34 monitoring objects with the monitoring frequency of 2 - 4 times per year. The results of laboratory analyses are evaluated by comparing the measured values with limits for Drinking water and results are published every year at Slovak Hydrometeorological Institute Bratislava as the Groundwater Quality Yearbook. Other institutions involved in groundwater research and monitoring are Water Research Institute, Geological Survey of Slovak Republic, Institute of Hydrology of the Slovak Academy of Science and Comenius University in Bratislava.

Technical approaches

The limits are generally based on the current World Health Organization (WHO) recommendations. They are fixed for parameters, which can produce immediate or long-term effects on human health.
The approach for derivation of guideline values for chemical substances varies according to whether or not there is a threshold for the appearance of the undesirable effect induced by the substance under consideration (Joyeux et al., 2004):

- When it is possible to define a threshold dose below which no harmful biological effect is observed, this is described as a compound with deterministic effect. Above that threshold the effect increases depending on the dose administered.
- Conversely, for certain compounds, it is not considered possible, in principle, to define a no-effect threshold. The effect is then described as probabilistic or stochastic, which is the case for genotoxic carcinogenic substances.

Scientific and practical weaknesses

As mentioned above for soils, practical weakness is caused by competence problems as soil and groundwater protection belong to the Ministry of Agriculture and the Ministry of Environment, respectively. These problems are now gradually eliminated during implementation of the 80/68/EEC and 91/676/EEC Council Directives.

Future developments

More attention should be paid also to the harmonization of limit values for soil and groundwater in the future research. This means that the limit values determined for soils (with respect to any protected receptor) will not lead to exceedance of any limit value in groundwater.

References

- DWQ (2004) Decree of the Ministry of Health of the Slovak Republic from the 26th January 2004 on demands for drinking water and control of drinking water quality, 151/2004 Digest.
- DMAP (1997) Decree of the Ministry for Administration and Privatization of National Property of the Slovak Republic and Ministry of Environment of the Slovak Republic from the 15th December 1997 No. 1617/97-min.
- Joyeux, M., Cabillic, P.J., Casellas, C., Montiel, A., Sauvant, M.P., Seux, R., Baert, A., Creppy, E. (2004) Assessment of the health risks from non-compliance with drinking water parametric values. Report, AFSSA, 91 p.
- LWP (2004) Act No. 364/2004 Coll. on Waters. Ministry of Environment of the Slovak Republic.

12 SPAIN

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12.1 Soil Screening values

Spanish soil screening values for the protection of both human health and the ecosystem have been published in January 2005, in a specific regulation, a Royal Decree (Royal Decree, 2005[12], hereinafter RD) recently explained by Tarazona et al. (2005). This RD offers a regulatory framework to establish those industrial activities which may result in soil contamination, and also indicates the methodology to set the Generic Values of Reference (GVRs) of contaminants, mainly derivated by using Risk Assessment approaches. It also includes a list of GVRs for sixty priority pollutants.

Legal framework

This regulation is supported by the previous Spanish Waste Law (Ministerio de Presidencia, 1998[13]) and encompasses exclusively soils polluted by industrial activities. This Waste Law transposes the European Waste Directives 75/442/EEC and 91/156/EEC into Spanish legislation.
This RD deals with the great ecological diversity and differences in the physico-chemical characteristics of soils within different Spanish regions. Thus, the approach is a flexible and tiered system that considers GVRs while taking into account the possibility of further refined Site-Specific Values (SSVs). On the basis of the results, the Autonomous[14] Administrations, may take one of the following decisions: a) declare the soil to be contaminated, b) require a site-specific risk assessment, or c) consider that the risk is low enough that no additional measurements are required.

Scientific basis

The RD is risk-based and covers the protection of both human and environmental health, combining chemical and biological tools. Three land uses have been considered (industrial, residential and natural-soil), for which different exposure routes are associated. Human protection has been considered in all three land-use instances, while protection of the ecosystem has only been considered relevant regarding natural-soil use. The environmental risk assessment includes chemical analyses and direct toxicity testing and covers three main ecological receptors: soil organisms, aquatic organisms and terrestrial vertebrates. Expected-risk threshold concentrations are established as "Generic Values of Reference" (GVRs, which ca be considered as trigger values); if these are exceeded, a site-specific risk assessment is required. The detection of a very high level of acute toxicity in the direct toxicity testing of a soil sample or its leachates will lead to the declaration of the soil as contaminated.
Two different risk based procedures have been used to derivate the GVRs regarding human health and the environment. Both approaches are based on worst-case as-

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[12] Real Decreto 9/2005, de 14 de enero, por el que se establece la relación de actividades potencialmente contaminantes del suelo y los criterios y estándares para la declaración de suelos contaminados. BOE número15 de 18 de enero de 2005.
[13] Ley 10/1998, de 21 de abril, de Residuos. BOE número 96 de 22 de abril de 1998.
[14] The administrative organization of Spain is made up by 17 Autonomous Communities, which have their own Parliaments and Executives.

sumptions, allowing for further refinement of the risk assessment if additional information is available.

Technical approaches

Human health screening values

Conceptual model

The RD does not include a description of the methodology used for establishing the human health threshold values for the three different land uses. Obviously, the level of protection increases from industrial soil to natural soil. In any case, there are recommended models developed by well-recognised institutions such as the European Chemicals Bureau and the USEPA.

Exposure modelling and protected receptors (for different land uses)

For each land use, the realistic most sensitive receptor and different potential exposure routes of contaminants from soil have been considered (Table 1).

Table 1. Exposure routes considered, in each land use, to derivate human health GVRs.

	Land use		
Exposure routes	Industrial	Urban/ residential	Natural
Vapour inhalation	●	●	●
Particle inhalation	●	●	●
Soil ingestion	●	●	●
Dermal contact		●	●
Ingestion of contaminated food			●

Derivation of human screening values

The derivation of the human health GVRs have been calculated taking into account the maximum concentration of contaminants in soil, according to the following criteria:

- For genotoxic carcinogens, the non-threshold assumption is adopted and the trigger GVR is set at the cancer exceeding probability of 10^{-5}.
- For systemic chemicals, in general, the risk is acceptable when the ratio between the long-term exposure dose and the maximum admissible dose is lower than 1, although a different toxicity threshold is assumed depending on the chemical group (Table 2); the screening values (GVRs) are fixed at the level at which the exposure of contaminants from soil, estimated through a worst-case approach, do not exceed the toxicological threshold.

The RD includes the percentage of the ADI, allocated to exposure from the contamination site, reflecting the fact that for widely-distributed chemicals, direct exposures from the (contaminated) site represent merely a minor part of the overall exposure of human beings.

Table 2. Proportion of the exposure allocated to the contaminated soil (ADI equivalence)

Chemical group	Threshold ratio
Pesticides	0.05
Organochlorinated compounds	0.20
Polycyclic Aromatic Hydrocarbons	0.05
Monocyclic Aromatic Hydrocarbons	0.10

Ecological screening values

Conceptual model

The conceptual base for deriving the ecological screening values presented in the RD is based on the INIA approach (2001) for the environmental protection of natural-soil use, which follows the Environmental Risk Assessment approach of the current European chemicals' policy (EC, 2003).

Exposure modelling and protected receptors

The protection of the ecosystems has only been considered relevant for natural-soil use (a soil which can stand any receptor). In this case, maximum protection for the following generic ecological receptors is taken into account: soil-dwelling organisms (considering the protection of soil-microorganisms, soil-invertebrates and plants), aquatic ecosystems (considering the protection of algae, aquatic-invertebrates and fish), and terrestrial vertebrates (considering the protection of vertebrates feeding on contaminated food/preys). Competent Authorities from each Autonomous Government can determine, on a case by case basis, the selection of those relevant site-specific ecological receptors. The generic organisms and exposure routes covering each receptor are described in Table 3.

Derivation of ecological screening values

Derivation of environmental GVRs is established through a set of Risk Characterization Ratios (RCRs) defined as the ratio between the Predicted Environmental Concentration (PEC) and the Predicted No-Effect Concentration (PNEC) for each environmental compartment (water column, soil, and wildlife food items). A backtrack approach has been applied, estimating the soil concentration of each chemical that would give a RCR of 1 according to the EU risk assessment scheme. This estimated soil concentration corresponds to the GVRs.

Table 3. Ecological receptors and exposure routes used for setting the GVRs..

Ecological receptor	**Organisms covered**	**Exposure routes**
Soil organisms	Soil microbial functions Terrestrial plants Soil invertebrates	Soil
Aquatic organisms	Fish Aquatic invertebrates Algae and aquatic plants	Interstitial Pore water
Terrestrial vertebrates	Mammals Birds Other vertebrates	Consumption of contaminated food (plants, invertebrates and vertebrates)

In this approach, PEC and PNEC values for each contaminant are calculated according to the Technical Guidance Document for the Environmental Risk Assessment of the European Community (EC, 2003).
In the case of wildlife receptors (natural-use soil), toxicological relationships have been expressed in terms of dietary exposures so as to estimate a corresponding soil concentration, according to the same UE approach (see Table 4). This value is converted to soil concentration using body weight, food ingestion rate, and soil ingestion rate for the species from which the Lowest Observed Adverse Effect Level (LOAEL) was determined. Generic protection criteria are presented in Table 4. Regarding aquatic organisms, the concentration in the interstitial pore water is weighed up as the fraction of contaminant that could be expected to migrate and reach both, groundwater and adjacent aquatic systems. For these approximations, the Equilibrium Partitioning Method is used.

Table 4. Generic protection criteria according to the INIA approach (2001).

Scenario	Environmental compartments considered	Protection criteria
Natural Soil	Soil Surface/ground water Complex terrestrial food chains	$Soil_{[C]}$ < lowest PNEC soil organisms Pore $Water_{[C]}$ < PNEC aquatic organisms Trophic chain $_{[C]}$ <PNEC high vertebrates

This model is described here only for the protection of the ecosystem in natural soils. However, each ecological receptor has been treated independently to allow for an appropriate selection of relevant receptors. The target receptors could be adapted by selecting any relevant and appropriate ecological receptor needing protection in any case. The INIA approach (2001) entails enough flexibility to allow for the selection of different target environmental receptors, depending on the land use and the realistic and specific priorities of the protection sought (i.e. small and/or higher vertebrates).

Ecotoxicological assessment

As previously indicated, the ecotoxicological assessment is based on both, the comparison of soil concentration of chemicals with GVRs and the direct toxicity assays of soil samples collected from the site (on soil microorganisms, plants and soil invertebrates) and their leachates (on algae, aquatic invertebrates and aquatic vertebrates).
After the selection of expected contaminants, their analytical concentration is compared to the "Generic Values of Reference" (GVRs) which can be defined as preliminary triggers (Figure 1). Direct soil and leachates' toxicity testing are also incorporated as a formal requirement, allowing for the decision to classify a soil as contaminated to be taken exclusively on the basis of measured toxicity. The soil would be directly classified as:

- NON-CONTAMINATED, if fulfill the following two conditions simultaneously: a) the concentration of expected chemicals in the soil is below the GVRs and b) there is no indication of ecotoxicity for the soil and the aquatic organisms, using undiluted samples.
- CONTAMINATED, if there is an indication that short-term toxicity L(E)C50 values of soil to the most sensitive specie of soil organisms is lower than 10 mg assay-soil/g standard-soil or if short term toxicity L(E)C50 values of soil leachates to the most sensitive specie of aquatic organisms is lower than 10 ml leachate /l standard-solution.

In some cases, soils cannot be directly included in any of the above categories:

- If GVRs are exceeded, soils are classified by comparing chemical concentration levels with new refined Specific-Site Values (SSVs), calculated taking into account site-specific circumstances and the toxicity criteria described above.
- If some toxicity is detected, but at a level that does not imply the direct classification as a contaminated soil, the regulation establishes the obligation to conduct a site-specific assessment, where additional bioassays, other biological tools and further specific cost-effective refinements may be carried out to allow a final classification.

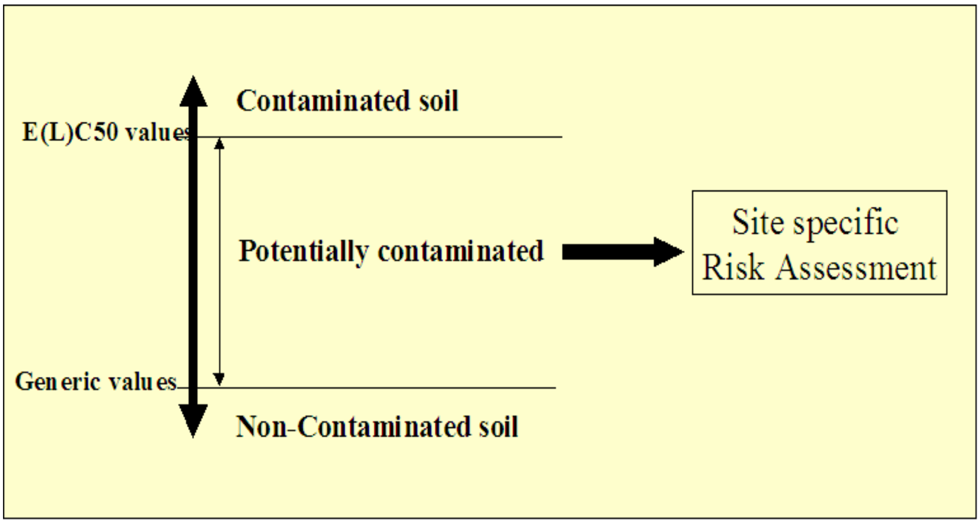

Fig. 1. General criteria for the ecosystem protection

Modelling tools

The procedures, models and default values used for the derivation of the ecological screening values are those included in the (EC, 2003). They are used to estimate the soil concentration of each chemical that would give an RCR of 1, according to the EU environmental risk assessment procedure.

Derivation of soil screening values

Integration of human health and ecological screening values

After the derivation of the GVRs, the following additional rules are applied to both human health and environment issues:

(i) The "Reduction Principle", establishing that for synthetic substances, the screening values can not exceed 100 mg/kg soil,

(ii) The "Continuity Rule", establishing that the screening level for urban soils can not exceed 10 times the screening level for natural areas, and the screening level for the industrial soils can not exceed 10 times the screening level established for urban soils and finally,

(iii) The "Limit of Detection Rule", allowing setting the screening values to the limit of detection of the analytical technique, when the estimated value is too low to be measured based on available technologies, and the limit of the analytical detection is considered sufficient accurate to guarantee an acceptable protection.

Within the RD, the human health screening values derived for three different land uses (industrial, urban and natural use) prevail over those derived for the protection of the environment. In fact, screening values for the protection of the environment will be applied only if the Autonomous Governments consider the protection of the ecosystem a priority.

Economic and social factors

This RD includes a list of potentially polluting activities and determines the duty to present, within two years' time, a preliminary report based on any available information explaining how chemicals are handled within the facility. The report would include identifying any possibility of soil contamination's resulting from current handling procedures.

A similar process is required before starting a new industrial activity in a site previously used for a potentially polluting activity, and also when a change in soil use is requested by the owner.

On the basis of the studies' results, the Autonomous Competent Authorities can:

a) declare the soil to be contaminated,

b) require a site-specific risk assessment, or

c) consider that the risk is low enough that no additional measures are required.

Current legislation includes a system to publicly communicate the current status of the soil assessment within the Land Registry. Declaring a site to be contaminated also implies that the owners are obliged to take risk reduction measures.

Consequently the main sectors affected by the new regulations are regional authorities and industrial companies. Regional authorities must make additional efforts to evaluate the reports and to develop specific normative according to the characteristics of the Autonomous Community.

Scientific and practical weaknesses

There are some practical weak points, especially due to the general lack of ecotoxicity information suitable for derivation of accurate values.
GVRs must be both sufficiently protective of the critical ecological functions and be reasonable. They should not be so low that even at trivial concentrations (i.e., well below the biological effects' thresholds) a chemical is screened out from further risk analysis undertakings. This is a difficult task, especially taking into account the high diversity regarding soil physico-chemical characteristics and the specific behaviour of contaminants in different soils. Thus, in many cases a site-specific risk refinement will be necessary.
Other aspects of Spanish legislation that would require additional development are decisions adopted for metals and petrol hydrocarbons. The RD does not cover the development of GVRs for metals, but rather transfers this responsibility to the Autonomous Governments. As an alternative, the regulation allows for the definition of site-specific reference levels as the mean plus two times the standard deviation of background levels as measured in a surrounding clean area of similar physico-chemical characteristics. The rationale for this proposal is based purely on statistics and assumes that this criterion is equivalent to significant differences for a confidence limit of 95% in the case of normal distributions.
In the same way, GVRs are not developed for petrol hydrocarbons. However, the RD establishes a GVR of 50 mg/kg soil based on total hydrocarbon measurements. This limit is not based on hydrocarbon toxicity since toxicity, and therefore the human and environmental risks, is highly dependent on the chemical composition of the hydrocarbons, the aging processes, etc. This value is selected because it is considered to be high enough to avoid false positives, which could be associated to the presence of natural organic compounds in Spanish soils. As a result, this value would prompt a site-specific risk assessment.

Future developments

The aspects listed below would result in future improvements to the approach:

- The use of probabilistic assessments in the derivation of the GVRs, with the possibility of arranging the toxicity values in a frequency distribution.
- The definition and establishment of different generic scenarios, i.e. characterization of generic types of soils covering the main general and/or relevant characteristics, thus allowing for an easy extrapolation of the proposed GVRs to different types of soils.
- The refinement of the GVRs through the incorporation of additional toxicity information in the values´ derivation. The lack of toxicity data, mainly to soil organisms, increases the level of uncertainty. The possibility of incorporating soil microcosms, such as the MS·3 approach (Fernández et al., 2005) covering the assessment of indirect effects and more realistic exposure conditions, is also a future possibility.
- Development of GVRs, specifically derived for metals at a regional level.
- Definition of a risk assessment system for remediated soils. According to the RD, the declaration ofa site as contaminated implies the owners obligation for soil remediation. Remediation processes must achieve acceptable risk levels. Risk assessment systems to define these acceptable risk levels must be developed.

References

- EC. 2003. Technical Guidance Document in support of Commission Directive 93/67/EEC on Risk Assessment for new notified substances, Commission Regulation (EC) No 1488/94 on Risk Assessment for existing substances and Directive 98/8/EC of the European Parliament and of the Council concerning the placing of biocidal products on the market. EUR 20418 EN/2. European Chemical Bureau. Ispra, Italy.
- Fernández, MD; Cagigal, E; Vega, MM; Urzelai, A; Babín, M; Pro, J; Tarazona, JV (2005) Ecological risk assessment of contaminated soils through direct toxicity assessment. Environ. Ecotox. Saf., 62: 174-184.
- INIA. 2001. Desarrollo de criterios para la caracterización de suelos contaminados y para determinar umbrales para la protección de los ecosistemas. Madrid. Spain. (only in Spanish).
- Ministerio de Presidencia (1998): Ley 10/98, de 21 de abril, de residuos. Boletín Oficial del Estado 96/1998, 13372-13382.
- Royal Decree, 2005. Real Decreto 9/2005, de 14 de enero, por el que se establece la relación de actividades potencialmente contaminantes del suelo y los criterios y estándares para la declaración de suelos contaminados. Boletín Oficial del Estado 15/2005, 1833-1843.
- Tarazona, JV; Fernández, MD and Vega, MM. 2005. Regulation of contaminated soils in Spain. J Soils & Sediments, 5(2): 121-124.

12.2 Groundwater Screening values

According to the presented approach, there is a lack of consideration of ground water regarding the human health for drinking uses. Groundwater protection has only been taken into account regarding the ecosystem's protection, through the protection of the aquatic organisms.

Legal framework

The RD deals with the soil characterization for the protection of the ecosystem, but it does not include GVRs derived specifically for groundwater protection. The contamination of groundwater is not directly dealt with in this normative. However, this RD establishes specifically in one of its articles that if there is any evidence, or indication, of threat to groundwater as a consequence of soil contamination, the Competent Authority must be informed.

Scientific basis

As indicated, an important point, when considering protection of the ecosystems, is the possible migration of pollutants from soil. They may drift and, subsequently, potentially reach the interstitial pore water and, eventually, the aquatic compartment.

In this sense, the protection of surface and groundwater compartments has been considered as a potential receptor when deriving GRVs for the protection of the ecosystems since;

- the concentration in the interstitial pore water is considered as the fraction of contaminant that could be expected to migrate and reach adjacent aquatic systems. The Equilibrium Partitioning Method is used for these estimations; and,
- a soil-leacheate direct toxicity test is also required to declare a soil as "non-contaminated".

Technical approaches

To avoid the repetition of the approach, see the on the Spanish "Ecological Soil Screening Values".

Scientific and practical weaknesses

- Information to estimate environmental GVRs for the protection of the aquatic compartment results from the use of generic adsorption/desorption models. The development of more specific models regarding different soil characteristics may result in accurate estimated values.
- The selection of any relevant receptor for each soil use should be the most relevant criteria. In this sense, the protection of surface and groundwater compartments should be considered as a potential receptor when calculating the generic values for each soil use, not only the protection of the ecosystems within the natural-soil use .

Future developments

See section "Scientific and practical weaknesses"

13 SWEDEN

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13.1 Soil screening values

Legal framework

The Swedish Environmental Protection Agency has developed guideline values for contaminated soils as part of a framework for risk assessment and remediation of contaminated areas (SEPA, 1996). In addition, the Swedish EPA and the Swedish Petroleum Institute have developed proposed guidelines for contaminated areas around petrol stations (SEPA/SPIMFAB 1998).

In Sweden, the assessment of risks from contaminated areas is based on the same principles as other aspects of environmental protection. The main points of the common basis are:

- The Environmental Code (the collected environmental legislation in Sweden)
- The precautionary principle
- The Environmental Objectives (National goals for the environment)
- Reduction of risks from prioritised hazardous substances.

Risk assessment is an important tool in the remediation of contaminated areas and is used at different stages in the remediation process, e.g. in order to prioritise between different areas, to estimate risks to health and the environment, to evaluate the need for risk reduction, and evaluate how well the available remediation techniques can fulfill these requirements.

Generic guideline values have been developed for use in simplified risk assessments. The generic guideline values are therefore intended to be applicable for typical Swedish conditions with respect to geology, hydrology, exposure conditions and the sensitivity of the site, and to be suitable for a large number of sites in Sweden.

However, for some sites, generic guideline values may not be applicable. This may be the case where one or more site-specific factors differ from the conditions assumed when calculating the generic values, e.g. where the exposure situation is different, where there is a particularly sensitive ecosystem, where contaminant transport differs. In such cases, site specific risk assessment is necessary. It may also be the case when the risk assessment needs to address questions which are not taken into account adequately by the generic model. In order to achieve consistency in simplified site specific risk assessment, the Swedish EPA has developed a spreadsheet based model for the calculation of guideline values (SEPA 2005a). It is based on the model used to calculate generic guideline values, and is available together with a database of contaminant specific parameter values (physical and chemical data, uptake to biota, toxicological and ecotoxicological data, background concentrations, background exposure). A guidance to risk assessment of contaminated areas is also available (SEPA 2005b) which gives advice on adaptation of methods for risk assessment and the use of the model for calculating guideline values when carrying out simplified site specific risk assessment. The model and the guidance document are currently undergoing review before final publication.

Scientific basis

The model used to calculate guideline values evaluates the distribution and transport of contaminants, human exposure and human health risks and risks to the environment. Some other aspects are also taken into account, e.g. taste and smell of contaminants, background concentrations, detection limits for contaminant analysis.

Separate risk assessment is carried out for human health risks and risks to the environment. The two resulting guideline values are integrated into a single guideline value by choosing the lower of the two.

Human health is protected at the level of the individual. The environment is protected by ensuring the ecological functions of the relevant environment.

Estimation of the distribution of contaminants between different phases in the soil (solid, liquid and vapour), and the transport of contaminants is based on the following assumptions:

- Contaminant concentrations in soil solid phase, pore water and pore air are in equilibrium.
- Contaminant concentration in soil is constant with time, i.e. changes in contaminant concentration due to transport away from the area or to due degradation are not taken into account.
- Transport of contaminants from the soil occurs as dust, in the vapour phase to indoor or to outdoor air, in the liquid phase to groundwater and surface water and as uptake by plants and fish.

Conservative assumptions are made concerning the leaching and transport of contaminants:

- The model for generic guideline values assumes that all analyzable contaminants are available for transport, i.e. the availability of contaminants for transport is only taken into account in a generic way (using contaminant-specific parameter values). In site-specific calculations, adjustments may be made to take into account information on the leachability of the contaminants.
- Sorption and degradation of contaminants during transport is not taken into account.

Certain simplification may in some cases underestimate contaminant transport:

- Transport of free-phase organic contaminants is not taken into account.
- Transport of contaminants in the particulate form is not taken into account (with the exception of dust).

The transport of contaminants in soil is determined to a large extent by the soil properties, e.g. organic matter content and porosity. When calculating generic guideline values, parameter values are chosen so that the normal range of soils in Sweden are considered in the transport calculations. The proposed branch-specific guideline values for petrol stations consider three different soil types with different permeabilities, and allow correction for different organic-matter contents (SEPA/SPI 1998).

Technical approaches

The model for calculation of generic guideline values takes into account risks from direct exposure to the contaminated area to the extent occurring for the defined land use. In addition, risks from exposure to contaminants transported from the contaminated area to ground- and surface water recipients are taken into account. In the case of groundwater, exposure occurs by use of the groundwater as drinking water. In the case of surface water, exposure occurs by consumption of fish from the recipient water body. When deriving site-specific guideline values with the same model, it is possible to consider additional receptors and exposure pathways.

Protected receptors

The generic guideline values have been developed for three types of land use, which differ from each other with respect to the exposure pathways included, the degree of exposure for the exposed group, and the degree of protection afforded the environment. The three types of land use are:

- Sensitive land use: where land use is not limited by soil quality and groundwater protection allows the use of groundwater for drinking. Children and adults can permanently occupy the area during a lifetime. The soil ecosystem is protected.
- Less sensitive land use, with groundwater protection: Soil quality limits the use of the land to commercial and industrial land use, or other less sensitive uses such as roads. The exposed group of people are assumed to occupy the area during working hours. Children occupy the area only temporarily. The soil ecosystem is protected so that the soil functions which are desirable for this land use are unimpaired, e.g. establishment of certain types of vegetation, temporary occupation by animals etc. Groundwater is protected so that drinking water may be withdrawn 500 m from the contaminated site.
- Less sensitive land use: As above, but with no groundwater protection.
- The proposed guideline values for petrol stations consider two additional land uses:
- Park: (parks, green areas, areas of natural vegetation, forest etc.) Both children and adults use these areas either temporarily or make short, regular visits. There are no existing or planned buildings. There is cultivation of plants, but harvesting of berries, fungus etc may occur. Groundwater in the area is protected. Protection of the environment as for sensitive land use.
- Land with low intensity of use: As for park areas, except for protection of the environment, which is as for less sensitive land use.

Based on the potential future use of the site, a set of exposure pathways (for man and the environment) are defined. In most cases the probability of the exposure pathway is not considered; it is assumed that exposure will occur, e.g. that there will be exposure via all identified exposure pathways. Exposure is estimated for each identified pathway, and the exposure from the different pathways is added up and compared to certain toxicological criteria.

Within an larger area with a given land use, several different types of land use may occur, for example, in a residential area there may also be parks, offices, shops, parking areas, roads. However, the Swedish Environmental Protection Agency recommends that division into small areas with different land use should be avoided because:

- Exposure is determined by the combined exposure from all these areas, not only from one small area.
- Contaminant transport is affected not only by environmental conditions in the local area but only by the conditions in the surrounding areas, (e.g. groundwater flows).
- Contaminants in one area may spread to neighbouring areas
- It is difficult to ensure that land use in the future will be exactly as it is today, or as it is planned at the moment.

Ideally, the area considered would be the whole surface area where contaminants are found (including contaminants at deeper levels in the soil) and the area affected by spreading of the contaminants from the source. However, in practice, assessments are often made of a particular property that is to be exploited, which may include one or more point sources and some uncontaminated areas, as well as the recipient and downstream areas affected by spreading. The final decision is made by the responsible local or regional authority.

Human health screening values

Conceptual model

Risks are calculated for a critically exposed individual of the exposed group who carries out all the activities that are possible for the land use. The individual considered is assumed to have normal habits as far as diet and activities are concerned and normal sensitivity to the contaminants.

Exposure modeling

The exposure pathways considered for the different land uses are shown in the table below:

	Sensitive	**Less sensitive + groundwater protection**	**Less sensitive**
Exposure pathway			
Direct ingestion of soil	Full time exposure	During working hours. (Less for children)	During working hours. (Less for children)
Skin contact	Full time exposure	During working hours. (Less for children)	During working hours. (Less for children)
Ingestion of dust	Full time exposure	During working hours. (Less for children)	During working hours. (Less for children)
Inhalation of vapour	Indoors	Indoors	Indoors
Consumption of plant produce	30% consumed grown on area	No	No
Consumption of groundwater	Well at area boundary	Well 500m from area	No
Consumption of fish	Recipient lake or river	Recipient lake or river	Recipient lake or river

When calculating generic guideline values, no account is taken of the depth at which the contaminants are found in the soil profile and the general recommendation is to avoid division into different depths. However, in site-specific risk assessments, it is possible to take the depth at which the contaminants lie into account. In these cases the soil profile should only be divided into a few layers of significant depth (e.g. above and below a frost-free depth of 30-50 cm). Exposure parameters for the deeper soil layer may then differ somewhat from the table above. The final decision is made by responsible local or regional authority.

Toxicological assessment

The assessment of health risks is based on the dose-response relationship for the contaminant. The guideline values are based on toxicological reference values, which have been derived from available data from epidemiological studies and experiments on animals concerning the dose-response relationship. The toxicological reference values indicate either a threshold dose for harmful effects (non-genotoxic substances) or a dose which is equivalent to a low risk of harmful effects (genotoxic substances). In Sweden, a low risk level is assumed to be a lifetime risk of cancer of 10^{-5}. Safety factors are used to take into account the uncertainties in the available data. The toxicological reference values used are the tolerable daily intake (TDI, in mg/kg body weight and day) for oral exposure and the reference dose (RfC mg/m^3) for inhalation exposure. The risk-based values for genotoxic substances are expressed in the same units.

In the substance-specific database, toxicological reference values have been chosen firstly from WHO. Values from USEPAs IRIS database, the Swedish Institute of Environmental Medicine (IMM), and the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWC) have also been used.
The contaminant is assumed to have the same bioavailability as the contaminant in the toxicological studies making up the database on which the toxicological reference values are derived.

Derivation of screening values

A generic guideline value is calculated for each exposure pathway and is expressed as the concentration of the contaminant in soil which is equivalent to the toxicological reference value. The values for all the exposure pathways are then to calculate an overall guideline value using the following equation:

$$C_{overall} = \frac{1}{\frac{1}{C_{ingestion}} + \frac{1}{C_{skin}} + \frac{1}{C_{dust}} + \frac{1}{C_{vapour}} + \frac{1}{C_{water}} + \frac{1}{C_{plants}} + \frac{1}{C_{fish}}}$$

The overall value is then adjusted to take the following factors into account:

- Exposure from other sources: For some substances, there is appreciable exposure from sources other than the contaminated area, e.g. in the diet. For substances where exposure from other sources is appreciable, and there is data about the extent of this exposure, adjustment is made so that the total exposure, ie exposure both from the contaminated area and other sources, does not exceed the toxicological reference value. This adjustment is at the moment made for lead, cadmium, mercury, nickel and dioxins.
- Acute toxicity: Some substances, e.g. arsenic and cyanide, have such a high acute toxicity that ingestion of even a small amount of contaminated soil can lead to harmful health effects. The risks are greatest for small children, who are most likely to consume large amount of soil and have lowest body weight. An adjustment is made based on a child of 10 kg and a soil intake of 5.0 g. A guideline value for acute effects is then calculated from a toxicological reference value for acute effects.
- Adjustment for protection of groundwater. Drinking water guidelines that are set by the Swedish Food administration, or the WHO, are taken into account by calculating a separate soil guideline value, set as the concentration in soils which does not lead to a contaminant concentration that exceeds the drinking water guideline in downstream groundwater.

The adjusted overall health-risk based value is the lowest of the overall unadjusted value and the values calculated for exposure from other sources, acute toxicity and protection groundwater.

Ecological screening values

Because we have limited knowledge about the effect of different contaminants on the soil and freshwater environments, guideline values are based largely on the collation and interpretation of ecotoxicological data. The possibility of making site specific adjustments to the guideline values in the model is therefore limited. A site specific risk assessment outside the model is of course possible, but still uncommon in Sweden for contaminated land, though ecological studies (ex benthic fauna studies) have been used in assessments of contaminated sediments.

Protection of the environment is based on protection of organisms (flora and fauna) at the level of the population as well as protection of ecological functions. The guideline value does not aim to protect individuals of populations of plants and animals.
Protection is achieved by setting guideline values which are equivalent to the concentration of contaminants in an environmental media under which the effects on populations of organisms or on ecosystem functions are not expected to be at an unacceptable level.
There are two guideline values for environmental risks, the first is based on effects in the contaminated soil environment, and the second is based on effects in the recipient freshwater system resulting from leaching from the contaminated area.

Conceptual model

The different land uses (see section 1.3) have different requirements concerning the capability of the soil ecosystem to carry out various functions. For sensitive land use, the soil ecosystem needs to be capable of carrying out the full range of ecological functions, to allowing growing of crops, forestry, cycling of carbon and nutrients, etc. For less sensitive land use, the soil ecosystem needs to be capable of the functions required of this type of land use, e.g. support vegetation (e.g. along the sides of roads), the temporary residence of birds and animals.
In the recipient water body, the range of ecological functions of that water body should not be limited by the contaminant concentrations in water.
The guideline for the contaminated soil environment is expressed as a concentration in soil at which ecological effects are consistent with the requirements of the land use. The guidelines are derived from the ecotoxicological assessment (see below).
The guideline for protection of the freshwater recipient is derived from freshwater quality criteria for the protection of aquatic life (see ecotoxicological assessment, below). The guideline value in soil is the concentration of a contaminant in soil above which the contaminant concentrations in the water of the recipient would exceed the freshwater guideline value, taking contaminant transport in the groundwater into account.

Exposure modeling

For all the land uses used for producing the generic guideline values, both the soil ecosystem on-site and the recipient surface water ecosystem are considered.
The bioavailability of the contaminants is assumed to be the same as the bioavailability of the contaminants in the ecotoxicological studies which make up the database for the ecotoxicological assessment (see below).
For exposure within the soil ecosystem on the contaminated site, no extra modelling is required, as exposure of soil organisms is expressed as the contaminant concentration in soil (mg/kg). The guideline value for soil, expressed as contaminant concentration in soil, is derived from the ecotoxicological assessment. Foodchain transport of the contaminants may be taken into account in the ecotoxicological assessment (see below).
For exposure in the recipient surface water body, transport of the contaminants to surface water is calculated using a simple dilution factor pore water, surface water and the equilibrium distribution coefficient Kd in soil. For generic guideline values, the dilution factor is equivalent to dilution in a small lake or stream. When deriving site specific guideline values with the model, an appropriate dilution factor may be chosen. The guideline values are expressed as the concentration in soil (mg/kg) which is equivalent to the environmental guideline values for contaminant concentration in surface water that is derived from the ecotoxicological assessment.

Ecotoxicological assessment

The assessment of environmental effects on site is based largely on the data collation and interpretation from RIVM, Netherlands (RIVM 1990, 1995, 1998, 2001). The collated data have been studied in order to derive guideline values for sensitive and less sensitive land use. The collated database includes, where possible, the results of ecotoxicological studies on terrestrial organisms. The studies from which results are taken are reviewed so that the data in the database is of acceptable quality. However, for many substances, results from studies on terrestrial organisms are non-existent or very limited and the results of ecotoxicological studies of aquatic organisms are used together with a soil-water partition coefficient to derive guideline values for soils. In some cases, the results of QSAR studies on aquatic organisms are also used to complement the database.

For some bioaccumulating substances, the RIVM data collations include assessment of food-chain transfer and bioconcentration/bioamagnification. These "secondary-poisoning" values are assessed together with other ecotoxicological data when environmental guideline values are derived.

For less sensitive land use, the appropriate degree of protection is assumed to be protection of 50% of species at the population level. This is the level of protection which RIVM use as the basis for their SRC-values (serious risk concentration). For sensitive land use, the Swedish generic guideline values aim to be equivalent to the NOEC values for Swedish environments. For some metals, Swedish data indicates that this concentration is equivalent to approximately half the SRC-value. For organic contaminants the guideline values for sensitive land use aim to protect 75% species. However, for most organic contaminants the database is insufficient to allow data analysis using a statistical distribution of ecotoxicological data. For these substances, guideline values have been based on an evaluation of the available data and are much more uncertain that guideline values based on a more complete database.

For a number of contaminants, there is no available data collation from RIVM or any other source. In these cases, ecotoxicological data in the literature have been reviewed in order to derive guideline values. For some contaminants, especially petroleum hydrocarbons, there are very few available data. For these substances, an environmental-risk based guideline value has nevertheless been derived, in order to give some protection of the environment for substances where health-risk based guideline values are high. These guideline values are the best assessment that can be made given the limited database, but do not have the same scientific basis as values based on a comprehensive database.

The assessment of ecotoxicological effects in the recipient surface water system is based on largely on the data collation and interpretation from CCME, Canada. CCMEs water quality criteria for the protection of aquatic life are set to protect aquatic species at all stages of the lifecycle and are based on data on the ecotoxicological effects of contaminants on aquatic species. For many substances, CCMEs values have been used as water quality criteria. However, for metals, CCMEs water quality criteria have not been used. Instead, a water quality criteria has been chosen that represents only a small increase in metal concentration over the background values which are normally observed in Sweden. The water quality criteria is chosen as the upper boundary from the class "small increase over background concentrations" from the classification system given by the Swedish EPAs environmental quality criteria for lakes and rivers (SEPA 2000). The size of the maximum allowed increase varies depending on the metal. Again, for a number of contaminants, there are no available data compilations. In these cases, guideline values have been based on reviews of data in the literature, background values and other information.

Modeling tools (both health-risk and ecological-risk assessment)

The Swedish EPA has recently developed a spreadsheet tool for calculating guideline values. This was needed to harmonize the use of the model for derivation of generic guideline values, which is frequently used for simplified site specific risk assessment for soil. The model is primarily intended to develop site specific guideline values, but can also be used to calculate guidelines for generic conditions. A set of scenarios are predefined and the user can change data concerning exposure, leaching and transport and contaminant properties. All changes from the predefined data are automatically documented to aid reviewing of the risk analysis. The tool is written in a flexible way allowing users to include additional exposure pathways or transport models. The use of other methods and models for risk assessment for soil is allowed, but still uncommon.

Derivation of soil screening values

The procedure for derivation of screening values is based on calculations of soil concentrations that correspond to an acceptable level of risk, exposure or environmental effects. The calculation is made in a "reverse" mode which implies that a linear relationship between soil concentrations and risk exists. Non-linear effects such as solubility limitation, non-linear sorption cannot be accounted for. Furthermore the calculations are based on an assumption of stationary conditions. Temporal variations and trends in soil concentration, contaminant leaching or transport are not considered.

Integration of human health and ecological screening values

Integration of the human health and ecological screening values is carried out by choosing the lowest of the guideline values for human health (the overall, adjusted value), for the soil environment and for the freshwater recipient.
Adjustment of the integrated value is then carried out to take into account the background concentration of the contaminant. Adjustment is made so that the calculated guideline value is not lower than the background concentration resulting either from the natural occurrence of the contaminant or from diffuse pollution. The background concentration is assumed to be the 90th percentile of measured background concentrations in Sweden.

Scientific, economic and social factors

These factors are not considered explicitly during derivation of guideline values, but are considered later during the stage of risk evaluation and the setting of remediation goals. However, the basis of a risk assessment includes some factors which are already the product of scientific, economic and social evaluations, e.g. the acceptable level of protection for the environment or human health (i.e. ecotoxicological and toxicological reference values and drinking water guidelines), are already a product of evaluations which have been made elsewhere.

Comparison with monitoring concentration

The intention of the generic guideline values is not to determine the need of remediation. The comparison of monitored concentrations with guideline values are though the basis for the decision concerning further investigations or remediation goals made by the responsible local or regional authority.

In the remediation phase the guideline value is normally compared with the mean soil concentration from a "selective remediation volume". In a normal case a volume of 50-100 m^3 should be sufficient (SEPA, 1997).
The model for calculating guideline values that is being reviewed, also allows output of the contaminant concentrations in different environmental media, e.g. groundwater, indoor air at the guideline concentration in soil. It is then possible to compare these concentrations with monitoring data.

Scientific and practical weaknesses

Risk assessment of contaminated soils are associated with a varying degree of uncertainty. Coping with uncertainty implies the use of conservative assumptions. A large number of uncertainties in different stages of the analysis may lead to overly conservative results. The Swedish guidelines for contaminated soils do not consider the worst case, ie the most conservative case, but aims to consider a pessimistic but probable case. An uncertainty analysis for specific substances has shown that this approach protects most individuals (ca 95%) (Öberg T, 2006).
When carrying out a risk assessment, it is difficult to take into account the combined effect of several sources of contaminants on human health or the environment (e.g. groundwater, recipient water bodies).

Future developments

Draft versions of the reports (SEPA 2005a and b), together with an excel-version of the model for calculating guideline values are currently under review. Preliminary versions have recently been released in Sweden and comments have been received. The immediate task is to update the material and issue a final version.
Before the recent issue of the model for guideline values, small updates were made to the database and some minor corrections were made to the way the model handles vapour exposure and exposure due to the consumption of fish. However, no major review of the model was carried out. At present, the model for calculating guideline values is being reevaluated. A more encompassing review and documentation of the accompanying databases is also being carried out. The SEPAs guidance to risk assessment of contaminated land is also being reevaluated.
An additional task is to develop models or methods for risk assessment of surface waters, groundwater and sediments and to integrate all the methods for assessment of contaminated media to one methodology for contaminated areas.
The Swedish EPA is currently running a programme for the development of knowledge concerning remediation of contaminated areas (Hållbar Sanering, or Sustainable Remediation). At present a number of projects on risk assessment are being carried out within this programme. In the long term, the information gained and methodologies developed within this programme will be incorporated into methods for risk assessment, including the derivation and use of guideline values.

References

- RIVM (1990): Bodemverontreiniging en bodemecosystemen:voorstel voor C-(toetsings)warden op basis van ecotoxicologische risico's- Bijlage bij rapportnr. 725201001. Denneman CAJ and van Gestel CAM. National Institute of Public Health and Environmental Protection, Netherlands. (In Dutch)
- RIVM (1995): Derivation of the ecotoxicological serious soil contaminantion concentration. Substances evaluated in 1993 and 1994. Crommentuijn GH, Posthumus R and Kalf DF. Report 715810008. National Institute of Public Health and Environmental Protection, Netherlands.
- RIVM (1998): Ecotoxicological serious soil contamination concentrations: Fourth series of compounds. Posthumus R, Crommentuijn T and van de Plassche EJ. Report 711701003. National Institute of Public Health and Environmental Protection, Netherlands.
- RIVM (2001): Ecotoxicologcial Serious Risk Concentrations for soil, sediment and groundwater: updated proposals for first series of compounds. Verbruggen EMJ, Posthumus R and van Wezel AP. Report 711701020. National Institute of Public Health and Environmental Protection, Netherlands.
- SEPA (1996): Development of generic guideline values. Model and data used for generic guideline values for contaminated soils in Sweden. Report 4639 Swedish Environmental Protection Agency, Stockholm.
- SEPA (1997): Required measures in remediation. Guidance to verification of acceptable residual concentrations and volumes. Methods and assurance. (In Swedish) Report 4807. Swedish Environmental Protection Agency. Stockholm.
- SEPA (2005a): Model to calculate guideline values for soil. Draft version for review. In Swedish. Swedish Environmental Protection Agency. Stockholm.
- SEPA (2005b): Guidance to risk assessment of contaminated areas. Draft version for review. In Swedish. Swedish Environmental Protection Agency. Stockholm.
- SEPA/SPI (1998): Proposed guideline values for contaminated petrol stations. (In Swedish) Report 4889. Swedish Environmental Protection Agency. Stockholm.
- Öberg T, (2006): Probabilistisk riskbedömning Fas 1. Rapport till Hållbar Sanering (in Swedish). Report 5532 Swedish Environmental Protection Agency, Stockholm.

13.2 Groundwater screening values

Legal framework and future developments

Generic guideline values for groundwater have not yet been derived in Sweden. The general recommendations from the Swedish EPA state that groundwater should be considered as a limited resource that should be protected, with special concern of groundwater bodies that are suitable for the extraction of drinking water, now or in the future.

However, reference values are used to evaluate contamination in cases were groundwater has been of concern. These reference values are based on drinking water guidelines or on the deviation from local or regional background values. When there is contaminated groundwater, site specific risk assessment is recommended by the Swedish EPA. Remediation requirements are however always decided by the responsible local or regional authorities.

There are no current plans to derive generic guideline values for groundwater, but it may be done after updating the generic guideline values for soil. Possible starting points are the environmental quality criteria for groundwater (SEPA, 2000), the guidance to risk assessment (SEPA, 2005) and the principles of the risk model for contaminated soil (SEPA,1996).

References

- SEPA (1996): Development of generic guideline values. Model and data used for generic guideline values for contaminated soils in Sweden. Report 4639 Swedish Environmental Protection Agency, Stockholm.
- SEPA (2000): Environmental quality criteria. Groundwater. Report 5051. Swedish Environmental Protection Agency. Stockholm.
- SEPA (2005): Guidance to risk assessment of contaminated areas. Draft version for review. In Swedish. Swedish Environmental Protection Agency. Stockholm.

Recommendations

As environmental conditions in the European countries differ from each other, a general risk assessment model which is developed for environmental conditions common in Europe may in practice not be applicable to Swedish sites. This problem will also occur in other European countries with unique types of environment.
A European system would instead usefully consist of a tool-box of models and data which can be used during risk assessments. A number of alternative models or sub-models could be provided. This would allow the risk assessor to choose and combine the most appropriate method of risk assessment for the specific situation and allow for necessary adjustments. This type of system would be of use in countries which have not established a methodology for risk assessment of contaminated land. It would also be useful in countries with established methodologies for comparison with other available methods for risk assessment.
Besides the necessary datasets for the models, a common databank of human toxicological reference data could be useful. Similarly, a compilation and documentation of available ecotoxicological data for contaminants in soil, freshwater and groundwater would be very useful. All data should be fully documented to allow an informed choice to be made. These compilations must be updated at regular intervals in order for them to be useful over a period of time. A system for the routine contribution of new data as it becomes available would facilitate updating of the database.
A further aspect of the risk assessment process in Sweden, which has been shown to be useful, is the independence of the risk assessment from the social and economic aspects of the remediation of contaminated land. Risk assessment and estimation of the required risk reduction is carried out as a first step in the evaluation phase of an environmental site assessment. Prioritisation, optimization and design of the remediation measures are carried out at a later stage. At this stage, the estimated risks are evaluated and consideration is made of the economic and social aspects associated with risk reduction by different remediation methods.
Since the social and economic factors, as well as national laws and regulations, are expected to differ widely between different European countries, a European system for risk assessment of contaminated land will be more widely applicable if it does not include social and economic factors.

14 THE NETHERLANDS

Risk-based assessment of soil and groundwater quality in The Netherlands (Dutch Soil Protection Act)

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General framework

Two generic risk-based soil screening values have been derived to assess soil and groundwater quality: i.e. the Target Value and Intervention Value. Both screening values are based on *potential* risks, i.e. the risk that would occur under "standardized" conditions. Besides, an Intermediate Value is used, being the numerical average between Target and Intervention Values. Target, Intermediate and Intervention Values are employed independent of soil use, e.g. for a residential or industrial site, nature reserve, et cetera. From the site investigation the following implications can result:

- Concentration < Target Value (*clean soil*) means no restrictions.
- Concentration > Target Value and < Intermediate Value (*slightly contaminated soil*); (Minor) restrictions can be imposed on site management.
- Concentration > Intermediate Value and < Intervention Value (*slightly contaminated soil*) implies the triggering of a Further Investigation.
- An average soil volume concentration of at least 25 m^3 (for soil quality assessment) or an average concentration in the pore water of a water-saturated soil volume of at least 100 m^3 (for groundwater quality assessment) > Intervention Value (*seriously contaminated soil*) means that in principle remediation will be necessary; the urgency of remediation has to be determined.

The latest update of screening values will be implemented in 2007.
The purpose of determining the urgency of remediation is to distinguish between two urgency classes: urgent and non-urgent cases of serious soil contamination. Non-urgent cases are taken up in the provincial soil remediation program without a defined time for starting the remediation. For urgent cases the remediation must have been initiated within a period of four years. The determination of remediation urgency is based on *actual* (i.e. site specific) risks to human health, the ecosystem and risk due to contaminant migration.
Besides, Reference Values have been derived for acceptable soil quality after remediation. Reference Values represent sustainable soil quality of the upper soil layer, varying from 0,5 meter to 1 meter in depth depending on land-use, or for application of a layer of soil material. A distinction is made between land-use specific National Reference Values and Local Reference Values, which can be derived on a site-specific basis. National Reference Values have been derived for several specific land-uses, for immobile contaminants only. Mobile contaminants should be removed, as far this is possible on a cost-efficient basis.
Remediation of contaminated groundwater is focused on three elements: eliminate the source, remove the plume as far this is possible on a cost-efficient basis and avoid (further) contaminant spreading as far as possible.
The framework has been schematized in Fig. 1.

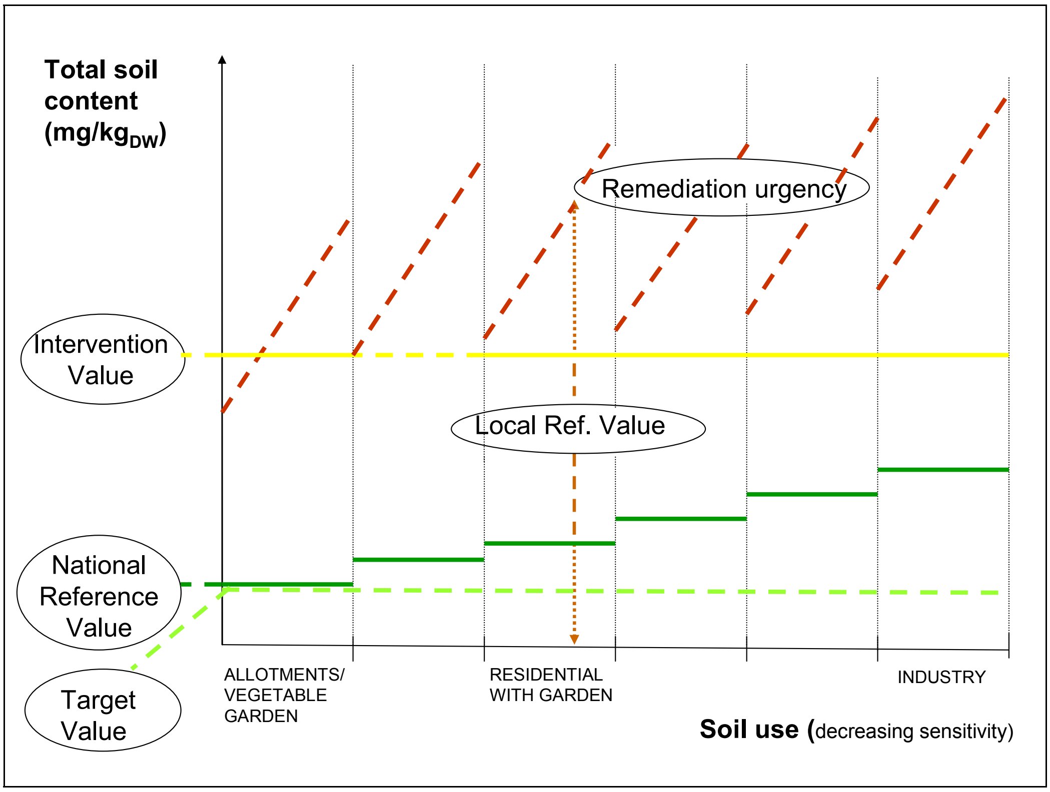

Fig. 1. Framework for soil quality assessment in the Netherlands.

All available tools, in regard to human health and ecological risk assessment and risks due to groundwater migration, are incorporated in a Toolbox.

14.1 Soil screening values

Target Value for soil

The Target Values *for soil* are related to the Negligible Risk for ecosystems. This Negligible Risk level is assumed to be 1% of the Maximal Permissible Risk level for ecosystems (MPR_{eco}) (*VROM, 1988*). This MPR_{eco} is defined as the HC5 (Hazardous Concentration for 5% of the species in the ecosystem), i.e. 95% protection.
For each contaminant two relationships, i.e. Species Sensitivity Distributions (SSDs), have been derived to quantify the ecotoxicological effects on ecosystems (*Posthuma et al., 2002*), see Fig. 2:

- the relationship between total soil concentration and the Potentially Affected Fraction (PAF) of species (representing the adverse, irreparable damage to terrestrial species composition);
- the relationship between total soil concentration and the PAF of microbial and enzymatic processes.

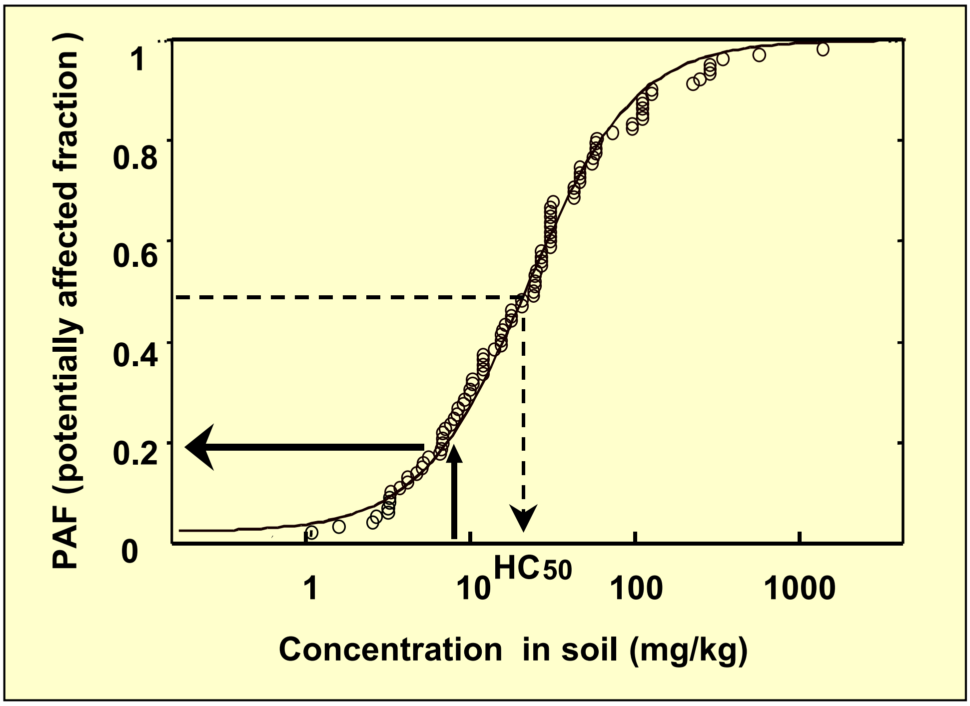

Fig. 2. Species Sensitivity Distribution (SSD).

The respective SSDs are represented by the HCp-terrestrial species and HCp-processes (Hazardous Concentration functions, where 'p' represents the threatened percentage of the ecosystem).
The SSDs are derived on an empirical basis by statistical interpretation of observed NOECs (No Observed Effect Concentrations) and LOECs (Lowest Observed Effect Concentrations) (*Aldenberg and Slob, 1993*), assuming that the sensitivity of species in an ecosystem can be described by a statistical frequency distribution. If NOECs are insufficiently available, L(E)Cs (Lethal Effect Concentrations) are used. In this case the L(E)Cs are divided by a factor of 10 to account for uncertainty. The ecotoxicological data are selected according to predefined criteria (*Traas, 2001*) and normalized for the influence of soil characteristics on the bioavailability, using the organic matter and clay content according to empirically derived formulae. If not enough data on terrestrial species and microbial processes are available to derive a reliable relationship, aquatic data are also used, in which case the aquatic effect levels are translated to terrestrial effect levels using the partition coefficient of the contaminant between solid phase and pore water, and the fraction pore water in soils (*Crommentuijn et al., 1994*). In this case an extra uncertainty factor of 10 is used.
Using the relations described above, the Target Value can be calculated as 1% of the HC5. To this purpose the lowest value of HC5-terrestrial species and HC5-processes is used. At this low soil concentration, no exposure to humans has been considered in the derivation of the Target Values. For metals the added risk approach was followed in the derivation of Target Values for soil. This means that the "natural" background concentration in soils was added to the risk-based concentration as described above (*Crommentuijn et al., 1997*).

Intervention Value for soil

The human health and the ecotoxicological risk limits have to be derived on the grounds of human toxicological and ecotoxicological risk assessment. Both values are integrated to yield the overall Intervention Values.
Human toxicological risk limit
Potential exposure
In agreement with "Premises for risk management" (*VROM*, *1988*), the human toxicological definition for serious soil contamination is taken as the soil quality resulting in exceeding of the Maximum Permissible Risk for intake (MPR_{human}). To derive human toxicological risk limits the oral and inhalative exposure are calculated, under standardized conditions (*potential* exposure), separately. Besides the MPR_{human} is derived for oral exposure and for inhalative exposure. The human toxicological risk limit is defined as the concentration of a contaminant in the soil for which the sum of the oral (inclusive dermal) and inhalative risk indexes equal 1:

$$(\Sigma \text{ oral exposure}/ MPR_{human}\text{oral}) + (\Sigma \text{ inhalative exposure}/ MPR_{human}\text{inhalative}) = 1$$

The potential exposure to contaminants in terrestrial soils is calculated using the CSOIL exposure model (*Van den Berg*, *1991/1994/1995; Otte et al.*, *2001;* see Fig.3). An exposure scenario has been defined to describe the standardized conditions. In this scenario, all exposure pathways in CSOIL are assumed to be operational on the basis of exposure to contaminants in a residential situation. In the next step the oral, dermal and inhalative exposure from all pathways is calculated for children and adults, separately. For lead a correction factor is applied for the limited availability in the human body after soil ingestion *(Oomen et al., 2006)*. Finally, the mean lifelong oral and inhalatieve exposure is calculated by summing up exposure of children and adults with a relative weight of $^{6}/_{70}$ (child during six years) and $^{64}/_{70}$ (adult during 64 years), respectively.

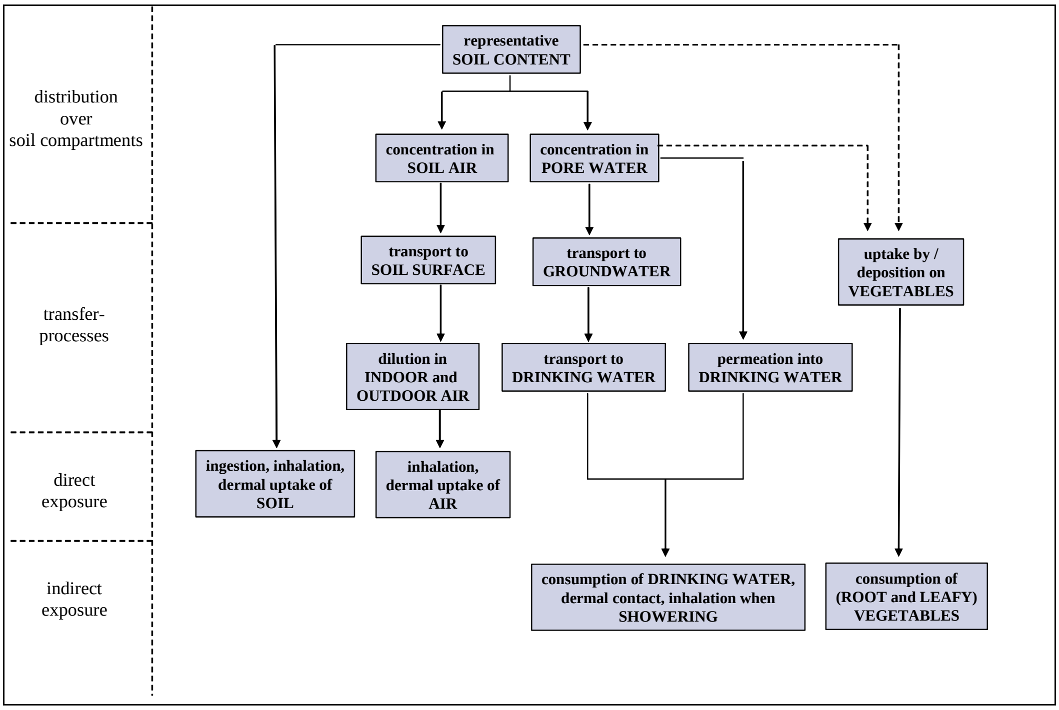

Fig. 3. Schematical lay-out of the CSOIL exposure model

Reference dose

To derive reference dose values, i.e. values for acceptable exposure, a distinction has been made between non-threshold contaminants (*genotoxic carcinogens*) and threshold contaminants (*non-carcinogens and non-genotoxic carcinogens*) (*Baars et al., 2001*).
For non-genotoxic carcinogens and non-carcinogenic contaminants (threshold contaminants), the toxicological Tolerable Daily Intake (TDI) is derived on the basis of effect data, usually on test animals, and extrapolation factors, in analogy with the procedure used by the WHO. This TDI, defined as the threshold exposure of a contaminant to which humans can be orally exposed to daily on the basis of body weight without experiencing adverse effects on health, is taken as the Maximum Permissible Risk for intake (MPR_{human}).
For genotoxic carcinogens (non-threshold contaminants) even the lowest exposure rate results in an increased chance of adverse effects for humans. The MPR_{human} is defined as the dose of a contaminant (based on body weight for oral intake or air volume for inhalator intake) which forms a risk of one additional case of lethal tumor in 10,000 lifelong exposed individuals; this definition is based on a political decision (*VROM, 1988*). The derivation of the MPR_{human} values is documented in *Janssen et al. (1995)*, *Janssen et al*. (1998) and *Baars et al. (2001)*.
The MPR_{human} for inhalation is derived from the TCA (Tolerable Concentration in Air).

Ecotoxicological risk limit

The ecotoxicological risk limit has been defined as the HC50 (Hazardous Concentration 50, i.e. 50% of the ecosystem could be affected). This risk level is much less stringent than the MPR_{eco}, which is defined as the HC5. The reason for this is a compromise between ecological acceptance (if 50% is protected the chance for recovery is acceptable) and practical use (the resulting contaminant concentrations in soil are high enough to avoid a huge part of the Netherlands being tagged as seriously contaminated). The extent of the adverse effects will vary among species and range from negligible to severe. An implication of this is that sensitive species are not protected at the level of the (ecotoxicological) risk limit. To quantify the HC50 the same SSDs are used as have been described in Section 2.1. In analogy with the derivation of the Target Value the lowest value of HC50-terrestrial species and HC50-processes is taken as ecotoxicological risk limit for the Intervention Value.

Overall Intervention Value for soil

An uncertainty score has been assigned to the human toxicological and ecotoxicological risk limits to be used during the integration of the first series (*Van den Berg and Roels, 1991*), the second series (*Van den Berg et al., 1994)*, the third series (*Kreule et al., 1995*) and the fourth series (*Kreule and Swartjes, 1998*). The same weight is given to human as to ecotoxicological protection. This means that the most stringent (i.e. the lowest) value of the human toxicological and the ecotoxicological risk limits is taken as 'the' Intervention Value. An exception is made if the lower value is much more uncertain, in which case, the higher, but more reliable value, is taken as the overall Intervention Value.
Risk for ecosystems and processes, as well as human risks are more-or-less related to the pore water concentration, rather than to the total soil concentration (*Peijnenburg et al, 1997*). For this reason, the Target and Intervention Values are corrected for organic matter and clay content (*Van den Berg et al., 1993*), and in doing so, indicate a simple correction for (bio-)availability.
The present Intervention Target and Intervention Values for soil were formalized by a Ministerial Circular (*VROM, 2000*) and have been listed in *Swartjes (1999)*.

In 2001 a major evaluation of the Intervention Values took place (*Lijzen et al., 2001*), resulting in new proposals for the first series of Intervention Values. These values, partly changed because of political considerations, will be implemented in the Dutch Soil Protection Act in 2007.

13.2 Groundwater screening values

Target Value for groundwater

The Target Values *for groundwater* are based on the Negligible Risk for aquatic ecosystems. However, because measured "natural" background metal concentrations in groundwater are exceeding these risk-based values, the Target Values for groundwater *for metals* are based on the "natural" background concentrations. When aquatic effect data for organic contaminants are lacking, the Target Value for groundwater for organic contaminants are based on other water quality standards or the detection limit.

Intervention Value for groundwater

The Intervention Value for groundwater is tuned with the Intervention Value for soil. To this purpose a risk limit is calculated on the basis of both the partitioning between the solid phase and pore water, and leaching into the groundwater. Besides a risk limit is derived that account for ecological effects in the groundwater (in analogy with the Intervention Value for soil at the HC50 level). The effect data in groundwater are supposed to correspond with the effect data in surface waters. Finally, the possible consumption of contaminated groundwater as drinking water is considered by comparing the exposure trough drinking water consumption with the acceptable human exposure (i.e. MPR_{human}). In principle the lowest of the three risk limits is taken as Intervention Value for groundwater.
The present Intervention Values for groundwater were formalized by a Ministerial Circular (*VROM, 2000*) and have been listed in *Swartjes (1999)*. The first series of Intervention Values for groundwater were also evaluated in 2001 (*Lijzen et al., 2001*). These values, partly changed because of political considerations, will also be implemented in the Dutch Soil Protection Act in 2007.

Determination of the urgency of remediation

Procedure

One main difference with the procedure used to derive generic soil and groundwater quality guidelines is that determination of the remediation urgency is based on *actual* risks. The actual risk focuses on the site-specific risks, now and in the (near) future. For assessing the remediation urgency, risk analysis is also based on risk to humans and to the ecosystem on the contaminated site. However, the risk due to contaminant migration, i.e. migration of the contaminants from a contaminated site to other targets, is also considered.

The methodology for assessing the remediation urgency accommodates the following conditions:

- the methodology is based on a tiered approach;
- the results are scientifically "sound", i.e. represent the real risks as much as possible;
- application of the methodology is "easy", i.e. applicable for a wide range of users;
- the result are uniform;
- the methodology is conservative. This means that actual risks are assumed for humans, ecosystems *and* the risk due to contaminant migration, unless it can be proved otherwise.

Actual risk for humans

Contrary to the calculation of the potential risks, the actual exposure of humans is focused on the exposure characteristics (soil properties, human behavior, et cetera) at a specific site. To this end, the exposure model CSOIL is used to assess the actual exposure to contaminated terrestrial soils, using site-specific input data. To enable assessment of exposure to sediments, the SEDISOIL model is used (*Bockting et al., 1996; Otte et al., 2000*). In the Netherlands there are many cases of groundwater contamination with volatile contaminants. The VOLASOIL model has been developed (*Waitz et al, 1996*) because the processes that determine the indoor air concentration are difficult to quantify, and the spatial and temporal variability of the indoor air concentration hampers accurate measuring. This model enables one to assess an indication of the *site specific* indoor air concentration via a crawl space as a function of type and positioning of the contaminants, building and soil characteristics, and groundwater depth.
Because of large uncertainties, calculations have, in most cases, to be combined with measurements in contact media (contaminant concentration in indoor air and in crops for exposure to terrestrial soils, and contaminant concentration in fish for exposure to sediments).

Actual risk for ecosystems

No exposure models in use for assessing the risk for ecosystems. To assess the actual ecological risks the TRIAD approach is used. In this tiered approach risk scores for three elements are combined, according to the weight of evidence procedure (*Rutgers et al., 2000)*, see Fig. 4:

- chemistry (taking bio-availability and bioaccumulation into account);
- toxicology (performing bio-assays);
- ecology (based on field surveys).

For each element in the TRIAD approach an average risk score is calculated from several calculations and/or experiments. In case the individual risk scores for the three elements demonstrate coherence the average value is taken from the three risks scores. Finally this overall risk score is compared to the overall risk score for one or more reference sites. Because these reference sites are supposed to be similar to the contaminated site, except for the presence of the contaminants in soil, the final risk score is assumed to exclusively represent the ecological effect of soil contamination.

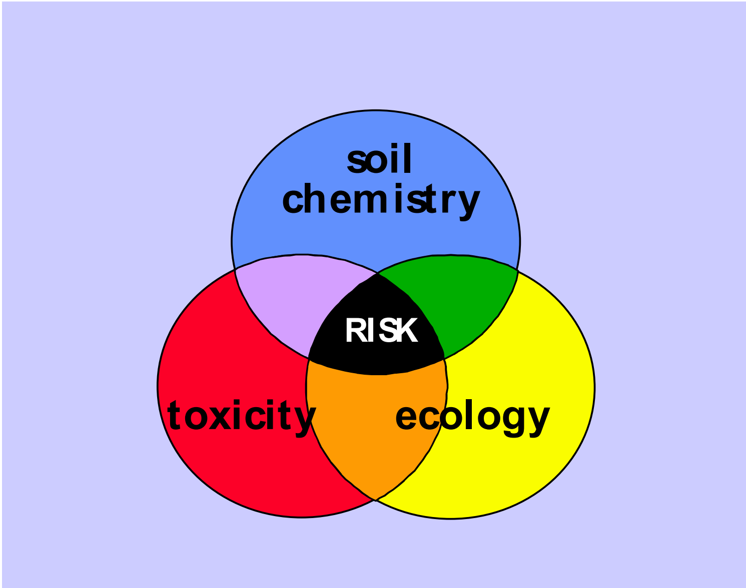

Fig. 4. Schematization of the elements involved in the TRIAD approach

Actual risk for the groundwater

To assess contaminant migration many processes might play a role, like transport of water through (subsurface) soil or aquifers, retardation of the contaminants due to sorption onto solid-phase particles, (microbiological) degradation of contaminants, precipitation/ solution reactions, diffusion and dispersion in the (subsurface) soil and aquifer, fluid transport driven by density differences and preferential flow. A (numerical) model can be used to assess the contaminant concentration at the location of a threatened target, combining (part of) the processes mentioned above. The disadvantage of these models is that a large number of parameters have to be determined and expert knowledge on model application is required. Therefore, a tiered approach has been derived. In a first step a generic formula is used, quantifying the flux of the contaminant, representing the increase in the volume of contaminated groundwater. In a second step, site-specific information is used in the flux formulae, while in a final step a (numerical) model can be used.

Reference Values

National Reference Values

National Reference Values (nRVs) for immobile contaminants have been defined for the following land-uses:

- residential sites, including garden;
- sites with the possibility for playing of children;
- allotments/ vegetable gardens;
- agriculture (excluding premise)
- nature reserves;
- green areas, with ecological value;
- other green areas, infrastructure and industry.

The values are derived according to the following four steps (*Lijzen et al., 1999;* (*Van Wezel et al., 2003*):

1. definition of land-use requirements;
2. selection of soil quality criteria;
3. derivation of risks limits for each soil quality criteria;
4. selection of nRVs.

The definition of land-use requirements is a political task. These requirements define the possibilities for specific land-uses, like for example "the possibility to consume the total amount of vegetables from a vegetable garden". In the second step soil quality criteria are selected for each land-use requirement. These soil quality criteria concern the risk-based expression of soil quality, e.g. "total exposure, including consumption of the total amount of vegetables from the vegetable garden, should not exceed the Maximal Permissible Risk for exposure".
In step 3, the derivation of risk limits for each soil quality criteria results in a risk limit, expressed as total concentration in soil. To this purpose the same tools have been used as have been described in the former sections.
Finally, in step 4, the National Reference Value is selected, usually as the lowest of all risk limits for a specific soil use (Van Breemen-Dirven et al., in press).
In the derivation of the National Reference Values several protection targets have been included, i.e. human health, the ecosystem, the groundwater, crop production (phytotoxicity), compost and surface water. Besides, background values in "relatively undisturbed soils" in the Netherlands have a prominent position in the determination of nRVs for the land-uses related to agriculture and for nature reserves.

Local Reference Values

In 2003 a Political Letter was published (*VROM, 2003*) which announced a major revision of the procedure for soil quality assessment. One of the most important changes concerns the need for an increased involvement and responsibility for local authorities. For that reason the possibility to derive Local Reference Values (lRVs), which overrule National Reference Values, will be incorporated in 2007. This offers local authorities the possibility to include site or region specific elements in the determination of a sustainable soil quality after remediation. These values could be in the range in between the nRVs and Intervention Values (see Fig. 1). In some extreme cases the lRV values can be lower than the nRV values or (for less sensitive land-use) higher than the Intervention Values.
To facilitate the derivation of lRVs a standardised procedure has been developed, not only accounting for "a traditional risk assessment based on chemical soil quality", but also for biological and physical soil quality.

References

- Aldenberg, T. and W. Slob (1993). Confidence limits for hazardous concentrations based on logistically distributed NOEC toxicity data. *Ecotox.Environ.Saf.* 25: 48-63.
- Baars, A.J., Theelen, R.M.C., P.J.C.M. Janssen, J.M. Hesse, M.E. van Apeldoorn, C.M. Meijerink, L. Verdam, M.J. Zeilmaker. Re-evaluation of the human-toxicological maximum permissible risk levels (2001). RIVM report 711701025, March 2001. RIVM, Bilthoven, The Netherlands.
- Bockting, J.G.M., J.G.M. Koolenbrander and F.A. Swartjes (1996). Model for the calculation of human exposure due to contaminated sediments (*in Dutch*). RIVM report 715810011. RIVM, Bilthoven, The Netherlands.
- Crommentuijn, G.H., E.J. Van der Plassche and J.H. Canton (1994). Guidance document on the derivation of ecotoxicological criteria for serious soil contamination in view of the intervention value for soil clean up. RIVM report 950011003. RIVM, Bilthoven, The Netherlands.
- Crommentuijn, T., M.D. Polder, and E.J. van der Plassche (1997). Maximum Permissible Concentrations and Negligible Concentrations for metals, taking background concentrations into account. RIVM report 601501001. RIVM, Bilthoven, The Netherlands.
- Janssen, P.J.C.M., M.E. Van Apeldoorn, J.E.M. Van Koten-Vermeulen, and W.C. Mennes (1995). Human-toxicological criteria for serious soil contamination: Compounds evaluated in 1993 & 1994. RIVM report 715810009. RIVM, Bilthoven, The Netherlands.
- Janssen, P.J.C.M., M.E. Van Apeldoorn, J.G.M. van Engelen, P.C.J.I. Schielen, and M.F.A. Wouters (1998). Maximal Permissible Risk Levels for Human Intake of Soil Contaminants: Fourth series of compounds. RIVM report 711701004. RIVM, Bilthoven, The Netherlands.
- Kreule, P., R. Van den Berg, M.F.W. Waitz, and F.A. Swartjes (1995). Calculation of human-toxicological serious soil contamination concentrations and proposals for intervention values for clean-up of soil and groundwater: Third series of compounds. RIVM report 715810010. RIVM, Bilthoven, The Netherlands.
- Kreule, P. and F.A. Swartjes (1998). Proposals for Intervention Values for soil and groundwater, including the calculation of the human-toxicological serious soil contamination concentrations: Fourth series of compounds. RIVM report 711701005. RIVM, Bilthoven, The Netherlands.
- Lijzen, J.P.A., F.A. Swartjes, P.F. Otte, J. Willems. 1999.
- Soil-use specific Remediation Objectives. Procedure and results (*in Dutch*): RIVM report 711701016. RIVM, Bilthoven, The Netherlands.
- Lijzen, J.P.A., A.J. Baars, P.F. Otte, M.G.J. Rikken, F.A. Swartjes, E.M.J. Verbruggen, A.P. Van Wezel. 2001. Technical evaluation of the Intervention Values for Soil/sediment and groundwater. RIVM report 711701023, February 2001. RIVM, Bilthoven, The Netherlands.
- Oomen A.G., E.F.A. Brandon, F.A. Swartjes, A.J.A.M. Sips. 2006.
- How can information on oral bioavailability improve human health risk assessment for lead-contaminated soils? Implementation and scientific basis. RIVM report 711701042. RIVM, Bilthoven, The Netherlands.
- Otte, P., M. van Elswijk, M. Bleijenberg, F. Swartjes, K. van der Guchte. 2000. Berekening van humane risicogrenzen voor waterbodems (*in Dutch*). RIZA werkdocument 2000.084x. RIZA/ RIVM, Mai 2000.
- Peijnenburg, W.J.G.M., L. Posthuma, H.J.P. Eijsackers, and H.E. Allen (1997). A conceptual framework for implementation of bioavailability of metals for environmental management purposes, *Ecotox.Environ.Saf.* 37: 163-172.

- Posthuma, L., G.W. Suter, T.P. Traas (2002). Species Sensitivity Distributions in ecotoxicology. CRS-press, Pensacola, FL, USA.
- Rutgers, M., J. Postma, J. Faber (2000). Basic approach for site specific, land-use specific ecological risk assessment of soil contamination in practice. Program Integrated Soil Research report 29, PGBO Wageningen.
- Swartjes, Frank A.. 1999. Risk-Based Assessment of Soil and Groundwater Quality in the Netherlands: Standards and Remediation Urgency. Risk Analysis, Vol. 19, No. 6, 1999.
- Traas, T.P. 2001.
- Guidance document on deriving environmental risk limits. RIVM report 601501012. RIVM, Bilthoven, The Netherlands.
- Van den Berg, R. and J.M. Roels (1991). Assessment of risks to man and the environment in case of exposure to soil contamination. Integration of the results of the proceeding studies. RIVM report 725201013. RIVM, Bilthoven, The Netherlands.
- Van den Berg, R. (1991/ 1994/ 1995). Exposure of man to soil contamination. A qualitative and quantitative analysis, resulting in proposals for human-toxicological C-Values (revision of the 1991 and 1994 reports). RIVM report 725201011. RIVM, Bilthoven, The Netherlands.
- Van den Berg, R., C.A.J. Denneman, and J.M. Roels (1993). Risk assessment of contaminated soil - Proposals for adjusted, toxicologically based Dutch soil clean-up criteria. In: Arendt et al., 1993 (Eds.). Contaminated Soil '93. Kluwer Academic Publ., The Netherlands.
- Van den Berg, R., G.J.M. Bockting, G.H. Crommentuijn, and P.J.C.M. Janssen (1994). Proposals for intervention values for soil clean up: Second series of chemicals. RIVM report 715810004. RIVM, Bilthoven, The Netherlands.
- Van Wezel, A., W. de Vries, M. Beek. Land-use specific Remediation Objectives for Agriculture, Nature reserves and Sediments. RIVM report 711701031. RIVM, Bilthoven, The Netherlands.
- VROM (1988). Premises for risk management (annex to the Dutch Environmental Policy Plan). Lower House, session 1988-1989, 21 137, no. 5.
- VROM (1991). Environmental quality objectives for soil and water. Lower House, session 1990-1991, 21 990, no. 1. (*in Dutch*)
- VROM (2000). Ministerial Circular on Target and Intervention Values (*in Dutch*). DBO/1999226863. 4 February 2000.
- VROM (2003). Political Letter on Soil (*in Dutch*). BWL/2003096250. December 2003.
- Waitz, F.M.W., J.L. Freijer, P. Kreule and F.A. Swartjes (1996). The VOLASOIL risk assessment model based on CSOIL for soils contaminated with volatile compounds. RIVM report 715810014. RIVM, Bilthoven, The Netherlands.

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14.1 Soil Screening Values

Legal Framework

Section 57 of Part 2A of the Environmental Protection Act 1990 (Crown Copyright, 2000) introduced a new statutory regime for the identification, assessment and remediation of contaminated land in England and Wales. It states that:

> *'Contaminated land' is any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that –*
>
> *significant harm is being caused or there is a significant possibility of such harm being caused; or pollution of controlled waters is being, or is likely to be, caused.*

In response to this the Environment Agency and the Department for Environment, Food and Rural Affairs (Defra) have developed risk-based procedures for assessing harm from contaminated sites to humans and ecosystems. There are significant differences in the approaches used to assess ecosystems and human receptors.

Scientific Basis

A tiered approach was developed for the assessment of risks to human and ecosystem receptors based on the Government's guidance for environmental risk assessment (DETR *et al*, 2000). Figure 1 illustrates the framework contained in the guidance. The approach consists of tiers that require further information the higher the tier of assessment.
The first requirement for a human health assessment is the identification of linkages between contaminant, receptor and pathway in a properly justified conceptual model (Tier 1). Once this has been identified a Tier 2 assessment is carried out using values derived using a generic conceptual model. The parameter values used in the calculations of Tier 2 assessment criteria are based on UK specific soils and receptor exposure parameters. Soil Guideline Values (SGVs) were calculated to be used in a Tier 2 assessment. The Contaminated Land Exposure Assessment (CLEA) model was used to calculate the SGVs (Defra and Environment Agency 2002d). The CLEA model incorporates some exposure parameters, such as body weight, that are probabilistic.

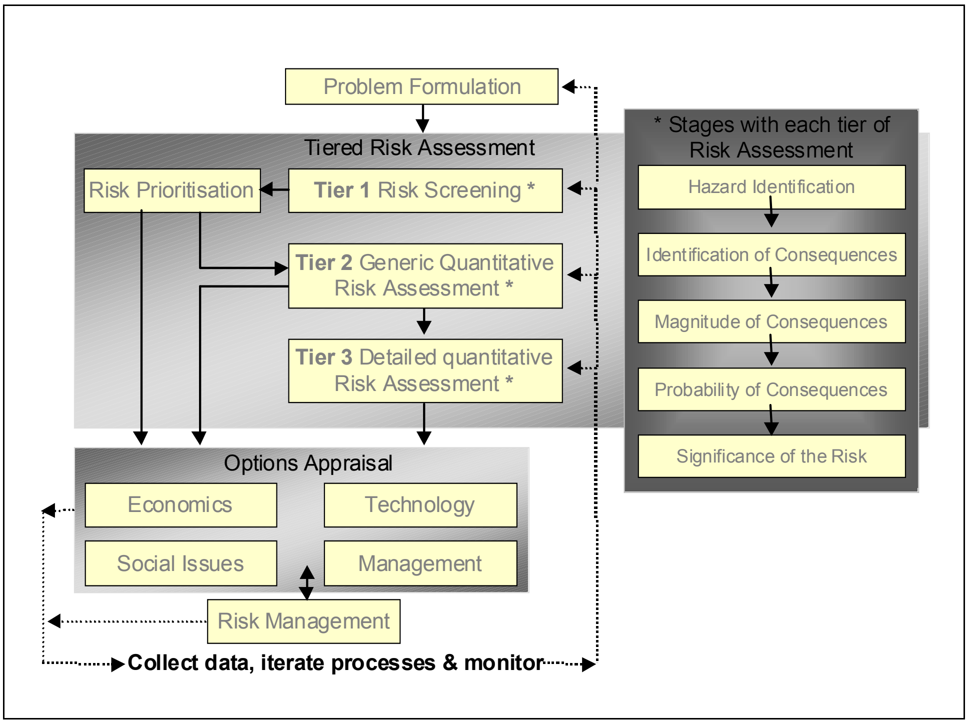


Fig. 1. UK Environmental Risk Assessment Framework (DETR et al 2000)

The ecological risk assessment (ERA) framework relies on the collection and interpretation of chemical, biological and ecological information (the *triad* approach). Each line of evidence is examined to determine whether it is: consistent with the exceedance of a threshold, inconsistent with exceedance, or ambiguous (weight-of-evidence; *cf.* Suter, 1997). The objective of the ERA is the requirement to demonstrate harm at the site or location being investigated. This depends upon the presence (or the potential) of one or more linkages between sources of contamination, ecological receptors and a route of exposure (pathway). Part 2A defines the types of receptors that may be investigated under this regime. These are of high conservational value and are confined to protected locations (*e.g.* Sites of Special Scientific Interest). Although primarily intended for use in Part 2A, the framework could also be used to support other regimes where ecological protection is the objective (*e.g.* Habitats Directive).

Technical Approaches

Defra and the Environment Agency have published a suite of reports, CLR7-10 (Defra & Environment Agency 2002a,b,c,d), which set out a procedure for assessing the risk to human health from contaminated sites. This procedure uses Soil Guideline Values (SGVs); SGVs are intervention values which, if exceeded, may trigger further assessment or remedial action.
Soil Screening Values (SSVs) were developed for ecological protection and are used in a manner similar to the use of SGVs. Thus, where concentrations of a particular contaminant in soil at a site exceed SSVs, further investigation may be required. The SSVs should afford a level of protection to terrestrial species and critical ecological functions.

Where contaminated sites poses a potential risk to both human *and* ecological health, initial screening would employ both SSVs and SGVs. Exceeding *either* screening value indicates the need for further investigation.

Human Health Screening Values

The three tiers used in the assessment of contaminated sites are:

- Tier 1 Preliminary risk assessment (risk screening)
- Tier 2 Generic quantitative risk assessment
- Tier 3 Detailed quantitative risk assessment.

Once the need for risk assessment has been identified, it will always be necessary to carry out a preliminary risk assessment. Depending on the circumstances and the outcome, it may not be necessary to carry out further risk assessment, or it may be appropriate to use only one of the two approaches to quantitative risk assessment rather than both. The approach used in the derivation of the SGVs is fully detailed in report CLR10 (Defra and Environment Agency 2002d).

Conceptual Model

The conceptual exposure models used in the derivation of Soil Guideline Values are based on three elements: land-use, fate and transport of contaminants, and contaminant toxicology. Conceptual Models were derived for three main land uses:

- Residential (female child receptor of 0 to 6 years)
- Allotments (female child receptor of 0 to 6 years)
- Commercial / Industrial (female adult worker of 16-59 years).

The residential land use is further subdivided into two uses (with or without plant uptake) to take into account the fact that not all residences have private gardens where vegetables are grown and consumed.

For each of the land uses a critical receptor has been identified and these are listed in the brackets after each land use above. These receptors are characterised by a predefined set of exposure parameters. Some of these parameters are defined by probability density functions (PDFs) populated with data from the UK population.

CLEA is partially probabilistic and overall exposure needs to be calculated using the PDFs for each receptor before a comparison with the HCV can be made. In order to determine the overall exposure CLEA calculates exposure using the PDF for each age class and for the selected critical receptor. For example, if the child of age class 0-6 years is the critical receptor then CLEA calculates the exposure using the PDF for each year. The 95^{th} percentile of the exposure is then selected from the exposure PDF for each year and these are then average to calculate an overall exposure for this critical receptor. The model also has the flexibility to include other receptor ages beyond the working life of an adult.

The exposure pathways included in the CLEA model are listed below.

Exposure Pathway	
Ingestion of soil	λ
Ingestion of household dust	λ
Ingestion of contaminated vegetables	λ
Ingestion of soil attached to vegetables	λ
Dermal contact with soil	λ
Dermal contact with household dust	λ
Inhalation of fugitive soil dust	λ
Inhalation of fugitive household dust	λ
Inhalation of vapours outside	λ
Inhalation of vapours inside	λ
Notes	
λ Included in the default conceptual model λ Optional to include in the default conceptual model	

Exposure Modelling

In deriving Soil Guideline Values, the CLEA model is used to estimate average daily human exposure (ADE) to soil contamination based on the conceptual exposure models for each standard land-use. CLEA considers the following routes of human exposure:

- Ingestion of contaminated soil and produce via the mouth
- Inhalation of contaminated dust[15] and vapour via the nose and mouth
- Absorption of the contaminant through the skin.

Equation 1

$$\text{ADE} = \frac{(IR_{inh} \times EF_{inh} \times ED_{inh})}{BW \times AT} + \frac{(IR_{oral} \times EF_{oral} \times ED_{oral})}{BW \times AT} + \frac{(IR_{dermal} \times EF_{dermal} \times ED_{dermal})}{BW \times AT}$$

Where:

ADE is the average daily human exposure to a chemical from soil (mg. kg^{-1} bw.day^{-1})
IR is the chemical exposure rate (mg.day^{-1})
EF is the exposure frequency (days.year^{-1})
ED is the exposure duration (years)
BW is human body weight (kg)
AT is the averaging time (days)

The subscripts inh, oral, and dermal apply to the inhalation, ingestion, and dermal contact routes respectively. IR_{oral} and IR_{inh} are normally measured as intakes. IR_{dermal} is normally measured as an uptake.

[15] Inhaled dust can also be ingested and swallowed as part of mucus / spittle after inhalation.

Fate and transport models are used to generate some of the chemical exposure rates such as those for:

- Uptake of contaminant into vegetables
- Volatilisation of contaminants to outdoor air
- Migration and subsequent concentration of contaminants to indoor air.

Uptake of contaminants into vegetables is modelled using the Briggs-Ryan approach (Briggs *et al* 1982; Ryan *et al* 1988) whilst the volatilisation of contaminants and migration into buildings is modelled using the Johnson and Ettinger (1991) approach.

Toxicological Assessment

In setting suitable health criteria values (HCVs) a distinction is made between chemicals with critical health effects for which there is considered to be a threshold and those chemicals for which a threshold for health effects cannot be assumed. Within toxicity it is often assumed that there is a threshold level of toxicant that needs to be present to produce an effect leading to the adverse effects. That is, there is a threshold level below which there is no effect. In some areas of toxicity, especially those for mutagenic and genotoxic carcinogens there is no theoretical reason why a single molecule should not trigger a tumour or mutation, possibly expressed in subsequent generations. For these substances no threshold can be assumed and so it is assumed that they carry some risk at any level of exposure.

The approach used to derive HCVs therefore differs for contaminants exhibiting threshold or non-threshold effects. In the context of deriving SGVs, when dealing with threshold effects, a certain amount of intake of a chemical can be tolerated and Tolerable Daily Intakes (TDIs) are derived. For non-threshold contaminants, Index Doses are derived and they convey minimal risk levels, with the additional requirement to keep any intake as low as reasonably practicable (ALARP).

The Index Dose differs from the TDI in a number of aspects. One important difference is the approach taken to background exposure[16]. In setting health criteria values for threshold effects, a proportion of the TDI is allocated to tolerable exposure from contaminants in soil that takes into account the general level of background exposure. This fraction of the TDI is referred to as the Tolerable Daily Soil Intake (TDSI) and it is this value that is used as the health criteria value for the derivation of the Soil Guideline Values.

Exposure to chemicals from soil may occur by ingestion, inhalation, and through the skin. A chemical substance may have a different health criteria value for each route of entry into the body. In theory, it is always possible that exposures via all three routes may combine to produce an adverse effect on health. Furthermore, the possibility of combined action to produce some adverse health effect cannot be excluded even if one or more of the relevant HCVs are based on health effects at the initial site of contact between the body and the chemical. Equation 1 above assumes that only one HCV would be available for the assessment. However, if HCVs are identified for other routes then the ADE for each route of exposure would be compared with a relevant HCV.

It must be noted that for non-threshold substances the UK has not specified an acceptable level of risk. Therefore, the HCV derived for non-threshold substances are not derived on this basis but on the basis of a hierarchy of authoritative sources developed specifically for soil contamination (Defra and Environment Agency 2002c).

[16] Described in CLR9 (DEFRA and the Environment Agency, 2001c) as the mean daily intake (MDI) for the UK population in terms of *the average 'background intake' to which that population may be exposed*. The MDI is estimated from published information on ambient air concentrations and average concentrations measured in water and food products. Where relevant, other sources are also considered (for example, the exposure of the general population to mercury vapour from dental amalgam).

Derivation of Screening Values

In deriving the Soil Guideline Values, the probabilistic parameters in the CLEA model are sampled 5000 times and the 95th percentile of the predicted exposure compared with the health criteria value. (See R&D Publication CLR10 for a detailed discussion (Defra and Environment Agency, 2002d)). The Soil Guideline Values are reported as a function of the land uses indicated above and for soils containing 1%, 2.5% and 5 % soil organic matter (SOM) content. A report is published for each contaminant, which includes the modelling details and the derived values with any uncertainties associated with the final value clearly indicated.

Modelling Tools

Defra and the Environment Agency have published a version of the modelling software used in the derivation of the first batch of SGVs. The software (CLEA 2002) had limited functionality and could not be used for deriving values for other contaminants. However, Defra and the Environment Agency will shortly be releasing a new version of the software which will allow users to add contaminants to the database and derive their own values.

Ecological screening values

Conceptual model

Tier zero in the ERA framework is to determine whether there is a potential pollutant linkage in the area under investigation between the source of contamination and a receptor via a pathway for exposure.
This information is compiled into a conceptual site model (CSM). The CSM is revisited at each stage of the risk assessment and updated as further information is gathered or lines of investigation are closed down. The CSM drives the investigation as it establishes a firm basis for continuing or terminating the assessment ensuring resources are allocated proportionately.
Where there is a plausible pollutant linkage, the assessment moves to Tier One of the ERA Framework. This is where the nature of the contamination is determined and field measured concentrations are compared against SSVs to determine if further investigations are warranted.

Exposure Modelling

Soil screening values are effects-based triggers. Exposure modelling is not a component of Tier One of the ERA Framework.

Ecotoxicological Assessment

Ecotoxicological and ecological assessments are undertaken at Tier Two of the ERA framework. Only when the risk assessor is sure that there are contaminants at a level likely to be a risk to ecosystems (Tier One) does the assessment move on to linking those contaminants to a measurable and harmful effect.

Derivation of Screening Values

The SSVs have been derived deterministically from ecotoxicological data using the methodology set out in the European Union Technical Guidance Document (TGD)(ECB, 2003; Environment Agency, 2004). From a regulatory perspective consistency across regimes is achieved through the use of this methodology. For ex-

ample, the TGD is also being used to derive water quality standards under Article 16 of the Water Framework Directive (2000/60EC) and is being used by other Member States for derivation of multi-media risk limits (van Vlaardingen *et al*., 2005).
The SSVs are predicted no effect concentrations (PNECs) and are compared with concentrations of the contaminant measured in soil at the site being assessed (predicted environmental concentrations or measured environmental concentrations (P)ECs). The (P)EC:SSV ratio provides a risk quotient which can be used to assess potential risk. The quotient method is widely used to express risk but is best suited to assessing high or low risk situations. When the ratio is close to unity additional information will almost certainly be necessary. Contaminants that exceed SSVs would be considered as contaminants of concern and warrant further investigation.
Where our priority contaminants correspond with European risk assessment reports, then PNECsoils are being adopted directly. Recently new methods discussed at a European level, under Existing Substances Regulations (ESR) and voluntary risk assessments, may allow further information on a site and a contaminant to be taken in to account. The UK is proposing a structured process within Tier One to refine a screening assessment (see Section 1.3.3.3).

Modelling Tools

Modelling is not a component of Tier One of the ERA Framework.

Application of Soil Screening Values

Integration of Human Health and Ecological Screening Values

Human and ecological screening values are not integrated in the UK. The UK legislation states that all receptors listed must be assessed on the basis of significant harm or significant possibility of significant harm. Therefore, where contaminated sites poses a potential risk to one or more receptors, then all receptors must be protected. During an initial assessment values or criteria derived for all receptors should be used (for ecosystems and human health these should be SSVs and SGVs). Exceeding *any* criteria indicates the need for further investigation.
The priority lists of contaminants differ for SGVs and SSVs (Defra, 2002b; Environment Agency, 2003). Priority contaminants are linked to hazard characterisations and only those contaminants that are a hazard to humans and/or ecosystems and are likely to be found in contaminated land in the UK are prioritised.

Scientific, Economic and Social Factors

At present the SGVs do not incorporate economic factors. These factors are only brought to bear during the selection of remedial actions. Recommending the EU TGD as a method that is suitable for setting SSVs for Part 2A regulations has been made because the TGD meets the following scientific criteria:

- Protects at the 95th percentile level of a statistical distribution. This is consistent with our policies on human health protection (Defra and Environment Agency, 2002a)
- Protects against sublethal effects that may have long-term impacts on populations
- Protects microbes, invertebrates and plants as a minimum, and higher organisms where contaminants are likely to bioaccumulate in the food chain

Socio-economic factors are not built in to the SSVs *per se*. But these factors are considered in the wider risk-based decisions when assessing and managing contaminated land in the UK.

Comparison with Monitoring Concentrations

An understanding of how soil properties affect the availability and subsequently the bioavailability of a substance, allows for an accurate assessment of risk. The UK is proposing a structured process within Tier One to refine a screening assessment for metals to incorporate this understanding (Merrington *et al.*, 2006).
The process involves four possible steps to refining or modifying the measured environmental concentration (P)EC. The modifications could be applied to either the SSV or the (P)EC, but by refining the (P)EC there is only one single SSV across the UK. Further, the refinements of the (P)EC are aimed at correcting the measured exposure for the contaminant of concern to a 'real' or 'effective' exposure level. The modifications can be made in the following way:

- Step 1 is a direct comparison of the (P)EC at the site with the SSV.
- For metals Step 2 considers the use of background concentrations but should only be used to modify (P)ECs where an SSV is based on the 'added' chemical and not total concentration. There are a number of possible values for background concentrations that could be used here ranging from a national background concentration for UK soils; a generic value for soils type (e.g. sandy); to a locally derived value. Site specificity and realism increases with each refinement.
- In Step 3 the risk assessor refines the (P)EC using a laboratory to field extrapolation factor. Toxicity data used in the derivation of SSVs is usually from tests under laboratory conditions (high availability), whereas contaminants in site soils may have aged (low availability). Where empirical data is available for comparative observations in the laboratory and the field, a factor can be applied to the (P)EC to adjust for these differences.
- In Step 4 understanding of the soil characteristics that influence the ecotoxicology of metals has developed considerably. Following recent developments in the environmental risk assessment of zinc under the Existing Substances Regulations (The Netherlands, 2004) significant relationships have been demonstrated between observed toxicity and soil pH, cation exchange capacity (CEC) and background zinc concentration. These relationships can be used in Tier One to adjust the (P)EC.

At each stage of the refinement, the (P)EC is compared against the SSV. If by the end of the above sequence the level of contamination exceeds the SSVs and no further refinements are possible - then the risk assessment moves to Tier Two of the ERA Framework.

Scientific and Practical Weaknesses

Lack or deficiency in data for the assessment of risks to human and ecological receptors is always an important uncertainty. Some contaminants have been studied a great deal and therefore data is available on the contaminant fate and transport and effects. This is not the case for most contaminants and therefore decisions are made based on limited data. Therefore, a certain level of precaution is always inherent in the derivation of generic screening values.

Human Health

The fate and transport models used in deriving the SGVs do not always mimic nature and therefore there are some uncertainties in the calculation of contaminant concentrations in the media of interest. For example, the Briggs-Ryan plant uptake model does not accurately predict plant uptake of contaminants and this is one area of work that the Environment Agency is currently pursuing. There are also uncertainties in the prediction of indoor air concentration. The models used to calculate concentrations of contaminants in indoor air and in vegetables may be conservative in nature. It should be noted that the SGVs are generic values for specific land uses and as such need to be protective for very generic circumstances. If the SGVs are exceeded there is always the option to carry out further assessment by using more site-specific information in a Detailed Quantitative Risk Assessment (DQRA) as illustrated in Figure 1.

Ecosystems

SSVs aim to be precautionary to ensure that all the potential sites of concern are captured at the screening stage. They are, however, generic values and may not account for geological differences and background concentrations of metals at a site-specific level. The proposed series of refinements in Steps 1-4 lead towards site-specific measures.

The ERA framework has been trialled by UK industries working in partnership with the Environment Agency. The partners applied the framework to their own potentially contaminated sites to assess the practicality of proposed activities and decision-making criteria, including SSVs and refining (P)ECs. The partners view the strengths of the draft framework to be its tiered nature and the early development of a CSM. A good CSM backed up with supporting evidence can mean that assessors may exit the framework early on where a pollutant linkage is unlikely. Partners consider some draft SSVs to be too conservative for practical application.

The Environment Agency is continuing to work with industry, Government and conservation agencies to address practical weaknesses in the framework. One such improvement is the Tier One process for refining measures of metal concentrations in soils to take account of site-specific differences in background concentrations making for a more ecologically realistic comparison with SSVs. In addition, funding is being secured to estimate ambient background concentrations of metals in UK soils. This will help to show if SSVs are too precautionary.

The findings of the partnership are being used to inform the further development of ERA Framework ensuring that it will be scientifically robust and practical.

Future Developments

The Environment Agency, with funding from UK Government, manages an ongoing programme of research to develop SGVs and SSVs for priority contaminants. Currently the priority list for SGV development contains 55 substances. The SGV work programme is to complete the derivation and publication of all 55 substances by 2009. Once this has been achieved a review process of all publications within the CLEA programme of work will commence. This will allow the UK government to ensure that the most up to date approaches are being used in the assessment of land contamination and that uncertainties are further reduced as scientific advances are made. In addition, Defra and the Environment Agency will be releasing a beta version of the new CLEA software in the winter of 2005. The new software (CLEA UK) will be available for download from the Environment Agency's web site (www.environment-agency.gov.uk).

The draft ERA framework has undergone three phases of consultation; a public consultation, road-testing with industry and a workshop with UK stakeholders. Feedback is now being used to improve the framework. The Environment Agency is continuing to work with practitioners to address the problems encountered so far to ensure that the final framework is fit for purpose. A strong message from a recent workshop was that even when we have an agreed framework it should remain flexible so that improvements can be made as ERA becomes better understood. Many practitioners see the value of end users and regulators working together and welcome the openness with which the framework is being developed. Specifically in relation to SSVs, it is likely that they will be revisited as the EU TGD is updated and new methodologies are discussed in the Technical Meetings (now Technical Committee for New and Existing Substances, TCNES) of Member States in the EU as part of the Existing Substances Regulation process.

References

- Briggs, G.G., Bromilow, R.H., and Evans, A.A. (1982) Relationship between lipophilicity and root uptake and translocation of non-ionised chemicals in barley. *Pesticide Science* 13: 495-504
- Crown Copyright (2000). The Contaminated Land (England) Regulations. Statutory Instrument 2000/227, The Stationery Office, London.
- Department for the Environment, Transport and the Regions (DETR), Circular 02/2000, Contaminated Land: Implementation of Part 2A of the Environmental Protection Act 1990. DETR.
- Defra and the Environment Agency (2002a) CLR 7 Assessment of risks to human health from contaminated sites: an overview of the development of soil guideline values and related research.
- Defra and the Environment Agency (2002b) CLR 8 Potential contaminants for the assessment of land.
- Defra and the Environment Agency (2002c) CLR 9 Contaminants in soils; Collation of toxicological data and intake values for humans.
- Defra and the Environment Agency (2002d) CLR 10 The Contaminated Land Exposure Assessment Model (CLEA): Technical basis and algorithms.
- ECB (2003) Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC on Risk Assessment for new notified substances, Commission Regulation (EC) No 1488/94 on Risk Assessment of existing substances and Directive 98/8/EC of the European Parliament and of the Council concerning the placing of biocidal products on the market. European Commission, Joint Research Centre, EUR 20418 EN.
- Environment Agency (2002) Assessing risks to ecosystems from land contamination. R&D Technical Report P299.
- Environment Agency (2003) Ecological risk assessment: A public consultation on a framework and methods for assessing harm to ecosystems from contaminants in soil.
- Environment Agency (2004) Soil screening values for use in ecological risk assessment. R&D Technical Report P5-091/TR, Environment Agency.
- Johnson P and Ettinger R (1991) Heuristic model for predicting the intrusion rate of contaminant vapours into buildings. *Environmental Science and Technology* 25(8): 1445 – 1452
- Merrington G, Fishwick S, and Brooke, D (2006) The derivation and use of soil screening values for metals for the ecological risk assessment of contaminated land: a regulatory perspective. *Land Contamination and Reclamation* 14 (3): 673 - 684
- Ryan, J.A., Bell, R.M., Davidson, J.M., and O'Connor, G.A. (1988) Plant uptake of non-ionic organic chemicals from soils. *Chemosphere* 17: 2299-2323

- Suter II, G. W. (1997) A framework for assessing ecological risks of petroleum-derived materials in soil. Oak Ridge TN, USA: *Oak Ridge National Laboratory*. Report ORNL/TM-13408, 78.
- The Netherlands (2004) Risk Assessment Report: Zinc metal. Final draft of December 2004 (R073_0412_env).
- van Vlaardingen, P.L.A., Posthumus, R. Posthuma-Doodeman, C.J.A.M. (2005) Environmental Risk Limits for nine trace elements. RIVM Report 601501029/2005. Bilthoven, The Netherlands.

14.2 Groundwater Screening values

Groundwater as a receptor is identified by the Part 2A regime but it is addressed under other more appropriate legislation – the European Groundwater Directive. However, this is soon to be superseded by the Water Framework Directive and a new daughter Directive. Until such a time, the Groundwater Standards derived by the EC still apply to pollution of groundwaters. The Nitrates Directive also applies as do the Plant Protection Substances and Biocides Directives, although it is less likely that these kinds of contamination will occur in Part 2A situations.

ANNEX 3

SCREENING VALUE

AUSTRIA

Austrian Standard S 2088-2 (2000-06-01)

Contaminated sites – Risk assessment for polluted soil concerning impacts on surface environments

Table 1. Guideline values for uses for which a direct hazard from oral intake of contaminated topsoil (0-10 cm) cannot be excluded (e.g. residential areas, sport fields, playgrounds)

Parameter	Unit	Trigger-Value	Intervention-Value*
Antimony (Sb)	mg/kg dw	2	5
Arsenic (As)	mg/kg dw	20	50
Lead (Pb)	mg/kg dw	100	500
Cadmium (Cd)	mg/kg dw	2	10
Chromium (Cr)	mg/kg dw	50	250
Copper (Cu)	mg/kg dw	100	600
Nickel (Ni)	mg/kg dw	70	140
Mercury (Hg)	mg/kg dw	2	10
Thallium (Tl)	mg/kg dw	2	10
Cyanide (CN total)	mg/kg dw	5	50
Fluoride (F)	mg/kg dw	200	1.000
Hydrocarbons (mineral oil)	mg/kg dw	50	---
PCDD/F	ng TE /kg dw	10	100
PCB	mg/kg dw	0,2	1
PAH	mg/kg dw	1	50
Benz(a)pyrene (BaP)	mg/kg dw	0,5	5

Table 2. Guideline values for pollutant concentrations in topsoil used for agricultural or gardening purposes, as well as non-agrarian ecosystems

Parameter	Unit	Trigger-Value
Antimony (Sb)	mg/kg dw	2
Arsenic (As)	mg/kg dw	20
Lead (Pb)	mg/kg dw	100
Cadmium (Cd)	mg/kg dw	1
Chromium (Cr)	mg/kg dw	100
Copper (Cu)	mg/kg dw	100
Nickel (Ni)	mg/kg dw	60
Mercury (Hg)	mg/kg dw	1
Thallium (Tl)	mg/kg dw	1
Vanadium (V)	mg/kg dw	50
Zinc (Zn)	mg/kg dw	300
Fluoride (F total)	mg/kg dw	200
Cyanide (CN total)	mg/kg dw	5
Hydrocarbons (mineral oil)	mg/kg dw	200
PCDD/F	ng TE /kg dw	10
PCB	mg/kg dw	0,3
PAH	mg/kg dw	1

If the trigger value is exceeded soil conditions (clay content, organic matter – humic content, colour – indication of ironhydroxides) can be considered for a simple estimation about sorption of metals and organic contaminants (only clay and humic content). If this estimations shows a probability for desorption and possibilty for higher mobilisation a NH4-NO3-extrakt of soil samples can/should be done. For agricultural uses no intervention-values are provided.

Table 9. Guideline values for assessing the content of mobilisable elements in the NH4-NO3-extrakt of soil samples (0-20 cm) with regard to soil-plant transfer (modified to PRUESS, 1994)

Parameter	Unit	Trigger-Value a	Trigger-Value b
Arsenic (As)	µg/kg dw	100	600
Lead (Pb)	µg/kg dw	300	#
Cadmium (Cd)	µg/kg dw	40	#
Chromium (Cr)	µg/kg dw	100**	---
Copper (Cu)	µg/kg dw	800§	1.500
Nickel (Ni)	µg/kg dw	#	1.000
Mercury (Hg)	µg/kg dw	5	#
Zinc (Zn)	µg/kg dw	#	4.000

Trigger value a: above the trigger value there is a potential risk of impaired food and forage crop quality
Trigger value b: above the trigger value there is a potential risk of impaired plant growth
§ ... is mainly used for forage plants in sheep farming
# ... no impaired functions expected
** .. for forage plants

AUSTRIA

ÖNORM S 2088-1: Table 4 - Screening Values for groundwater (inorganic parameters)

Parameter	Unit	MQL - min. quantification limit	Difference to local BL		Trigger Value [3])	Intervention Threshold Value [4)]
			A [1])	B [2])		
General phys.-chem. Parameters						
Conductivity	µS/cm	-	25%	-	-	-
pH		-	-	-	< 6,5 bzw. > 9,5	-
hadrness (total)	°dH	1	25%	-	-	-
hardness (carbonate)	°dH	1	25%	-	-	-
Hydrogencarbonate	mg/l	3	100%	50%	-	-
KMnO4	mg/l	0,5	100%	50%	12	20
Oxygen (in Solution)	mg/l	0,2	-50%	-	-	-
INORGANIC PARAMETERS - Elements (Ions)						
Al - Aluminium	mg/l	0,01	300%	150%	0,12	0,2
As - Arsen	mg/l	0,001	300%	100%	0,006	0,01
B - Bor	mg/l	0,02	100%	50%	0,6	1
Ca - Kalcium	mg/l	3	100%	50%	240	-
Cd - Cadmium	mg/l	0,0002	300%	100%	0,003	0,005
Cr - Chrom, gesamt	mg/l	0,001	300%	100%	0,01 [5)]	0,05
Cu - Kupfer	mg/l	0,001	300%	100%	0,06	0,1
Fe - Eisen	mg/l	0,02	300%	150%	-	-
Hg - Quecksilber	mg/l	0,0002	300%	100%	0,0006	0,001
K - Kalium	mg/l	2	100%	50%	12	-
Mg - Magnesium	mg/l	1	100%	50%	30	-
Mn - Mangan	mg/l	0,02	300%	150%	-	-
Na - Natrium	mg/l	1	100%	50%	30	-
Ni - Nickel	mg/l	0,001	300%	100%	0,012	0,02
Pb - Blei	mg/l	0,001	300%	100%	0,006	0,01
Sb - Antimon	mg/l	0,0005	300%	100%	0,003	0,005
Se - Selen	mg/l	0,001	300%	100%	0,006	0,01
Sn - Zinn	mg/l	0,005	300%	100%	0,05	-
Zn - Zink	mg/l	0,02	300%	100%	1,8	-
INORGANIC PARAMETERS - Compounds (Ions)						
Cl - Chlorid	mg/l	1	100%	50%	60	-
CN - Cyanid, gesamt	mg/l	0,005	200%	100%	0,03	0,05
F - Fluorid	mg/l	0,1	200%	100%	0,9	1,5
NH_4 - Ammonium	mg/l	0,01	200%	100%	0,3	-
NO_2 - Nitrit	mg/l	0,01	200%	100%	0,3	-
NO_3 - Nitrat	mg/l	1	100%	50%	50	-
SO_4 - Sulfat	mg/l	1	100%	50%	150	-

[1)] Measurements < MQL x 5

[2)] Measurements > MQL x 5

[3)] The Screening Values have been identified under consideration of the Groundwater Threshold Value Ordinance (1991), the "Screening values for contaminated sites and groundwater" (Baden-Württemberg, 1998) as well as the proposal of the ad-hoc-AK "Trigger VAlues" of the LAWA (German Lände-Workinggroup Water, 1999).

[3)] The Screening Values have been identified under consideration of the Drinking Water Ordinance (/2001), the "Screening values for contaminated sites and groundwater" (Baden-Württemberg, 1998) as well as the proposal of the ad-hoc-AK "Trigger VAlues" of the LAWA (German Lände-Workinggroup Water, 1999).

[5]) If Chromium VI is the contaminant and due to the toxicological relevance the Trigger Value of 0,01 mg/l has to be considered as Intervention Threshold Value. (NOTE: Due to the high detection limits for Chromium VI the measurements have to be performed and referenced to the analysis of Chromium, total).

ÖNORM S 2088-1: Table 5 - Screening Values for groundwater (organic parameters)

Parameter	unit	MQL - min. quantification limit	Difference to local BL		Trigger Value [3])	Intervention Threshold Value [4)]
			A [1])	B [2])		
ORGANIC PARAMETERS - Halogenorganic						
AOX	µg/l	5	100%	50%	10	-
Chlorobenzenes	µg/l	0,05	200%	100%	1	-
PCP	µg/l	0,05	300%	100%	0,1	-
Σ CHC [5])	µg/l	0,1 [6])	100%	100%	18	30
PCE+ TCE	µg/l	0,1 [6])	100%	100%	6	10
Vinylchlorid	µg/l	0,1	100%	100%	0,3	0,5
Σ PCB [7])	µg/l	0,01	300%	100%	0,06	0,1
ORGANIC PARAMETERS - Others						
DOC (Dissolved Organic Carbon)	µg/l	500	100%	50%	-	-
TPH (Gaschromatography)	µg/l	100	100%	50%	60	100
TPH (Infrared)	µg/l	50	100%	50%	60	100
MTBE	µg/l	1	100%	50%	5	-
Phenols (phenolindex)	µg/l	10	100%	50%	30	-
Σ BTEX [8])	µg/l	0,5 [9])	200%	100%	30	50
Benzene	µg/l	0,5	200%	100%	0,6	1
Toluoene	µg/l	0,5	200%	100%	6	10
Σ PAH [10])	µg/l	0,05	200%	100%	0,5	-
Σ PAH (DW) [11])	µg/l	0,05	200%	100%	0,1	0,2
Naphthalene	µg/l	0,1	200%	100%	1	-

[1)] Measurements < MQL x 5

[2)] Measurements > MQL x 5

[3)] The Screening Values have been identified under consideration of the Groundwater Threshold Value Ordinance (1991), the "Screening values for contaminated sites and groundwater" (Baden-Württemberg, 1998) as well as the proposal of the ad-hoc-AK "Trigger VAlues" of the LAWA (German Lände-Workinggroup Water, 1999).

[3)] The Screening Values have been identified under consideration of the Drinking Water Ordinance (/2001), the "Screening values for contaminated sites and groundwater" (Baden-Württemberg, 1998) as well as the proposal of the ad-hoc-AK "Trigger VAlues" of the LAWA (German Lände-Workinggroup Water, 1999).

[5)] Sum of volatile halogenated C_1- und C_2-Hydrocarbons

[6)] MQL referenced to single substances; some CHC's have elevated MQLs until 0,3 µg/l

[7)] Sum of 6 substances (Nr. 28, Nr. 52, Nr. 101, Nr. 153, Nr. 180 - Ballschmiter)

[8)] Sum of benzene, toluoene, ethylbenzene and xylenes

[9)] MQL referenced to single substances

[10)] Sum of 15 refenrece substances (16 reference substances of the US-EPA without Naphthalene)

[11)] Sum of 4 reference substances according to Drinking Water Ordinance: (Benzo(b)fluoranthen, Benzo(k)fluoranthen, Indeno (1,2,3,c,d), Benzo(g,h,i)perylen

BELGIUM

Reference:

Order of the Brussels Capital Government concerning the values for soil and groundwater pollution above which a risk investigation has to be undertaken. Date 9/12/2004, Belgian law gazette 13/01/2005

PART 1

	soil (mg/kg dm)			groundwater (µg/l)
sensibility classes	**special area**	**residential area**	**industrial area**	
heavy metals				
arsenic	45	110	300	20
cadmium	2	6	30	5
chromium	130	300	800	50
copper	200	400	800	100
mercury	10	15	30	1
lead	200	700	2500	20
nickel	100	470	700	40
zinc	600	1000	3000	500
organic compounds				
benzene	0,5	0,5	1	10
toluene	5	15	200	700
ethylbenzene	1,5	5	70	300
xylene	3,5	15	190	500
styrene	0,5	1,5	13	20
hexane	1	1	10	180
heptane	25	25	25	3000
octane	75	90	90	600
mineral oil	1000	1000	1500	500
chlorinated solvents				
1,2-dichloroethane	0,035	0,075	4	30
dichloromethane	0,13	0,35	3,5	20
tetrachloromethane	0,02	0,02	1	2
tetrachlorethene	0,7	1,4	35	40
trichloromethane	0,02	0,02	0,55	200
trichloroethene	0,65	1,4	10	70
vinyl chloride	0,02	0,02	0,35	5
monochlorobenzene	2,5	8	40	300
1,2-dichlorobenzene	35	110	690	1000
1,3-dichlorobenzene	40	140	1260	1000
1,4-dichlorobenzene	4	15	190	300
trichlorobenzene	0,5	2	80	20
tetrachlorobenzene	0,1	0,3	275	9
pentachlororbenzene	0,5	1,3	385	2,4
hexachlorobenzene	0,05	0,1	55	1
1,1,1-trichloroethane	10	13	300	500
1,1,2-trichloroethane	0,2	0,6	1	12
1,1-dichloroethane	2	5	95	330
c+t-1,2-dichloroethene	0,4	0,7	33	50

PART 2

sensibility classes	soil (mg/kg dm) special area	residential area	industrial area	groundwater (µg/l)
polycyclic aromatic hydrocarbons				
naphtalene	1,5	5	160	60
benzo(a)pyrene	0,5	1,5	3	0,7
phenanthrene	60	65	1650	120
fluoranthene	20	30	270	4
benzo(a)antracene	5	10,5	30	7
chrysene	10	180	320	1,5
benzo(b)fluoranthene	2	7	30	1,2
benzo(k)fluoranthene	1	11,5	30	0,76
benzo(ghi)perylene	160	3920	4690	0,26
indeno(1,2,3-cd)pyrene	1	20	30	0,1
anthracene	3	70	4690	75
fluorene	45	3950	4690	120
dibenz(a,h)anthracene	0,5	1,5	3	0,5
acenaphtene	9	14	210	180
acenaphtylene	1	1	40	70
pyrene	125	395	3150	90
cyanides				
total cyanides				70
free cyanides	5	5	110	
cyanides not oxidizable by chlorine	5	12	550	
pesticides				
aldrin + dieldrin				0,03
chlordane (c+t)				0,2
DDT+DDD+DDE				2
lindane (gamma HCH)				2
alfa HCH				0,06
beta HCH				0,2
endosulfan (alfa, beta, sulphate)				1,8
methyl t-butyl ether	2	9	140	300
polychlorobiphenyls (PCBs)	0,25	0,9	10,4	0,1

special area

green area, green area with high biological value, parcs, cemetery areas forest zones, servitude areas along forests and woods, agricultural areas protection areas for groundwater collection

residential area

residential areas, mixed areas, administrative areas, areas with public functions, sport and recreation areas in open air industrial area

urban industrial areas, areas with harbour and transport activities, railway areas

Reference:

Order of the Flemish Government of 6 March 1999 on the Flemish Regulation for soil remediation

clean-up levels (part 1)

	soil (mg/kg dm)					Groundwater (µg/l)
land use	**nature area**	**agricultural area**	**residential area**	**recreational area**	**industrial area**	
heavy metals (1)						
arsenic	45	45	110	200	300	20
cadmium	2	2	6	15	30	5
chromium (III)	130	130	300	500	800	50
copper	200	200	400	500	800	100
mercury	10	10	15	20	30	1
lead	200	200	700	1500	2500	20
nickel	100	100	470	550	700	40
zinc	600	600	1000	1000	3000	500
organic compounds (2)						
benzene	0,5	0,5	0,5	1	1	10
toluene	5	5	15	135	200	700
ethylbenzene	1,5	1,5	5	25	70	300
xylene	3,5	3,5	15	70	190	500
styrene	0,5	0,5	1,5	6	13	20
hexane	1	1	1	6,5	10	180
heptane	25	25	25	25	25	3000
octane	75	75	90	90	90	600
mineral oil	1000	1000	1000	1500	1500	500
chlorinated solvents (2)						
1,2-dichloroethane	0,035	0,035	0,075	1,1	4	30
dichloromethane	0,13	0,13	0,35	3,5	3,5	20
tetrachloromethane	0,02	0,02	0,02	0,85	1	2
tetrachlorethene	0,7	0,7	1,4	30	35	40
trichloromethane	0,02	0,02	0,02	0,55	0,55	200
trichloroethene	0,65	0,65	1,4	10	10	70
vinyl chloride	0,02	0,02	0,02	0,15	0,35	5
monochlorobenzene	2,5	2,5	8	30	40	300
1,2-dichlorobenzene (3)	35	35	110	690	690	1000
1,3-dichlorobenzene (3)	40	40	140	750	1260	1000
1,4-dichlorobenzene (3)	4	4	15	80	190	300
trichlorobenzene (4)	0,5	0,5	2	20	80	20
tetrachlorobenzene (4)	0,1	0,1	0,3	6,5	275	9
pentachlororbenzene	0,5	0,5	1,3	65	385	2,4
hexachlorobenzene	0,05	0,05	0,1	8	55	1
1,1,1-trichloroethane	10	10	13	230	300	500
1,1,2-trichloroethane	0,2	0,2	0,6	1	1	12
1,1-dichloroethane	2	2	5	95	95	330
c+t-1,2-dichloroethene	0,4	0,4	0,7	18	33	50

clean-up levels (part 2)

land use	soil (mg/kg dm) nature area	agricultural area	residential area	recreational area	industrial area	Groundwater (µg/l)
polycyclic aromatichydrocarbons (5)						
naphtalene	1,5	1,5	5	80	160	60
benzo(a)pyrene	0,5	0,5	1,5	3	3	0,7
phenanthrene	60	60	65	1650	1650	120
fluoranthene	20	20	30	270	270	4
benzo(a)antracene	5	5	10,5	30	30	7
chrysene	10	10	180	320	320	1,5
benzo(b)fluoranthene	2	2	7	30	30	1,2
benzo(k)fluoranthene	1	1	11,5	30	30	0,76
benzo(ghi)perylene	160	160	3920	4300	4690	0,26
indeno(1,2,3-cd)pyrene	1	1	20	30	30	0,1
anthracene	3	3	70	2380	4690	75
fluorene	45	45	3950	4320	4690	120
dibenz(a,h)anthracene	0,5	0,5	1,5	3	3	0,5
acenaphtene	9	9	14	210	210	180
acenaphtylene	1	1	1	20	40	70
pyrene	125	125	395	3150	3150	90
cyanides						
total cyanides						70
free cyanides	5	5	5	60	110	
cyanides not oxidizable by chlorine	5	5	12	300	550	
pesticides						
aldrin + dieldrin						0,03
chlordane (c+t)						0,2
DDT+DDD+DDE						2
lindane (gamma HCH)						2
alfa HCH						0,06
beta HCH						0,2
Endosulfan (alfa, beta, sulphate)						1,8
methyl t-butyl ether (6)	2	2	9	140	140	300

NOTES:

(1): soil clean-up values have to be corrected for clay and organic matter content of the soil by

$$N(x,y) = N(10,2) * \frac{A + B * x + C * y}{A + B * 10 + C * 2}$$

where:

N: soil remediation value at a clay content of x % or 10 % and an organic matter content of y % or 2 %
A, B, C: coefficients specified hereafter
x: clay content of the soil sample (%)
y: organic matter content of the soil sample (%)

	A	B	C		A	B	C
arsenic	14	0,5	0	**mercury**	0,5	0,0046	0
cadmium	0,4	0,03	0,05	**lead**	33	0,3	2,3
chromium	31	0,6	0	**nickel**	6,5	0,2	0,3
copper	14	0,3	0	**zinc**	46	1,1	2,3

minimum and maximum clay content equals 1 % and 50 % respectively
minimum and maximum organic matter content equals 1 % and 10 % respectively

(2): soil clean-up values have to be corrected for organic matter content of the soil by

$$N(y) = N(2) * \frac{y}{2}$$

where:

N: soil remediation value at an organic matter content of y % or 2 %
minimum and maximum organic matter content equals 1 % and 10 % respectively

(3): the concentrations of the isomers of dichlorobenzene should fulfill the following requirement:

$$\frac{1{,}2 - dichlorobenzene}{soil\ clean-up\ value} + \frac{1{,}3 - dichlorobenzene}{soil\ clean-up\ value} \leq 1$$

(4): the soil clean-up values of trichlorobenzene, respectively tetrachlorobenzene apply for the sum of their isomers

(5): soil clean-up values have to be corrected for organic matter content of the soil by

$$N(y) = N(2) * (A + B * y)$$

Bestemmingstype	I		II		III		IV		V	
	A	B	A	B	A	B	A	B	A	B
Naftaleen	0,64	0,18	0,64	0,18	0,79	0,10	0,074	0,46	0,02	0,49
Benzo(a)pyreen	1	0	1	0	0,92	0,041	1	0	1	0
Fenantreen	0,26	0,37	0,26	0,37	0,15	0,42	1	0	1	0
Fluoranteen	0,68	0,16	0,68	0,16	0,49	0,25	0,98	0,012	0,98	0,012
Benzo(a)antraceen	0,94	0,029	0,94	0,029	0,86	0,069	1	0	1	0
Chryseen	1	0	1	0	1	0	1	0	1	0
Benzo(b)fluoranteen	0,96	0,021	0,96	0,021	0,74	0,13	1	0	1	0
Benzo(k)fluoranteen	1	0	1	0	1	0	1	0	1	0
Benzo(ghi)peryleen	1	0	1	0	1	0	1	0	1	0
Indeno(1,2,3-cd)pyreen	1	0	1	0	1	0	1	0	1	0
Antraceen	1	0	1	0	1	0	1	0	1	0
Fluoreen	0,082	0,46	0,082	0,46	1	0	1	0	1	0
Dibenz(a,h)antraceen	1	0	1	0	0,91	0,044	1	0	1	0
Acenafteen	1	0	1	0	0,72	0,14	0,27	0,37	0,27	0,37
Acenaftyleen	0,74	0,13	0,74	0,13	0,63	0,19	0,20	0,4	0,59	0,21
Pyreen	0,44	0,28	0,44	0,28	1	0	1	0	1	0

(6): soil clean-up values have to be corrected for organic matter content of the soil by

$$N(y) = N(2) * (0.6 + 0.2 * y)$$

background values

	soil (mg/kg dm)	Groundwater (µg/l)		soil (mg/kg dm)	Groundwater (µg/l)
heavy metals			***polycyclic aromatic hydrocarbons***		
arsenic	19	5	naphtalene	0,1	0,02 (d)
cadmium	0,8	1	benzo(a)pyrene	0,1	0,02 (d)
chromium (III)	37	10	phenanthrene	0,08	0,02 (d)
copper	17	20	fluoranthene	0,2	0,02 (d)
mercury	0,55	0,05	benzo(a)antracene	0,06	0,02 (d)
lead	40	5	chrysene	0,15	0,02 (d)
nickel	9	10	benzo(b)fluoranthene	0,2	0,02 (d)
zinc	62	60	benzo(k)fluoranthene	0,2	0,02 (d)
			benzo(ghi)perylene	0,1	0,02 (d)
organic compounds			indeno(1,2,3-cd)pyrene	0,1	0,02 (d)
benzene	0,1 (d)	0,5 (d)	anthracene	0,1	0,02 (d)
toluene	0,1 (d)	0,5 (d)	fluorene	0,1	0,02 (d)
ethylbenzene	0,1 (d)	0,5 (d)	dibenz(a,h)anthracene	0,1	0,02 (d)
xylene	0,1 (d)	0,5 (d)	acenaphtene	0,2	0,02 (d)
styrene	0,1 (d)	0,5 (d)	acenaphtylene	0,2	0,02 (d)
hexane	0,5 (d)	1 (d)	pyrene	0,1	0,02 (d)
heptane	0,5 (d)	1 (d)			
octane	0,5 (d)	1 (d)	***cyanides***		
mineral oil	50 (d)	100 (d)	total cyanides	1 (d)	5 (d)
			free cyanides		
chlorinated solvents			cyanides not oxidizable by chlorine		
1,2-dichloroethane	0,02 (d)	0,5 (d)			
dichloromethane	0,02 (d)	0,5 (d)	***pesticides***		0,01 (d)
tetrachloromethane	0,02 (d)	0,5 (d)	aldrin + dieldrin		0,02 (d)
tetrachlorethene	0,02 (d)	0,5 (d)	chlordane (c+t)		0,01 (d)
trichloromethane	0,02 (d)	0,5 (d)	DDT+DDD+DDE		0,005 (d)
trichloroethene	0,02 (d)	0,5 (d)	lindane (gamma HCH)		0,005 (d)
vinyl chloride	0,02 (d)	0,5 (d)	alfa HCH		0,005 (d)
monochlorobenzene	0,02 (d)	0,5 (d)	beta HCH		0,005 (d)
1,2-dichlorobenzene	0,02 (d)	0,5 (d)	endosulfan (alfa, beta, sulphate)		0,005 (d)
1,3-dichlorobenzene					
1,4-dichlorobenzene			***methyl t-butyl ether***	0,02 (d)	1 (d)
trichlorobenzene	0,02 (d)	0,5 (d)			
tetrachlorobenzene	0,02 (d)	0,1 (d)			
pentachlororbenzene	0,02 (d)	0,1 (d)			
hexachlorobenzene	0,02 (d)	0,1 (d)			
1,1,1-trichloroethane	0,02 (d)	1 (d)			
1,1,2-trichloroethane	0,02 (d)	1 (d)			
1,1-dichloroethane	0,02 (d)	1 (d)			
c+t-1,2-dichloroethene	0,02 (d)	1 (d)			

NOTES:

(1): background values have to be corrected for clay and organic matter content of the soil by

$$\boxed{N(x,y) = N(10,2) * \frac{A + B * x + C * y}{A + B * 10 + C * 2}}$$

where:

N: soil remediation value at a clay content of x % or 10 % and an organic matter content of y % or 2 %
A, B, C: coefficients specified hereafter x: clay content of the soil sample (%) y: organic matter content of the soil sample (%)

	A	B	C		A	B	C
arsenic	14	0,5	0	**mercury**	0,5	0,0046	0
cadmium	0,4	0,03	0,05	**lead**	33	0,3	2,3
chromium	31	0,6	0	**nickel**	6,5	0,2	0,3
copper	14	0,3	0	**zinc**	46	1,1	2,3

minimum and maximum clay content equals 1 % and 50 % respectively
minimum and maximum organic matter content equals 1 % and 10 % respectively

BELGIUM - FLANDERS

Reference

Order of the Flemish Government of 6 March 1999 on the Flemish Regulation for soil remediation

clean-up levels (part 1)

land use	soil (mg/kg dm) nature area	agricultural area	residential area	recreational area	industrial area	Groundwater (µg/l)
heavy metals (1)						
arsenic	45	45	110	200	300	20
cadmium	2	2	6	15	30	5
chromium (III)	130	130	300	500	800	50
copper	200	200	400	500	800	100
mercury	10	10	15	20	30	1
lead	200	200	700	1500	2500	20
nickel	100	100	470	550	700	40
zinc	600	600	1000	1000	3000	500
organic compounds (2)						
benzene	0,5	0,5	0,5	1	1	10
toluene	5	5	15	135	200	700
ethylbenzene	1,5	1,5	5	25	70	300
xylene	3,5	3,5	15	70	190	500
styrene	0,5	0,5	1,5	6	13	20
hexane	1	1	1	6,5	10	180
heptane	25	25	25	25	25	3000
octane	75	75	90	90	90	600
mineral oil	1000	1000	1000	1500	1500	500
chlorinated solvents (2)						
1,2-dichloroethane	0,035	0,035	0,075	1,1	4	30
dichloromethane	0,13	0,13	0,35	3,5	3,5	20
tetrachloromethane	0,02	0,02	0,02	0,85	1	2
tetrachlorethene	0,7	0,7	1,4	30	35	40
trichloromethane	0,02	0,02	0,02	0,55	0,55	200
trichloroethene	0,65	0,65	1,4	10	10	70
vinyl chloride	0,02	0,02	0,02	0,15	0,35	5
monochlorobenzene	2,5	2,5	8	30	40	300
1,2-dichlorobenzene (3)	35	35	110	690	690	1000
1,3-dichlorobenzene (3)	40	40	140	750	1260	1000
1,4-dichlorobenzene (3)	4	4	15	80	190	300
trichlorobenzene (4)	0,5	0,5	2	20	80	20
tetrachlorobenzene (4)	0,1	0,1	0,3	6,5	275	9
pentachlororbenzene	0,5	0,5	1,3	65	385	2,4
hexachlorobenzene	0,05	0,05	0,1	8	55	1
1,1,1-trichloroethane	10	10	13	230	300	500
1,1,2-trichloroethane	0,2	0,2	0,6	1	1	12
1,1-dichloroethane	2	2	5	95	95	330
c+t-1,2-dichloroethene	0,4	0,4	0,7	18	33	50

clean-up levels (part 2)

land use	soil (mg/kg dm) nature area	agricultural area	residential area	recreational area	industrial area	Groundwater (µg/l)
polycyclic aromatic hydrocarbons (5)						
naphtalene	1,5	1,5	5	80	160	60
benzo(a)pyrene	0,5	0,5	1,5	3	3	0,7
phenanthrene	60	60	65	1650	1650	120
fluoranthene	20	20	30	270	270	4
benzo(a)antracene	5	5	10,5	30	30	7
chrysene	10	10	180	320	320	1,5
benzo(b)fluoranthene	2	2	7	30	30	1,2
benzo(k)fluoranthene	1	1	11,5	30	30	0,76
benzo(ghi)perylene	160	160	3920	4300	4690	0,26
indeno(1,2,3-cd)pyrene	1	1	20	30	30	0,1
anthracene	3	3	70	2380	4690	75
fluorene	45	45	3950	4320	4690	120
dibenz(a,h)anthracene	0,5	0,5	1,5	3	3	0,5
acenaphtene	9	9	14	210	210	180
acenaphtylene	1	1	1	20	40	70
pyrene	125	125	395	3150	3150	90
cyanides						
total cyanides						70
free cyanides	5	5	5	60	110	
cyanides not oxidizable by chlorine	5	5	12	300	550	
pesticides						
aldrin + dieldrin						0,03
chlordane (c+t)						0,2
DDT+DDD+DDE						2
lindane (gamma HCH)						2
alfa HCH						0,06
beta HCH						0,2
endosulfan (alfa, beta, sulphate)						1,8
methyl t-butyl ether (6)	2	2	9	140	140	300

NOTES:

(1): soil clean-up values have to be corrected for clay and organic matter content of the soil by

$$\boxed{N(x,y) = N(10,2) * \frac{A + B * x + C * y}{A + B * 10 + C * 2}}$$

where:

N: soil remediation value at a clay content of x % or 10 % and an organic matter content of y % or 2 %
A, B, C: coefficients specified hereafter
x: clay content of the soil sample (%)
y: organic matter content of the soil sample (%)

	A	B	C		A	B	C
arsenic	14	0,5	0	**mercury**	0,5	0,0046	0
cadmium	0,4	0,03	0,05	**lead**	33	0,3	2,3
chromium	31	0,6	0	**nickel**	6,5	0,2	0,3
copper	14	0,3	0	**zinc**	46	1,1	2,3

minimum and maximum clay content equals 1 % and 50 % respectively
minimum and maximum organic matter content equals 1 % and 10 % respectively

(2): soil clean-up values have to be corrected for organic matter content of the soil by

$$\boxed{N(y) = N(2) * \frac{y}{2}}$$

where:

N: soil remediation value at an organic matter content of y % or 2 %
minimum and maximum organic matter content equals 1 % and 10 % respectively

(3): the concentrations of the isomers of dichlorobenzene should fulfill the following requirement:

$$\boxed{\frac{1{,}2-dichlorobenzene}{soil\ clean-up\ value} + \frac{1{,}3-dichlorobenzene}{soil\ clean-up\ value} \leq 1}$$

(4): the soil clean-up values of trichlorobenzene, respectively tetrachlorobenzene apply for the sum of their isomers

(5): soil clean-up values have to be corrected for organic matter content of the soil by

$$\boxed{N(y) = N(2) * (A + B * y)}$$

Bestemmingstype	I		II		III		IV		V	
	A	B	A	B	A	B	A	B	A	B
Naftaleen	0,64	0,18	0,64	0,18	0,79	0,10	0,074	0,46	0,02	0,49
Benzo(a)pyreen	1	0	1	0	0,92	0,041	1	0	1	0
Fenantreen	0,26	0,37	0,26	0,37	0,15	0,42	1	0	1	0
Fluoranteen	0,68	0,16	0,68	0,16	0,49	0,25	0,98	0,012	0,98	0,012
Benzo(a)antraceen	0,94	0,029	0,94	0,029	0,86	0,069	1	0	1	0
Chryseen	1	0	1	0	1	0	1	0	1	0
Benzo(b)fluoranteen	0,96	0,021	0,96	0,021	0,74	0,13	1	0	1	0
Benzo(k)fluoranteen	1	0	1	0	1	0	1	0	1	0
Benzo(ghi)peryleen	1	0	1	0	1	0	1	0	1	0
Indeno(1,2,3-cd)pyreen	1	0	1	0	1	0	1	0	1	0
Antraceen	1	0	1	0	1	0	1	0	1	0
Fluoreen	0,082	0,46	0,082	0,46	1	0	1	0	1	0
Dibenz(a,h)antraceen	1	0	1	0	0,91	0,044	1	0	1	0
Acenafteen	1	0	1	0	0,72	0,14	0,27	0,37	0,27	0,37
Acenaftyleen	0,74	0,13	0,74	0,13	0,63	0,19	0,20	0,4	0,59	0,21
Pyreen	0,44	0,28	0,44	0,28	1	0	1	0	1	0

(6): soil clean-up values have to be corrected for organic matter content of the soil by

$$\boxed{N(y) = N(2) * (0.6 + 0.2 * y)}$$

background values

	soil (mg/kg dm)	Groundwater (µg/l)
heavy metals		
arsenic	19	5
cadmium	0,8	1
chromium (III)	37	10
copper	17	20
mercury	0,55	0,05
lead	40	5
nickel	9	10
zinc	62	60
organic compounds		
benzene	0,1 (d)	0,5 (d)
toluene	0,1 (d)	0,5 (d)
ethylbenzene	0,1 (d)	0,5 (d)
xylene	0,1 (d)	0,5 (d)
styrene	0,1 (d)	0,5 (d)
hexane	0,5 (d)	1 (d)
heptane	0,5 (d)	1 (d)
octane	0,5 (d)	1 (d)
mineral oil	50 (d)	100 (d)
chlorinated solvents		
1,2-dichloroethane	0,02 (d)	0,5 (d)
dichloromethane	0,02 (d)	0,5 (d)
tetrachloromethane	0,02 (d)	0,5 (d)
tetrachlorethene	0,02 (d)	0,5 (d)
trichloromethane	0,02 (d)	0,5 (d)
trichloroethene	0,02 (d)	0,5 (d)
vinyl chloride	0,02 (d)	0,5 (d)
monochlorobenzene	0,02 (d)	0,5 (d)
1,2-dichlorobenzene	0,02 (d)	0,5 (d)
1,3-dichlorobenzene		
1,4-dichlorobenzene		
trichlorobenzene	0,02 (d)	0,5 (d)
tetrachlorobenzene	0,02 (d)	0,1 (d)
pentachlororbenzene	0,02 (d)	0,1 (d)
hexachlorobenzene	0,02 (d)	0,1 (d)
1,1,1-trichloroethane	0,02 (d)	1 (d)
1,1,2-trichloroethane	0,02 (d)	1 (d)
1,1-dichloroethane	0,02 (d)	1 (d)
c+t-1,2-dichloroethene	0,02 (d)	1 (d)

	soil (mg/kg dm)	Groundwater (µg/l)
polycyclic aromatic hydrocarbons		
naphtalene	0,1	0,02 (d)
benzo(a)pyrene	0,1	0,02 (d)
phenanthrene	0,08	0,02 (d)
fluoranthene	0,2	0,02 (d)
benzo(a)antracene	0,06	0,02 (d)
chrysene	0,15	0,02 (d)
benzo(b)fluoranthene	0,2	0,02 (d)
benzo(k)fluoranthene	0,2	0,02 (d)
benzo(ghi)perylene	0,1	0,02 (d)
indeno(1,2,3-cd)pyrene	0,1	0,02 (d)
anthracene	0,1	0,02 (d)
fluorene	0,1	0,02 (d)
dibenz(a,h)anthracene	0,1	0,02 (d)
acenaphtene	0,2	0,02 (d)
acenaphtylene	0,2	0,02 (d)
pyrene	0,1	0,02 (d)
cyanides		
total cyanides	1 (d)	5 (d)
free cyanides		
cyanides not oxidizable by chlorine		
pesticides		0,01 (d)
aldrin + dieldrin		0,02 (d)
chlordane (c+t)		0,01 (d)
DDT+DDD+DDE		0,005 (d)
lindane (gamma HCH)		0,005 (d)
alfa HCH		0,005 (d)
beta HCH		0,005 (d)
endosulfan (alfa, beta, sulphate)		0,005 (d)
methyl t-butyl ether	0,02 (d)	1 (d)

NOTES:

(1): background values have to be corrected for clay and organic matter content of the soil by

$$N(x,y) = N(10,2) * \frac{A + B * x + C * y}{A + B * 10 + C * 2}$$

where:

N: soil remediation value at a clay content of x % or 10 % and an organic matter content of y % or 2 %
A, B, C: coefficients specified hereafter
x: clay content of the soil sample (%)
y: organic matter content of the soil sample (%)

	A	B	C		A	B	C
arsenic	14	0,5	0	**mercury**	0,5	0,0046	0
cadmium	0,4	0,03	0,05	**lead**	33	0,3	2,3
chromium	31	0,6	0	**nickel**	6,5	0,2	0,3
copper	14	0,3	0	**zinc**	46	1,1	2,3

minimum and maximum clay content equals 1 % and 50 % respectively
minimum and maximum organic matter content equals 1 % and 10 % respectively

WALLON REGION - Feuil 1

		Sol (mg/kg$_{\text{matière sèche}}$)					Eaux souterraines (µg/L)
Type of Landuse		**I "natural"**	**II "agricultural"**	**III "residential"**	**IV "recreational"**	**V "industrial"**	
Inorganics							
	RV	12	12	12	12	12	1
arsenic	TV	15	15	40	40	50	10
	IV	120	120	300	300	300	30
	RV	0,2	0,2	0,2	0,2	0,2	0,25
cadmium	TV	1	1	3	10	10	5
	IV	10	10	30	40	50	20
	RV	34	34	34	34	34	2,5
chromium (total)	TV	60	85	125	125	165	50
	IV	95	175	520	520	700	150
	RV	2,5	2,5	2,5	2,5	2,5	2,5
chromium VI	TV	4,2	4,2	4,2	13	13	50
	IV	42	42	42	130	130	90
	RV	14	14	14	14	14	15
copper	TV	40	50	110	110	120	100
	IV	80	145	290	290	500	200
	RV	0,05	0,05	0,05	0,05	0,05	0,1
mercury	TV	0,5	0,5	9	13	18	1
	IV	5	5	56	56	84	4
	RV	24	24	24	24	24	10
nickel	TV	35	35	150	150	210	20
	IV	100	200	300	300	500	80
	RV	25	25	25	25	25	2,5
lead	TV	80	80	195	280	385	10
	IV	170	400	700	700	1360	40
	RV	67	67	67	67	67	90
zinc	TV	120	155	230	230	320	200
	IV	215	300	710	710	1300	400
Monoaromatic Hydrocarbons							
	RV	0,1	0,1	0,1	0,1	0,1	0,25
benzène	TV	0,20	0,20	0,20	0,20	0,20	10
	IV	0,40	0,40	0,40	0,40	0,60	40
	RV	0,1	0,1	0,1	0,1	0,1	2
Éthylbenzène	TV	7,8	4,7	5,6	5,6	11,6	300
	IV	28	17	28	28	76	1520
	RV	0,1	0,1	0,1	0,1	0,1	2
Toluène	TV	6,0	3,6	3,3	7,1	8,5	700
	IV	20	12	33	42	85	5850
	RV	0,2	0,2	0,2	0,2	0,2	4
Xylènes (somme)	TV	1,9	1,1	2	2	2	500
	IV	4,4	2,5	10	10	20	2175
Unhaloganated polyaromatic hydrocarbons							
	RV	0,01	0,01	0,01	0,01	0,01	0,01
benzo(a)anthracène	TV	0,8	0,5	1	1	1	7
	IV	2,5	1,5	5	5	10	14
	RV	0,01	0,01	0,01	0,01	0,01	0,01
Benzo(b)fluoranthène	TV	0,7	0,1	0,3	0,9	0,9	1,5
	IV	2,1	1,3	3,8	4,3	8,6	69
	RV	0,01	0,01	0,01	0,01	0,01	0,01
benzo(k)fluoranthène	TV	3,2	0,5	1,3	3,9	3,9	0,8
	IV	9,5	4,7	13	19	39	1,6
	RV	0,01	0,01	0,01	0,01	0,01	0,01
Benzo(g,h,i)pérylène	TV	2,5	1,5	3	3	3	0,26
	IV	7,4	4,6	15	15	30	0,52
	RV	0,01	0,01	0,01	0,01	0,01	0,01
benzo(a)pyrène	TV	0,7	0,1	0,5	0,9	0,9	0,7
	IV	2,2	1	4,4	4,4	8,8	1,4

WALLON REGION - Feuil 2

		Sol (mg/kg$_{\text{matière sèche}}$)					Eaux souterraines (µg/L)
Type of Landuse		**I "natural"**	**II "agricultural"**	**III "residential"**	**IV "recreational"**	**V "industrial"**	
Chrysène	VR	0,01	0,01	0,01	0,01	0,01	0,01
	VS	4,8	3	4,9	4,9	4,9	1,5
	VI	9,8	6	24,5	24,5	49	3
Fluoranthène	VR	0,01	0,01	0,01	0,01	0,01	0,01
	VS	8,4	5,2	23	23	30	4
	VI	77	47	125	125	300	60
Indéno(1,2,3-c,d)pyrène	VR	0,01	0,01	0,01	0,01	0,01	0,01
	VS	1	0,1	0,2	1,2	1,2	0,22
	VI	2,4	0,8	2,6	5,8	11,6	0,44
Naphtalène	VR	0,1	0,1	0,1	0,1	0,1	2
	VS	1,1	0,7	1,7	1,7	1,7	60
	VI	4,1	2,5	8,6	8,6	17	410
Phénanthrène	VR	0,1	0,1	0,1	0,1	0,1	2
	VS	5,3	3,3	5,5	5,5	5,5	120
	VI	11	6,8	27	27	55	240
Petroleum hydrocarbons							
Mineral Oil (C10-C40)	VR	50	50	50	50	50	50
	VS	250	250	750	750	1000	350
	VI	2000	2000	5000	5000	5000	3000

BELGIUM Wallon Region

Type of Landuse		Sol (mg/kg$_{matière\ sèche}$) I "natural"	II "agricultural"	III "residential"	IV "recreational"	V "industrial"	Eaux souterraines
Inorganics							
arsenic	RV	12	12	12	12	12	1
	TV	15	15	40	40	50	10
	IV	120	120	300	300	300	30
cadmium	RV	0,2	0,2	0,2	0,2	0,2	0,25
	TV	1	1	3	10	10	5
	IV	10	10	30	40	50	20
chromium (total)	RV	34	34	34	34	34	2,5
	TV	60	85	125	125	165	50
	IV	95	175	520	520	700	150
chromium VI	RV	2,5	2,5	2,5	2,5	2,5	2,5
	TV	4,2	4,2	4,2	13	13	50
	IV	42	42	42	130	130	90
copper	RV	14	14	14	14	14	15
	TV	40	50	110	110	120	100
	IV	80	145	290	290	500	200
mercury	RV	0,05	0,05	0,05	0,05	0,05	0,1
	TV	0,5	0,5	9	13	18	1
	IV	5	5	56	56	84	4
nickel	RV	24	24	24	24	24	10
	TV	35	35	150	150	210	20
	IV	100	200	300	300	500	80
lead	RV	25	25	25	25	25	2,5
	TV	80	80	195	280	385	10
	IV	170	400	700	700	1360	40
zinc	RV	67	67	67	67	67	90
	TV	120	155	230	230	320	200
	IV	215	300	710	710	1300	400
Monoaromatic Hydrocarbons							
benzène	RV	0,1	0,1	0,1	0,1	0,1	0,25
	TV	0,20	0,20	0,20	0,20	0,20	10
	IV	0,40	0,40	0,40	0,40	0,60	40
Éthylbenzène	RV	0,1	0,1	0,1	0,1	0,1	2
	TV	7,8	4,7	5,6	5,6	11,6	300
	IV	28	17	28	28	76	1520
Toluène	RV	0,1	0,1	0,1	0,1	0,1	2
	TV	6,0	3,6	3,3	7,1	8,5	700
	IV	20	12	33	42	85	5850
Xylènes (somme)	RV	0,2	0,2	0,2	0,2	0,2	4
	TV	1,9	1,1	2	2	2	500
	IV	4,4	2,5	10	10	20	2175
Unhaloganated polyaromatic hydrocarbons							
benzo(a)anthracène	RV	0,01	0,01	0,01	0,01	0,01	0,01
	TV	0,8	0,5	1	1	1	7
	IV	2,5	1,5	5	5	10	14
Benzo(b)fluoranthène	RV	0,01	0,01	0,01	0,01	0,01	0,01
	TV	0,7	0,1	0,3	0,9	0,9	1,5
	IV	2,1	1,3	3,8	4,3	8,6	69
benzo(k)fluoranthène	RV	0,01	0,01	0,01	0,01	0,01	0,01
	TV	3,2	0,5	1,3	3,9	3,9	0,8
	IV	9,5	4,7	13	19	39	1,6
Benzo(g,h,i)pérylène	RV	0,01	0,01	0,01	0,01	0,01	0,01
	TV	2,5	1,5	3	3	3	0,26
	IV	7,4	4,6	15	15	30	0,52
benzo(a)pyrène	RV	0,01	0,01	0,01	0,01	0,01	0,01
	TV	0,7	0,1	0,5	0,9	0,9	0,7
	IV	2,2	1	4,4	4,4	8,8	1,4

BELGIUM - BRUXELLES

Reference:

Order of the Brussels Capital Government concerning the values for soil and groundwater pollution above which a risk investigation has to be undertaken. Date 9/12/2004, Belgian law gazette 13/01/2005

PART 1

sensibility classes	**soil (mg/kg dm)** special area	residential area	industrial area	**groundwater (µg/l)**
heavy metals				
arsenic	45	110	300	20
cadmium	2	6	30	5
chromium	130	300	800	50
copper	200	400	800	100
mercury	10	15	30	1
lead	200	700	2500	20
nickel	100	470	700	40
zinc	600	1000	3000	500
organic compounds				
benzene	0,5	0,5	1	10
toluene	5	15	200	700
ethylbenzene	1,5	5	70	300
xylene	3,5	15	190	500
styrene	0,5	1,5	13	20
hexane	1	1	10	180
heptane	25	25	25	3000
octane	75	90	90	600
mineral oil	1000	1000	1500	500
chlorinated solvents				
1,2-dichloroethane	0,035	0,075	4	30
dichloromethane	0,13	0,35	3,5	20
tetrachloromethane	0,02	0,02	1	2
tetrachlorethene	0,7	1,4	35	40
trichloromethane	0,02	0,02	0,55	200
trichloroethene	0,65	1,4	10	70
vinyl chloride	0,02	0,02	0,35	5
monochlorobenzene	2,5	8	40	300
1,2-dichlorobenzene	35	110	690	1000
1,3-dichlorobenzene	40	140	1260	1000
1,4-dichlorobenzene	4	15	190	300
trichlorobenzene	0,5	2	80	20
tetrachlorobenzene	0,1	0,3	275	9
pentachlororbenzene	0,5	1,3	385	2,4
hexachlorobenzene	0,05	0,1	55	1
1,1,1-trichloroethane	10	13	300	500
1,1,2-trichloroethane	0,2	0,6	1	12
1,1-dichloroethane	2	5	95	330
c+t-1,2-dichloroethene	0,4	0,7	33	50

PART 2

sensibility classes	soil (mg/kg dm) special area	residential area	industrial area	groundwater (µg/l)
polycyclic aromatic hydrocarbons				
naphtalene	1,5	5	160	60
benzo(a)pyrene	0,5	1,5	3	0,7
phenanthrene	60	65	1650	120
fluoranthene	20	30	270	4
benzo(a)antracene	5	10,5	30	7
chrysene	10	180	320	1,5
benzo(b)fluoranthene	2	7	30	1,2
benzo(k)fluoranthene	1	11,5	30	0,76
benzo(ghi)perylene	160	3920	4690	0,26
indeno(1,2,3-cd)pyrene	1	20	30	0,1
anthracene	3	70	4690	75
fluorene	45	3950	4690	120
dibenz(a,h)anthracene	0,5	1,5	3	0,5
acenaphtene	9	14	210	180
acenaphtylene	1	1	40	70
pyrene	125	395	3150	90
cyanides				
total cyanides				70
free cyanides	5	5	110	
cyanides not oxidizable by chlorine	5	12	550	
pesticides				
aldrin + dieldrin				0,03
chlordane (c+t)				0,2
DDT+DDD+DDE				2
lindane (gamma HCH)				2
alfa HCH				0,06
beta HCH				0,2
endosulfan (alfa, beta, sulphate)				1,8
methyl t-butyl ether	2	9	140	300
polychlorobiphenyls (PCBs)	0,25	0,9	10,4	0,1

special area
agricultural areas protection areas for groundwater collection
residential area
industrial area
urban industrial areas, areas with harbour and transport activities, railway areas

CZECH REPUBLIC

Decree No. 13/1994 Sb. of Ministry of Environment, regulating some details of agricultural soil protection.
Appendix 2 – Indicators of agricultural soil pollution - Maximum admissible values.

Risk elements

Element	2 M HNO_3 extraction (mg.kg^{-1})		Aqua regia extraction (Hg total content) (mg.kg^{-1})	
	light soils	**other soils**	**light soils**	**other soils**
As	4,5	4,5	30	30
Be	2	2	7	7
Cd	0,4	1	0,4	1
Co	10	25	25	50
Cr	40	40	100	200
Cu	30	50	60	100
Hg	-	-	0,6	0,8
Mo	5	5	5	5
Ni	15	25	60	80
Pb	50	70	100	140
V	20	50	150	220
Zn	50	100	130	200

Notes:

1. Figures for contents of hazardous elements are not valid for organic soils.

2. Light soils are understood to be sandy and loamy sand soils according to the analytical method of Prof. Novák (Complex Methods of Plant Nutrition No. 1/1990, Published by The Institute of Scientific and Technical Information in Agriculture, Prague).

3. On the contents of hazardous elements in soils (mg . kg-1): The values given are valid for mixed samples obtained from the upper layer of the test mineral soils in a thickness of 0.25 m, dried in the air to constant weight.

Decree No. 13/1994 Sb. of Ministry of Environment, regulating some details of agricultural soil protection.
Appendix 2 – Indicators of agricultural soil pollution - Maximum admissible values.

Other inorganic and organic substances

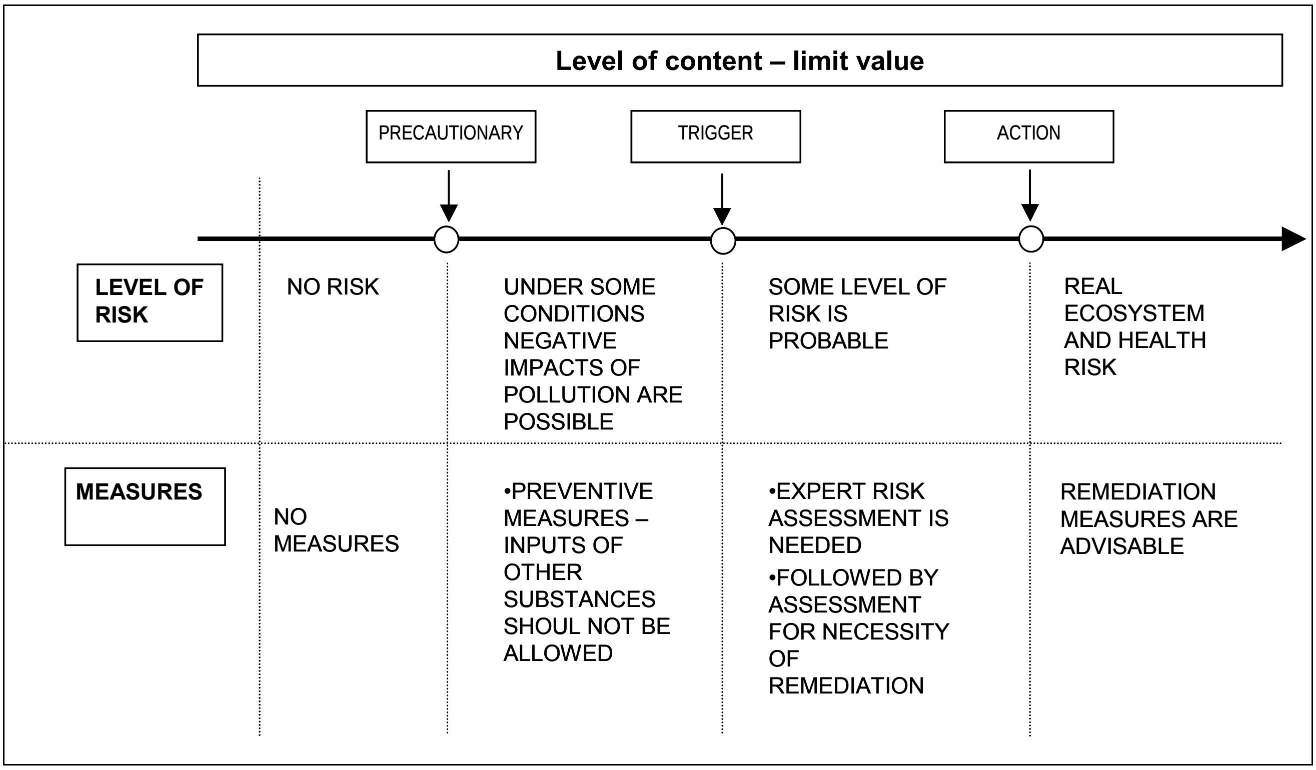
Substance	Admissible concentration (mg.kg-1 d.m.)
I. ***Inorganic substances***	
B	40
Br	20
F	500
CN total	5
CN toxic	1
S suphatic	2
II. ***Organic substances***	
a) aromatic hydrocarbons	
benzene	0,05
ethyl benzene	0,05
phenol	0,05
xylenes	0,05
total amount of hydrocarbons	0,3
b) polycyclic aromatic hydrocarbons	
anthracene	0,01
benzo (a) anthracene	1
benzo (a) pyrene	0,1
phenanthrene	0,1
fluoranthene	0,1
chrysene	0,01
naphtalene	0,1
total amount of PAH	1
c) chlorinated hydrocarbons	
aliphatic (individual)	0,1
aliphatic (total)	0,1
chlorobenzens (individual)	0,01
chlorophenols (individual)	0,01
PCB	0,01
EOCl (extractable organically bonded chlorine)	0,1
d) pesticides	
organic chlorinated (individual)	0,01
organic chlorinated (total)	0,1
other (individual)	0,01
other (total)	0,1
e) other substances	
cyclohexanol	0,1
pyridine	0,1
styrene	0,1
nonpolar hydrocarbons (total)	50

Methodical guideline of the Ministry of Environment, Section of ecological damage – criteria of soil and groundwater pollution

SOIL	A	B.	C residental	C recreation	C industrial	C generally
I. metals	**mg.kg^{-1} d.m.**					
As	30	65	70	100	140	55
Ba	600	900	1000	2000	2800	625
Be	5	15	20	25	30	-
Cd	0,5	10	20	25	30	12
Co	25	180	300	350	450	240
Cr	130	450	500	800	800	380
Cu	70	500	600	1000	1500	190
Hg	0,4	2,5	10	15	20	10
Mo	0,8	50	100	160	240	100
Ni	60	180	250	300	500	210
Pb	80	250	300	500	800	300
Sb	1	25	40	50	80	-
Sn	15	200	300	400	600	-
V	180	340	450	500	550	-
Zn	150	1500	2500	3000	5000	720
II. Monocyclic aromatic hydrocarbons						
benzene	0,03	0,5	0,8	1	5	1
toluene	0,03	50	100	120	150	100
ethylbenzene	0,04	25	50	60	75	50
xylens	0,03	25	30	50	75	25
sum of phenols	0,05	25	50	60	120	50
styrene	0,03	15	30	50	75	30
III. Polycyclic aromatic hydrocarbons						
anthracene	0,1	40	60	80	100	-
benz[a]anthracene	0,1	4	5	10	50	-
benz[a]pyrene	0,1	1,5	2	4	10	-
benz[b]fluoranthene	0,1	4	5	10	50	-
benz[ghi]perylene	0,05	20	30	40	80	-
benz[k]fluoranthene	0,05	10	15	20	30	-
fluoranthene	0,3	40	50	80	150	-
phenanthrene	0,15	30	40	60	100	-
chrysene	0,05	25	40	50	80	-
indeno[1,2,3-cd]pyrene	0,1	4	5	10	50	-
naphtalene	0,05	40	60	80	100	-
pyrene	0,2	40	60	80	100	-
PAH total (A)[1)]	-	-	-	-	-	40
PAH total (B)[1)]	1	190	280	380	640	-
IV. Monocyclic aromatic hydrocarbons (halogenated)						
chlorbenzenes (individual)	0,05	2,5	3	5	10	-
chlorphenols (individual)	0,05	1,5	2	4	10	-
V. Chlorinated pesticides						
individual	0,05	2	2,5	5	10	2,5
VI. Other pesticides						
individual	0,05	3	4	7,5	12	
VII. Chlorinated aliphatic hydrocarbons						
VIII. Other hydrocarbons						
Nonpolar extractable substances	100	400	500	750	1000	500
IX. Other aromatic hydrocarbons (halogenated)						
Sum PCB 28,52,101,118,138,153, 180	0,02	2,5	5	10	30	1
PCDD/PCDF (in ng I-TEQ TeCdd/g)	0,001	0,1	0,5	1	10	-

PAH A = sum of the contents of all PAH in the table
PAH B = sum of the contents of all PAH without anthracene, naphtalene and benzo(b)fluoranthene.

Scheme of the system of limit values - proposal



Proposal

Contents of pollutants in soil – Ruling criteria for soil protection from inputs of risk substances - precautionary values

Risk elements

Risk element	Preventive value	
	normal soils	light soils
	mg.kg^{-1} aqua regia extraction, Hg total content	
As	20,00	15,00
Be	2,00	1,50
Cd	0,50	0,40
Co	30,00	20,00
Cr	90,00	55,00
Cu	60,00	45,00
Hg	0,30	0,30
Ni	50,00	45,00
Pb	60,00	55,00
V	130,00	120,00
Zn	120,00	105,00
Tl	0,50	0,50

Proposal

Contents of pollutants in soil – Ruling criteria for soil protection from inputs of risk substances - precautionary values

Persistent organic pollutants

Substance	precautionary value ug.kg^{-1}
Monocyclic aromatic hydrocarbons	
benzene	30
toluene	30
xylene	30
styrene	50
ethylbenzene	40
Polycyclic aromatic hydrocarbons	
fluoranthene	300
pyrene	200
phenanthrene	150
benzo(b)fluoranthene	100
benzo(a)anthracene	100
anthracene	50
indeno(cd)pyrene	100
benzo(a)pyrene	100
benzo(k)fluoranthene	50
benzo(ghi)perylene	50
chrysene	100
nphtalene	50
Σ PAH	1000
Chlorinated hydrocarbons	
PCB Σ 7 congeners[1)]	20
HCB	20
DDT	30
DDE	25
DDD	20
HCH (Σ α+β+γ)	10

[1)] 28, 52, 101, 118, 138, 153, 180

DENMARK

Table 1. Danish ecotoxicological soil quality criteria for selected organic and inorganic compounds (Scott-Fordsmand and Pedersen 1995, Jensen and Folker-Hansen 1995, Jensen et al 1997).

Organic compounds[1]	ESQC (mg/kg dry soil)
Anionic surfactants (general)	5.0
Benzo(a)pyrene	0.1
Chlorobenzenes:	
Mono-	0.1
Di-	0.1
Tri-	0.001
Tetra-	0.001
Penta-	0.001
Hexa-	0.001
Chlorophenols (sum of 1-4 CP)	0.01
LAS	5.0
Nonylphenol	0.01
Pentachlorophenol	0.005
Phthalates	
di-methyl-	0.1
di-ethyl-	0.1
di-butyl-	0.1
di-iso-octyl-	1.0
di(2-ethylhexyl)-	1.0
di-n-octyl-	1.0
Polycyclic Aromatic Hydrocarbons (PAH)	1.0
Polychlorinated biphenyls (PCB's)	0.01
Inorganic Compounds	
Arsenic	10.0
Cadmium	0.3
Chromium (III)	50.0
Chromium (VI)	2.0
Copper	30.0
Lead	50.0
Mercury (inorganic)	0.1
Molybdenum	2.0
Nickel	10.0
Selenium	1.0
Silver	1.0
Thallium	0.5
Tin (inorganic)	20.0
Zinc	100.0

FINLAND

Substance	Threshold value mg/kg-dw	Lower guideline value[1] mg/kg-dw	Upper guideline value[1] mg/kg-dw
Antimony (Sb) (p)	2	10 (t)	50 (e)
Arsenic (As) (p)	5	50 (e)	100 (e)
Mercury (Hg)	0.5	2 (e)	5 (e)
Cadmium (Cd)	1	10 (e)	20 (e)
Cobolt (Co) (p)	20	100 (e)	250 (e)
Chromium (Cr)	100	200 (e)	300 (e)
Copper (Cu)	100	150 (e)	200 (e)
Lead (Pb)	60	200 (t)	750 (e)
Nickel (Ni)	50	100 (e)	150 (e)
Zinc (Zn)	200	250 (e)	400 (e)
Vanadium (V)	100	150 (e)	250 (e)
Cyanide (CN)	1	10 (e)	50 (e)
Benzene (p)	0.02	0,2 (t)	1 (t)
Toluene (p)	0.5	5 (t)	25 (t)
Ethylbenzene (p)	0.5	10 (t)	50 (t)
Xylenes[3] (p)	0.5	10 (t,e)	50 (e)
TEX[2]	1		
Anthrasene	1	5 (e)	15 (e)
Benzo(a)anthrasene	1	5 (e)	15 (e)
Bezso(a)pyrene	0.2	2 (t)	15 (e)
Benzo(k)fluoranthene	1	5 (e)	15 (e)
Phenanthrene	1	5 (e)	15 (e)
Fluoranthene	1	5 (e)	15 (e)
Napthalene	1	5 (e)	15 (e)
PAH_{tot}[4]	15	30 (e)	100 (e)
PCB_{tot}[5], (28, 52, 101, 118, 138, 153, 180)	0.1	0,5 (t)	5 (e)
PCDD-PCDF-PCB (WHO-TEQ)[6]	0.00001	0,0001 (t)	0,0015 (e,t)
Dichloromethane (p)	0.01	1 (t)	5 (t, e)
Vinylchloride (p)	0.01	0,01 (t)	0,01 (t)
Dichlorethene[3] (p)	0.01	0,05 (t)	0,2 (t)
Trichlorethene (p)	0.01	1 (e,t)	5 (e)
Tetrachlorethene (p)	0.01	0,5 (t)	2 (t)
Trichlorbezenes[3]	0.05	5 (t)	20 (e)
Tetrachlorbenzenes[3]	0.1	0,5 (t)	5 (e)
Pentachlorbenzene	0.1	1 (t)	5 (e)
Hexachlorbenzene	0.01	0,05 (t)	2 (e)
Monochlorophenols[3] (p)	0.5	5 (e,t)	10 (e)
Dichlorophenols[3] (p)	0.5	5 (t)	40 (e)
Trichlorophenols[3] (p)	0.5	10 (e,t)	40 (e)
Tetrachlorophenols[3] (p)	0.5	10 (e,t)	40 (e)
Pentachlorophenol[3] (p)	0.5	10 (e,t)	20 (e)
Atrazine (p)	0.05	1 (e)	2 (e)
DDT[7]	0.1	1 (e)	2 (e)
Dieldrin	0.05	1 (e)	2 (e)
Endosulfan[8] (p)	0.1	1 (e)	2 (e)
Heptachlor	0.01	0,2 (t)	1 (e)
Lindane (p)	0.01	0,2 (t)	2 (e)
Tributhyltin (TBT)[9]	0.1	1 (e)	2 (e)
MTBE-TAME[10] (p)	0.1	5 (e)	50 (e,t)
Benzin fraction, (C5-C10)		100	500
Medium fraction, (>C10-C21)		300	1000
Heavy fraction, (>C21-C40)		600	2000
Oil fractions (>C10-C40)	300		

1) Value can be based on ecological risks (e) or risks to human health (t). Substances which can pose a risk to groundwater quality in soil concentrations below the lower guideline value have been marked in the first column (p). In the case of metals, the natural background (median) has been considered (added risk approach).

2) Sum of toluene, ethylbenzene and xylene

3) Sum of the isomers.

4) Sum of the PAHs listed above and other so-called EPA-PAHs: Asenaphthen, Benzo(ghi)perylene, Indeno(1,2,3-c,d)pyren, Benzo(b)fluoranthene, Dibenzo(a,h)anthrasene, Fluoren, Pyreeni, Chrysene, 6-Methychrysene.

5) Sum of PCBs including the congeners 28, 52, 101, 118, 138, 153, 180.

6) Sum of PCDD/F compounds and coplanar PCBs. Concentration in WHO-TEQs.

7) Sum of DTT, DDE and DDD.

8) Sum of alpha-endosulphane and beta-endosulphane

9) Sum of TBT and TPT.

10) Sum of MTBE and TAME

FRANCE

Les unités, pour les concentrations, sont exprimées en µg/L pour les eaux, sauf indication contraire (ex : mg/L), et en mg/kg matière sèche pour les sols.

	VDSS	VCI sol		VCI eaux	
	mg/kg MS	Usage sensible	Usage non sensible	Usage sensible	Usage non sensible
METAUX ET ASSIMILES					
Aluminium total, Al	(6)	(6)	(6)	200 (21)	1 mg/l
Antimoine, Sb	50	100 (3)	250 (3)	5 (17)	25
Arsenic, As	19 (8)	37 (1) (8)	120 (1) (8)	10 (17)	100 (22)
Baryum, Ba	312	625 (4)	3125	700 (17)	2 mg/l
Beryllium, Be	250	500 (3)	500 (3)	(6)	(6)
Cadmium, Cd	10	20 (2)	60 (2)	5 (17)	25
Chrome total, Cr	65	130 (1)	7000 (1)	50 (17)	250
Cobalt, Co	120	240 (4)	1200	(6)	(6)
Cuivre, Cu	95	190 (4)	950	2 mg/l (17)	4 mg/l
Manganèse, Mn	(6)	(6)	(6)	50 (21)	250
Mercure, Hg	3,5	7 (1)	600 (1)	1 (17)	5
Molybdène, Mo	100	200 (4)	1000	70 (18)	350
Nickel, Ni	70	140 (2)	900 (2)	20 (17)	100
Plomb, Pb	200	400 (2)	2000 (2)	25 (17)	125
Sélénium, Se	(6)	(6)	(6)	10 (17)	50
Thallium, Tl	5	10 (3)	pvl (3)	(6)	(6)
Vanadium, V	280	560 (3)	pvl (3)	(6)	(6)
Zinc, Zn	4500	9000 (1)	pvl (1)	3 mg/l (18)	6 mg/l
PRINCIPAUX IONS					
Ammonium, NH_4^+	(6)	(6)	(6)	100 (17)	4 mg/l (22)
Chlorure, Cl^-	(6)	(6)	(6)	250 mg/l (21)	500 mg/l
Cyanures totaux, $(CN)_x^{y-}$	25	50 (2)	100 (2)	50 (17)	250
Fluorure, F^-	(6)	(6)	(6)	1,5 mg/l (17)	3 mg/l
Nitrate, NO_3^-	(6)	(6)	(6)	50 mg/l (17)	100 mg/l
Nitrite, NO_2^-	(6)	(6)	(6)	500 (17)	2,5 mg/l
Sulfate, $SO_4^=$	(6)	(6)	(6)	250 mg/l (21)	500 mg/l
DIVERS					
Acrylamide	(6)	(6)	(6)	0,1 (17)	0,5
Oxyde de tributylétain	(6)	(6)	(6)	2 (18)	10
Hydrocarbures totaux	2500 (14)	5000 (4) (14)	25000	10 (27) (29)	1 mg/l (28) (29)
HYDROCARBURES AROMATIQUES					
Benzène	1	2,5 (1)	pvl (1)	1 (17)	5
Ethylbenzène	25	50 (4)	250	300 (18)	1,5 mg/l
Styrène	50	100 (4)	500	20 (18)	100
Toluène	5	10 (3)	120 (3)	700 (18)	3,5 mg/l
Xylènes totaux	5	10 (3)	100 (3)	500 (18)	2,5 mg/l
HYDROCARBURES AROMATIQUES POLYCYCLIQUES					
Anthracène		pvl (1)	pvl (1)	(6)	(6)
Benzo(a)anthracène	7	13,9 (1)	252 (1)	(6)	(6)
Benzo(k)fluoranthène	450	900 (1)	2520 (1)	(6)	(6)
Chrysène	5175	10350 (1)	25200 (1)	(6)	(6)
Benzo(a)pyrène	3,5	7 (1)	25 (1)	0,01 (17)	0.05
Fluoranthène	3050	6100 (1)	pvl (1)	(6)	(6)
Indéno(1,2,3-c,d)pyrène	8	16,1 (1)	252 (1)	(6)	(6)
Naphtalène	23	46 (1)	pvl (1)	(6)	(6)
HAP totaux (7)	(9)	(9)	(9)	0,1 (17)(23)	1 (25)

Les unités, pour les concentrations, sont exprimées en µg/L pour les eaux, sauf indication contraire (ex : mg/L), et en mg/kg matière sèche pour les sols.

	VDSS	VCI sol		VCI eaux	
	mg/kg MS	Usage sensible	Usage non sensible	Usage sensible	Usage non sensible
HYDROCARBURES MONOAROMATIQUES HALOGENES					
Monochlorobenzène	8	15 (3)	170 (3)	300 (18)	1,5 mg/l
1,2-Dichlorobenzène	25	50 (3)	pvl (3)	1 mg/l (18)	5 mg/l
1,3-Dichlorobenzène	25	50 (3)	pvl (3)	(6)	(6)
1,4-Dichlorobenzène	25	50 (3)	pvl (3)	300 (18)	1,5 mg/l
1,2,4-Trichlorobenzène	12	25 (3)	300 (3)	20 (18)(24)	100(24)
Hexachlorobenzène	4	8 (2)	200 (2)	1 (18)	5
HYDROCARBURES POLYAROMATIQUES HALOGENES					
Chloronaphtalène	5 (4)	10 (4)	50	(6)	(6)
PCDD / PCDF	500 ngTE/kg	1000 ngTE/kg (2)	10000 ngTE/kg (2)	(6)	(6)
PCB	(6) (10)	(6) (10)	(6) (10)	(6)	(6)
Arochlor 1016	0.05	0,1 (1)	60 (1)	(6)	(6)
Arochlor 1254	0.05	0,1 (1)	17 (1)	(6)	(6)
HYDROCARBURES ALIPHATIQUES HALOGENES					
Hexachlorobutadiène	13	27 (1)	pvl	0,6 (18)	3
1,2-Dichloropropane	0.5	1 (3)	5 (3)	40(19)	200
1,3-Dichloropropène	(6)	(6)	(6)	20 (18)	100
1,1,1-Trichloroéthane	7.5	15 (3)	180 (3)	2 mg/l (18)	10 mg/l
1,2-Dichloroéthane	2	4 (4)	20	3 (17)	15
Tétrachlorométhane	0.5	1 (4)	5	2 (18)	10
Bromoforme	(6)	(6)	(6)	100 (20)	500 (20)
Chloroforme	LQ	0,1 (3)	0,5 (3)	100 (20)	500 (20)
Total Trihalométhanes	(6)	(6)	(6)	100 (20)	500
Dichlorométhane	LQ	0,1 (3)	2 (3)	20 (18)	100
Tétrachloroéthylène	3	6 (1)	5300 (1)	10 (17)(26)	50 (26)
Trichloroéthylène	0.1	0,2 (1)	3020 (1)	10 (17)(26)	50 (26)
1,1-Dichloroéthylène	(6)	(6)	(6)	30 (18)	150
1,2-Dichloroéthylène (cis)	3 (1)	6 (1)	pvl (1)	50 (18)	250
Chlorure de vinyle	LQ (11)	0,02 (1)	30 (1)	0,5 (17)	2.5
PHENOLS et CHLOROPHENOLS					
Phénol	25	50 (3)	pvl (3)	(6)	(6)
Catéchol	10	20 (4)	100	(6)	(6)
Résorcinol	5	10 (4)	50	(6)	(6)
Hydroquinone	5	10 (4)	50	(6)	(6)
Pentachlorophénol	50	100 (2)	250 (2)	9 (18)	45
2,4,6-Trichlorophénol	13	27 (1)	pvl	200 (18)	1 mg/l
Chlorophénols totaux	5 (12)	10 (4) (12)	50	(6)	(6)
Crésols totaux	2	5 (4)	25	(6)	(6)
PHTALATES					
Phtalates totaux	30 (13)	60 (4) (13)	300	(6)	(6)
Di(2-éthylhexyl)phtalate	(6)	(6)	(6)	8 (18)	40

Les unités, pour les concentrations, sont exprimées en µg/L pour les eaux, sauf indication contraire (mg/L), et en mg/kg matière sèche pour les sols.

	VDSS	VCI sol		VCI eaux	
	mg/kg MS	Usage sensible	Usage non sensible	Usage sensible	Usage non sensible
PESTICIDES					
Aldrine	2	4 (2)	pvl (2)	0,03 (17)	2 (22)
Atrazine	3	6 (4)	30	0,1 (17)	2 (22)
Carbaryl	2	5 (4)	25	0,1 (17)	2 (22)
Carbofurane	1	2 (4)	10	0,1 (17)	2 (22)
DDD,DDE,DDT total	2	4 (4)	20	0,1 (17)	2 (22)
Dieldrine	(6)	(6)	(6)	0,03 (17)	2 (22)
"Drines" totaux	2	4 (4)	20	0,1 (17)	2 (22)
HCH totaux	5	10 (2) (15)	400 (2) (15)	0,1 (17)	2 (22)
Heptachlore et époxyde d'heptachlore	(6)	(6)	(6)	0,03 (17)	2 (22)
Lindane	0,2	0,5 (1)	470 (1)	0,1 (17)	2 (22)
Manèbe	17	35 (4)	175	0,1 (17)	2 (22)
Autres pesticides, par substance	(6)	(6)	(6)	0,1 (17)	2 (22)

Commentaires relatifs aux tableaux

Les unités, pour les concentrations sont exprimées :

- pour les eaux en µg/l, sauf indication contraire (ex : mg/l),
- pour les sols en mg/kg matière sèche.

(1) Valeurs françaises
(2) Valeurs allemandes réglementaires
(3) Valeurs allemandes en projet ""Berchnung von Prüfwerten zur Bewertung von Altlasten" (Umweltbundesamt) par G. Bachmann, J. Oltmann, R. Konietzka et K. Schneider, Erich Schmitt velag (1999)
(4) Valeurs hollandaises 1994
(5) Valeurs hollandaises 1998
(6) Valeur à déterminer, si la substance peut être présente dans le sol ou dans les eaux. Se référer à la méthode mise au point par l'INERIS (www.ineris.fr ou www.fasp.info)
(7) Milieu eau. Pour les sols, utiliser les valeurs par substance (voir anthracène, benzo(a)anthracène, benzo(k)fluoranthène, benzo(a)pyrène, chrysène, fluoranthène, indéno(1,2,3,c,d)pyrène, naphtalène).
(8) Valeurs pour pH > 7 ou Eh > -250 mV.
(9) Pour les sols, utiliser les valeurs par substance.
(10) Analyses à comparer en référence à l'Arochlor (1016 ou 1254) de composition la plus proche de celle des congénères à caractériser :

Substances	France Arochlor 1016	France Arochlor 1254	Substances	France Arochlor 1016	France Arochlor 1254
MonoCB	x		2,3',4,4',5-PentaCB		x
DiCB	x		2,2',3,4,4',5'- HexaCB		x
2,4,4'-TriCB	x	x	2,2',3,4,4',5-HexaCB		x
2,2',5,5'-TétraCB	x	x	2,2',4,4',5,5'-HexaCB		x
2,2',4,5,5'-PentaCB	x	x	2,2',3,4,4',5,5'-HeptaCB		x

(11) LQ = Limite de quantification
(12) Si la contamination est due à un seul composé de la famille des chlorophénols, la valeur lui est appliquée
(13) Valeur applicable à la somme des phtalates présents
(14) Lorsque la contamination est due à des mélanges (essence, fioul, ….), il convient de déterminer également les teneurs en hydrocarbures aromatiques et HAP
(15) Valeur allemande s'appliquant à la somme des isomères □□□
(16) Valeur hollandaise s'appliquant à la somme des isomères □□□□
(17) Décret du 20 décembre 2001, annexe I–1
(18) Valeurs guides OMS, annexe 2 (1994)
(19) Valeurs guides OMS, annexe 2 (1998)
(20) Valeur s'appliquant également à la somme des trihalométhanes. Par Total Trihalométhanes (THM) on entend la somme de chloroforme, bromoforme, dibromochlorométhane et bromodichlorométhane
(21) Décret du 20 décembre 2001, annexe I-2
(22) Décret du 20 décembre 2001, annexe III
(23) Valeur pour la somme des 4 substances : benzo(b)fluoranthène, benzo(k)fluoranthène, benzo(ghi)pérylène, indéno(1,2,3-cd)pyrène (décret du 20 décembre 2001, annexe I-1)
(24) Somme des trichlorobenzènes, selon (18)
(25) Valeur pour la somme des 6 substances : benzo(3,4)fluoranthène, benzo(11,12)fluoranthène, benzo(1,12)pérylène, benzo(3,4)pyrène, fluoranthène, indéno(1,2,3-cd)pyrène (décret du 20 décembre 2001, annexe III)
(26) Somme des concentrations en trichloroéthylène et tétrachloroéthylène, selon (20)
(27) Décret du 3 janvier 1989, annexe 1-1
(28) Décret du 3 janvier 1989, annexe 3
(29) Hydrocarbures dissous ou émulsionnés après extraction au tétrachlorure de carbone, selon (27) ou (28)

GERMANY

1.3 Action Levels, Trigger levels and Precaution Levels

1.3.1 Pathway: Soil - Human Beings (direct contact)

Action Levels

Substance	playing grounds	residential	parks / recreation	industrial areas
	[ng TE/kg dm]*			
PCDD/PCDF*	100	1,000	1,000	10,000

* 2, 3, 7, 8 - TCDD toxicity equivalent (NATO/CCMS)

Trigger Levels

Substance	Playing grounds	residential	parks/recreation	industrial areas
	[mg / kg dry matter]			
Arsenic	25	50	125	140
Lead	200	400	1,000	2,000
Cadmium	10 [2)]	20 [2)]	50	60
Cyanid	50	50	50	100
Chromium	200	400	1,000	1,000
Nickel	70	140	350	900
Mercury	10	20	50	80
Aldrin	2	4	10	
Benzo(a)pyrene	2	4	10	12
DDT	40	80	200	
Hexachlorobenzene	4	8	20	200
HCH (compounds)	5	10	25	400
Pentachlorophenol	50	100	250	250
PCB (PCB_6) [1)]	0.4	0.8	2	40

[1)] If total PCB is examined, the analysed levels have to be divided through 5
[2)] For gardens, which are used as well as playing ground for children as for growing food plants, the level for cadmium is 2

1.3.2 Pathway: Soil - Plants (transfer)

Soil Use

- **a) agriculture**
  areas for the cultivation of alternating crops
- **b) gardening**
  gardens, which are used for the cultivation of crops
- **c) green land**
  areas which are continuously used as green land

Trigger and Action Levels

(in relation to the quality of plants)

substance	agriculture, gardening [mg/kg dm]			green land [mg/kg dm]	
	method [1)]	trigger levels	action levels	method [1)]	action levels
Arsenic	KW	200 [2)]		KW	50
Cadmium	AN		0.04 / 0.1 [3)]	KW	20
Lead	AN	0.1		KW	1,200
Copper				KW	1,300 [4)]
Nickel				KW	1,900
Mercury	KW	5		KW	2
Thallium	AN	0.1		KW	15
BaP		1			
PCB_6					0.2

1) Analytical method: KW: HCl-HNO_3-extract [mg/kg dm]
AN: ammonium nitrate extract [mg/kg dm]
2) Soils with reducing conditions: trigger level = 50 [mg/kg dm]
3) 0.04 [mg/kg dm]: for the cultivation of bread wheat and strongly cadmium accumulating crops
0.1 [mg/kg dm]: for other crops
4) If the greenland is used by sheep, the action level = 200 [mg/kg dm]

Trigger Levels (in relation to the growth inhibiting)

Substance	agriculture [mg/kg dm]	
	method	trigger levels
Arsenic	AN	0.4
Copper	AN	1
Nickel	AN	1.5
Zinc	AN	2

Application of the Trigger Levelsand the Action Levels

The trigger levels and the action levels apply to a soil depth from 0 to 30 cm (agriculture, gardening) and to 0 to 10 cm (green land). For the application to a soil depth from 30 to 60 cm (agriculture, gardening) and to 10 to 30 cm (green land) the levels have to be multiplied by a factor of 1.5.

1.3.3 Pathway: Soil - Groundwater

Trigger Levels [µg/l] (for leachate)

Substance	trigger level		Substance	trigger level
Antimony	10		**cyanide, total**	50
arsenic	10		**cyanide, easy releasable**	10
lead	25		**fluoride**	750
cadmium	5		**mineral oil hydrocarbons** [1)]	200
chromium, total	50		**BTEX** [2)]	20
chromate	8		**benzene**	1
cobalt	50		**VHH** [3)]	10
copper	50		**Aldrin**	0.1
molybdenum	50		**DDT**	0.1
nickel	50		**phenols**	20
mercury	1		**PCB, total** [4)]	0.05
selenium	10		**PAH, total** [5)]	0.2
zinc	500		**naphtaline**	2
tin	40			

[1)] n-alkanes (C 10...c39), isoalkanes, cycloalcanes and aromatic hydrocarbons
[2)] volatile aromatic hydrocarbons (benzene, toluene, xylene, ethyl benzene, styrene, cumol)
[3)] volatile halogenated hydrocarbons (amount of halogenated C1- and C2-hydrocarbons)
[4)] amount of the polychlorinated biphenyls
[5)] amount of the polychlorinated aromatic hydrocarbons without naphtaline and methynaphtaline; usually determination according the list of the US EPA without naphtaline

Application of the Trigger Levels

a) The trigger levels apply to the transition zone between the unsaturated and the saturated soil zone (relevant point).
b) The assessment, whether it is likely that the groundwater trigger levels are exceeded at relevant point, has to take into account the change of the concentration of hazardous substances in the leachate on its way through the unsaturated zone and the depth of the groundwater with its variations.
c) At former waste disposal sites the assessment of the concentration of hazardous substances in the leachate by examining the disposed material is not appropriate because of its inhomogeneities. This is also the case at former industrial sites with no uniform distribution of the hazardous substances. In these cases it is allowed to estimate or calculate the concentration of hazardous substances in the leachate from the concentration in the downstream taking into account the concentration in the upstream.
d) If it is possible to measure the concentration in the leachate, the sampling should be made at the relevant point.
e) If the contaminated soil is in the saturated zone, the assessment concerning the risks for the groundwater has to be made pursuant to water law regulations.
f) Using the trigger levels, the geogenic background situation of the groundwater region has to be taken into account.

1.3.4 Precaution Levels

Precaution Levels for metals in soils (mg/kg dry matter, HCl-HNO_3-extract)

soils	cadmium	lead	chromium	copper	mercury	nickel	zinc
clay	1.5	100	100	60	1	70	200
loam	1	70	60	40	0.5	50	150
sand	0.4	40	30	20	0.1	15	60

Precaution Levels for organic substances in soils (mg/kg dry matter)

Soils	PCB_6	benzo(a)pyrene	PAH_{16}
humus content > 8 %	0.1	1	10
humus content < 8 %	0.05	0.3	3

1.3.5 Acceptable Additional Annual Load of Hazardous Substances

Substance	load [g/ha * a]
Lead	400
cadmium	6
chromium	300
copper	360

Substance	load [g/ha * a]
nickel	100
mercury	1.5
zinc	1,200

ITALY

SOIL

CAS Number	SUBSTANCES	Proposed limit for public park use area (mg/Kg d.s.)	Proposed limit for commercial /industrial use area (mg/Kg d.s.)	Proposed limit for groundwaters (µ/l)
75-09-2	DICHLOROMETHANE	--	--	0,15
67-63-0	ISOPROPYL ALCOHOL	0,5	5	5
67-63-0	ISOPROPYL ALCOHOL	10	250	350
64-17-5	ETHANOL	10	250	350
108-93-0	CYCLOHEXANOL	10	250	350
78-83-1	ISOBUTYL ALCOHOL	2300	31000	180
104-76-7	ETILESIL ALCOOL	10	250	350
100-51-6	BENZYL ALCOHOL	10	250	10
555-16-8	4-NITROBENZENALDEHYDE	0,5	30	3,5
71-55-6	1,1,1 TRICHLOROETHANE	--	--	200
630-20-6	1,1,1,2-TETRACHLOROETHANE	0,5	10	0,05
96-18-4	1,2,3- TRICHLOROPROPANE	1	10	
75-09-2	DICHLOROISOPROPYLENE	0,03	15	60
87-68-3	HEXACHLOROBUTADIENE	0,5	10	0,15
26523-63-7	HEXACHLOROBUTANE	0,5	10	0,05
67-72-1	HEXACHLOROETHANE	0,5	10	0,05
75-69-4	FLUOROTRI CHLOROMETHANE	0,1	5	0,15
76-13-1	1,1,2TRICHLOROTRIFLUOROETHANE	1	15	0,2
	PENTACHLOROBUTADIENE	0,5	10	0,15
76-01-7	PENTACHLORO ETHANO	0,5	10	0,05
	TETRACHLOROBUTADIENE	0,5	10	0,15
56-23-5	CARBONTETRACHLORIDE	0,1	5	0,15
105-60-2	CAPROLACTAM	10	250	--
68-12-2	DIMETHYLFORMAMIDE	10	250	--
111-92-2	DIBUTYL AMINE	0,5	25	10
111-42-2	DIETHANOLAMINE	0,5	25	910
102-82-9	TRIBUTYLAMINE	0,5	25	910
95-54-5	1,2PHENYLENEDIAMINE	0,05	5	10
108-45-2	1,2PHENYLENEDIAMINE	0,05	5	10
134-32-7	1-NAPHTHYLAMINE	0,1	10	20
634-67-3	2,3,4- TRICHLOROANILINE	0,05	5	10
608-27-5	2,3-DICHLOROANALINE	0,05	5	10
87-59-2	2,3DIMETHYLANILINE	0,05	5	10
636-30-6	2,4,5-TRICHLOROANILINE	0,05	5	10
634-93-5	2,4,6-TRICHLOROANILINE	0,05	5	10
88-05-1	2,4,6-TRIMETHYLANILINE	0,05	5	10
554-00-7	2,4-DICHLOROANILINE	0,05	5	10
95-68-1	2,4-DIMETHYLANILINE	0,05	5	10
2735-04-8	2,4-DIMETHOXYANILINE	0,1	10	20
97-02-9	2,4-DINITROANILINE	0,05	5	10
95-82-9	2,5-DICHLOROANILINE	0,05	5	10
95-78-3	2,5-DIMETHYLANILINE	0,05	5	10
102-56-7	2,5-DIMETHOXYANILINE	0,1	10	20
99-30-9	2,6-DICHLORO-4-NITROANILINE	0,05	5	10
608-31-1	2,6-DICHLOROANILINE	0,05	5	10
579-66-8	2,6-DIETHYLANILINE	0,05	5	10
87-62-7	2,6-DIMETHYLANILINE	0,05	5	10
90-41-5	2-AMINOBIPHENYL	0,1	10	20
615-65-6	2-CHLORO-4-METHYLANILINE	0,05	5	10
95-81-8	2-CHLORO-5-METHYLANILINE	0,05	5	10
6283-25-6	2-CHLORO-5-NITROANILINE	0,05	5	10
87-63-8	2-CHLORO-6-METHYLANILINE	0,05	5	10
578-54-1	2-ETHYLANILINE	0,05	5	10
94-70-2	2-ETHOXYANILINE	0,1	10	20
603-83-8	2-METHYL-3-NITROANILINE	0,05	5	10
99-52-5	2-METHYL-4-NITROANILINE	0,05	5	10
99-55-8	2-METHYL-5-NITROANILINE	0,05	5	10
570-24-1	2-METHYL-6-NITROANILINE	0,05	5	10
89-63-4	2-NITRO-4-CHLOROANILINE	0,05	5	10

CAS Number	SUBSTANCES	Proposed limit for public park use area (mg/Kg d.s.)	Proposed limit for commercial /industrial use area (mg/Kg d.s.)	Proposed limit for groundwaters (μ/l)
91-94-1	3,3-DICHLOROBENZIDINE	0,05	5	10
119-93-7	3,3-DIMETHYLBENZIDINE	0,05	5	10
119-90-4	2,4-DIMETHOXYBENZIDINE	0,05	5	10
634-91-3	3,4,5-TRICHLOROANILINE	0,05	5	10
95-76-1	3,4-DICHLOROANILINE	0,05	5	10
95-64-7	3,4-DIMETHYLANILINE	0,05	5	10
6315-89-5	3,4-DIMETHOXYANILINE	0,1	10	20
626-43-7	3,5-DICHLOROANILINE	0,05	5	10
108-69-0	3,5-DIMETHYLANILINE	0,05	5	10
10272-07-8	3,5-DIMETHOXYANILINE	0,1	10	20
87-60-5	3-CHLORO-2-METHYLANILINE	0,05	5	5
95-74-9	3-CHLORO-4-METHYLANILINE	0,05	5	10
587-02-0	3-ETHYLANILINE	0,05	5	10
	3-METHYL-2-NITROANILINE	0,05	5	10
108-44-1	3-METHYLANILINE	0,05	5	10
106-49-0	4-MTHYLANILINE	0,05	5	10
92-67-1	4-AMMINEBIPHENYL	0,05	5	10
93-50-5	4-CHLORO-2-ANISIDINE	0,1	10	20
635-22-33	4-CHLORO-3-NITROANILINE	0,05	5	10
	4-CHLORO-3-METHYLANILINE	0,05	5	10
932-96-7	4-CHLORO-N-METHYLANILINA	0,05	5	10
589-16-2	4-ETHYLANILINE	0,05	5	10
60-09-3	4-PHENYLAZOANILINE	0,05	5	10
89-62-3	4-METHYL-2-NITROANILINE	0,05	5	10
119-32-4	4-METHYL-3-NITROANILINE	0,05	5	10
121-87-9	4-NITROCHLOROANILINE	0,05	5	10
1635-61-6	5-CHLORO-2-NITROANILINE	0,05	5	10
95-79-4	5-CHLORO-2-TOLUIDINE	0,05	5	10
92-87-5	BENZIDINE	0,05	5	10
91-59-8	BETA-NAPHTHYLAMINE	0,05	5	10
108-42-9	M-CHLOROANILINE	0,05	5	10
99-09-2	M-NITROANILINE	0,05	5	10
121-69-7	N,N-METHYLANILINE	0,05	5	10
102-27-2	N-ETHYL-3-METHYLANILINE	0,05	5	10
103-69-5	N-ETHYLANILINE	0,05	5	10
612-28-2	N-METHYL-2-NITROANILINE	0,05	5	10
100-15-2	N-METHYL-4-NITROANILINE	0,05	5	10
100-61-8	N-METHYLANILINE	0,05	5	10
95-51-2	O-CHLOROANILINE	0,05	5	10
88-74-4	O-NITROANILINE	0,05	5	10
95-53-4	O-TOLUIDINA	0,05	5	10
106-47-8	P-CHLOROANILINA	0,05	5	10
100-01-6	P-NITROANILINE	0,05	5	10
	ALFAAMINOANTHRAQUINONE	5	50	50
551-92-8	DIMETRIDAZOLO	0,01	1	0,3
14885-29-1	IPRONIDAZOLO	0,01	1	0,3
1336-21-6	AMMONIA	--	--	500
19811-05-3	2,4-DICHLOROBENZOPHENONE	0,01	0,1	0,1
85-20-0	2,4' - DICHLOROBENZOPHENONE	0,01	0,1	0,1
78-33-3	2-BUTYLKETONE	5	50	50
6284-79-3	3,4 - DICHLOROBENZOPHENONE	0,01	0,1	0,1
90-98-2	4,4 - DICHLOROBENZOPHENONE	0,01	0,1	0,1
67-64-1	ACETONE	10	250	350
84-65-1	ANTHRAQUINONE	5	50	50
108-94-1	CYCLOHEXANONE	10	250	350
78-93-3	METHYL HEXYL KETONE	10	250	350
108-10-1	4-METHYL-2-PENTANONE	5	50	50
	DICHLORODIAZOBENZENE	0,01	10	--
634-66-2	1,2,3,4-TETRACHLOROBENZENE	1	25	1,8
634-90-2	1,2,3,5-TETRACHLOROBENZENE	1	25	1,8
95-94-3	1,2,3,5-TETRACHLOROBENZENE	1	25	1,8
87-61-6	1,2,3-TRICHLOROBENZENE	1	50	190
108-70-3	1,3,5-TRICHLOROBENZENE	1	50	190
82-68-8	PENTACHLORONITROBENZENE	0,1	50	5
121-86-8	2-CHLORO-4NITROTOLUENE	0,01	10	--

CAS Number	SUBSTANCES	Proposed limit for public park use area (mg/Kg d.s.)	Proposed limit for commercial /industrial use area (mg/Kg d.s.)	Proposed limit for groundwaters (µ/l)
646-06-0	DIOXOLANE	0,1	--	0,5
130-14-3	1-NAPHTHALENESULFONIC ACID	0,5	10	50
117-14-6	1,5-ANTHRAQUINONE DISULFONIC ACID	0,5	10	50
81-04-9	1,5-NAPHTHALENDISULFONIC ACID	0,5	10	50
14486-58-9	1,6-ANTHRAQUINONE DISULFONIC ACID	0,5	10	50
525-37-1	1,6-NAPHTHALENDISULFONIC ACID	0,5	10	50
82-48-4	1,8-ANTHRAQUINONE DISULFONIC ACID	0,5	10	50
82-49-5	1-ANTHRAQUINONE SULFONIC ACID	0,5	10	50
532-02-5	2-NAPHTHALENESULFONIC ACID	0,5	10	50
92-70-6	2 HYDROXY-3 NAPHTHOIC ACID	0,5	10	50
581-75-9	2,6-NAPHTHALENDISULFONIC ACID	0,5	10	50
84-49-1	2,7-ANTHRAQUINONE DISULFONIC ACID	0,5	10	50
92-41-1	2,7-NAPHTHALENDISULFONIC ACID	0,5	10	50
84-48-0	2-ANTHRAQUINONE SULFONIC ACID	0,5	10	50
14542-08-06	2-HYDROXY-1,5-NAPHTHALENDISULFONIC ACID	0,5	10	50
69422-83-9	2-HYDROXY-1,6-NAPHTHALENDISULFONIC ACID	0,5	10	50
25059-14-7	2-HYDROXY-1-NAPHTHALENSULFONIC ACID	0,5	10	50
6259-66-1	2-HYDROXY-3,6,8-NAPHTHALENTRISULFONIC ACID	0,5	10	50
148-75-4	2-HYDROXY-3,6-NAPHTHALENDISULFONIC ACID	0,5	10	50
6357-85-3	2-HYDROXY-4-NAPHTHALENSULFONIC ACID	0,5	10	50
25059-15-8	2-HYDROXY-5-NAPHTHALENSULFONIC ACID	0,5	10	50
118-32-1	2-HYDROXY-6,8-NAPHTHALENDISULFONIC ACID	0,5	10	50
93-01-6	2-HYDROXY-6-NAPHTHALENSULFONIC ACID	0,5	10	50
92-40-0	2-HYDROXY-7-NAPHTHALENSULFONIC ACID	0,5	10	50
132-57-0	2-HYDROXY-8-NAPHTHALENSULFONIC ACID	0,5	10	50
98-47-5	META-NITROBENZENSULFONIC ACID	0,5	10	50
135-19-3	BETANAPHTOL	0,5	10	50
87-02-5	2-AMINO-5-HYDROXY-7-NAPHTHALENSULFONIC ACID	0,1	10	10
86-60-2	2-AMINO-8-NAPHTHALENSULFONIC ACID	0,1	10	10
90-51-7	2-AMINO-8-HYDROXY-6-NAPHTHALENSULFONIC ACID	0,1	10	10
81-16-3	2-NAPHTHYLAMINE-1-SULFONIC ACID	0,1	10	10
118-33-2	2-NAPHTHYLAMINE-5,7-DISULFONIC ACID	0,1	10	10
86-65-7	2-NAPHTHYLAMINE6,8-DISULFONIC ACID	0,1	10	10
121-47-1	META-ANILINSULFONIC ACID	0,1	10	10
88-21-1	ORTO-ANILINSULFONIC ACID	0,1	10	10
121-57-3	PARA-ANILINSULFONIC ACID	0,1	10	10
78-00-2	TETRAETHYLLEAD	0,01	0.068	0,01
104-15-4	p-TOLUENSULFONIC ACID	0,5	10	50
109-99-9	TETRAHYDROFURAN	1	10	10
131-17-9	ALLYL PHTHALATE	10	60	
117-81-7	DI (2-ETHYLHEXYL) PHTHALATE	1	6	3
3319-31-1	tris(2-ETHYLHEXYL) MELLITATE	20	750	350
637-92-3	ETHYL TERTIARY BUTYL ETHER (ETBE)	10	250	10
60-29-7	DIETHYL ETHER	180	180	120
1634-04-4	METHYL TERBUTYL ETHER	10	250	10
	DICHLOROISOPROPYLETHER	0,3	15	60
101-84-8	DIPHENYL OXIDE	0,5	50	50
92-52-4	BIPHENYL	0,05	50	15
	PHENOLI (INDEX)			0,05
108-39-4	m-CRESOL	0,1	25	40
106-44-5	p-CRESOL	0,1	25	40
4901-51-3	2,3,4,5TETRACHLOROPHENOL	0,01	5	0,5
59-50-7	4-CHLORO, 3-METHYL-PHENOL	0,1	25	40
108-43-0	M-CHLORO-PHENOL	0,1	25	180
106-48-9	P-CHLORO-PHENOL	0,1	25	180
	trichlorophenol	0,01	10	--
527-60-6	2,4,6-TRIMETHYL-PHENOL	0,1	25	40
105-67-9	2,4-DIMETHYL-PHENOL	0,1	25	40
51-28-5	2,4DINITROPHENOL	0,1	25	15
88-75-5	2-NITROPHENOL	0,5	30	3,5
100-02-7	4-NITROPHENOL	0,5	30	3,5
591-27-5	META-AMINOPHENOL	0,1	10	10
90-00-6	O-ETHYL-PHENOL	0,1	25	40
111-46-6	DIETHYLENE GLYCOL	10	250	350
	PROPYLENEMETHYLGLYCOL	10	250	350

CAS Number	SUBSTANCES	Proposed limit for public park use area (mg/Kg d.s.)	Proposed limit for commercial /industrial use area (mg/Kg d.s.)	Proposed limit for groundwaters (µ/l)
107-21-1	ETHANE-1,2DIOL	10	250	350
	TOTAL HYDROCARBON / MINERAL OIL	--	--	10
110-82-7	CYCLOHEXANE	10	250	350
77-73-6	DICYCLOPENTADIENE	0,1	--	0,2
110-54-3	N-HEXANE	--	--	10
7440-62-2	VANADIUM	--	--	50
95-73-8	2,4DICHLOROTOLUENE	0,5	50	40
95-49-8	2-CHLOROTOLUENE	0,5	50	40
106-43-4	4-CHLOROTOLUENE	0,5	50	40
75-05-8	ACETONITRILE	0,5	5	5
89-61-2	2,5-DICHLORONITROBENZENE	0,1	10	20
99-54-7	3,4-DICHLORONITROBENZENE	0,1	10	20
51-28-5	2,4-DINITROPHENOL	--	25	--
88-75-5	2-NITROPHENOL	--	30	--
100-02-7	4-NITROPHENOL	--	30	--
118-96-7	2,4,6-TRINITROTOLUENE	0,05	5	10
121-14-2	2,4-DINITROTOLUENE	0,05	5	10
99-99-0	4-NITROTOLUENE	0,01	10	10
	OTHER DINITROTOLUENES (CUMULATIVE)	0,01	25	--
	OTHER DINITROTOLUENES (SINGLE)	0,05	0,05	--
94-36-0	BENZOYLE PEROXIDE	5	75	10
	1,1'-BINAPHTHALENE	0,05	50	15
575-41-7	1,3-DIMETHYLNAPHTHALENE	0,05	50	15
571-58-4	1,4-DIMETHYLNAPHTHALENE	0,05	50	15
569-41-5	1,8-DIMETHYLNAPHTHALENE	0,05	50	15
90-12-0	1-METHYLNAPHTHALENE	0,05	50	5
	2,3,5-TRIMETHYLNAPHTHALENE	0,05	50	15
581-40-8	2,3,-DIMETHYLNAPHTHALENE	0,05	50	15
581-42-0	2,6,-DIMETHYLNAPHTHALENE	0,05	50	15
91-57-6	2-METHYLNAPHTHALENE	0,05	50	5
	ALFANAPHTHOL	0,01	25	0,05
	BENZO ANTHRACENONE	5	50	--
83-32-9	ACENAPHTHENE	5	50	5
208-96-8	ACENAPHTHYLENE	5	50	5
120-12-7	ANTHRACENE	5	50	5
205-82-3	BENZOFLUORANTHENE	0,5	10	0,05
192-65-4	DIBENZOPYRENE	0,5	10	0,05
85-01-8	PHENANTHRENE	5	50	5
206-44-0	FLUORANTHENE	5	50	5
86-73-7	FLUORENE	5	50	5
91-20-3	NAPHTHALENE	5	50	5
141-78-6	ETHYL ACETATE	5	50	50
3926-62-3	SODIUM MONOCHLORO ACETATE	10	250	10
526-73-8	1,2,3 TRIMETHYLBENZENE	50	250	10
95-63-6	1,2,4 TRIMETHYLBENZENE	50	250	10
108-67-8	1,3,5 TRIMETHYLBENZENE	50	250	10
108-38-3	METHAXYLENE	0,5	50	10
95-47-6	ORTHOXYLENE	0,5	50	10
106-42-3	PARAXYLENE	0,5	50	10
98-82-8	ISOPROPYLBENZENE	0,5	50	50
149-30-4	2-MERCAPTOBENZOTHIAZOLE	10	250	10
100-68-5	THIOANISOLE	1	25	10
	DIBUTYL DISULFIDE	10	250	10
	DIISOPROPYLENE DISULFIDE	10	250	10
629-19-6	DIPROPYL DISULFIDE	10	250	10
	ISOPROPYLENE -PROPYLE DISULFIDE	10	250	10
	DI-TER-BUTYLE DISULFIDE	10	250	10
	CELLULOSE XANTHATE	50	750	--
60-51-5	DIMETHOATE			
947-02-4	PHOSFOLAN			
121-75-5	MALATHION			
950-10-7	MEPHOSFOLAN			
16752-77-5	METHOMYL			
51218-45-2	METOLACLOR			
40487-42-1	PENDIMETHALIN			

ITALY

Limit values for surface and subsurface soil according to land use

Compounds	Residential/ Public (green) use mg/Kg on dry	Industrial/ Commercial use mg/Kg on dry
Inorganic compounds		
Antimony	10	30
Arsenic	20	50
Beryllium	2	10
Cadmium	2	15
Cobalt	20	250
Total Chromium	150	800
Chromium (VI)	2	15
Mercury	1	5
Nickel	120	500
Lead	100	1000
Copper	120	600
Selenium	3	15
Thallium	1	350
Tin	1	10
Vanadium	90	250
Zinc	150	1500
Free Cyanides (Total Cyanides*) *Revision proposed by National Institute of Health (ISS)	1	100
Fluoruride	100	2000
Organic aromatic compounds		
Benzene	0,1	2
Ethyl benzene	0,5	50
Styrene	0,5	50
Toluene	0,5	50
Xylene	0,5	50
Sum of aromatic compounds (from 20 to 23)	1	100
Polycyclic aromatic compounds		
Benzo(a)anthracene	0,5	10
Benzo(a)pyrene	0,1	10
Benzo(b)fluoranthene	0,5	10
Benzo(k)fluoranthene	0,5	10
Benzo(g,h,i)perylene	0,1	10
Chrysene	5	50
Dibenzo(a)pyrene (Dibenzo(a,e)pyrene, Dibenzo(a,i)pyrene, Dibenzo(a,l)pyrene, Dibenzo(a,h)pyrene either*) *Revision proposed by National Institute of Health (ISS)	0,1	10
Dibenzo(a,h)anthracene	0,1	10
Indeno(1,2,3-c,d)pyrene	0,1	5
Pyrene	5	50
Sum of polycyclic aromatic compounds (from 25 to 34)	10	100
Aliphatic chlorinated compounds (carcinogens)		
Chloromethane	0,1	5
Dichloromethane	0,1	5
Trichloromethane	0,1	5
Vinyl chloride	0,01	0,1
1,2-Dichloroetane	0,2	5
1,1-Dichloroethylene	0,1	1
1,2-Dichloropropane	0,3	5
1,1,2-Trichloroethane	0,5	15
Trichloroethylene	1	10
1,2,3-Trichloropropane	0,1 (1**)	1 (10**)
1,1,2,2-Tetrachloroethane	0,5	10
Tetrachloroethylene (PCE)	0,5	20
Aliphatic chlorinated compounds (not carcinogens)		
1,1-Dichloroethane	0,5	30
1,2-Dichloroethylene	0,3	15
1,1,1-Trichloroethane	0,5	50
Aliphatic halogenated compounds (carcinogens)		
Tribromomethane (bromoforme)	0,5	10
1,2-Dibromoehtane	0,01	0,1
Dibromochloromethane	0,5	10
Bromodichloromethane	0,5	10

Compounds	Residential/ Public (green) use mg/Kg on dry	Industrial/ Commercial use mg/Kg on dry
Nitro-aromatic compounds		
Nitrobenzene	0,5	30
1,2-Dinitrobenzene	0,1	25
1,3-Dinitrobenzene	0,1	25
Chloronitrobenzenes (each)	0,1	10
Chlorinated aromatic compounds		
Monochlorobenzene	0,5	50
1,2-Dichlorobenzene (not carcinogenic)	1	50
1,4-Dichlorobenzene (carcinogenic)	0,1	10
1,2,4-Trichlorobenzene	1	50
1,2,4,5-Tetrachlorobenzene	1	25
Pentachlorobenzene	0,1	50
Hexachlorobenzene	0,05	5
Phenols (not chlorinated)		
Metylphenols (o-, m-, p-)	0,1	25
Phenol	1	60
Chlorinated phenols		
2-Chlorophenol	0,5	25
2,4-Dichlorophenol	0,5	50
2,4,6-Trichlorophenol	0,01	5
Pentachlorophenol	0,01	5
Aromatic amine		
Aniline	0,05	5
o-Anisidine	0,1	10
m,p-Anisidine	0,1	10
Diphenylamine	0,1	10
p-Toluidine	0,1	5
Sum of aromatic amine (from 73 to 77)	0,5	25
Pesticides		
Alachlor	0,01	1
Aldrin	0,01	0,1
Atrazine	0,01	1
□ -hexachlorohexane	0,01	0,1
□ -hexachlorohexane	0,01	0,5
□ -hexachlorohexane (Lindane)	0,01	0,5
Chlordane	0,01	0,1
DDD,DDT, DDE	0,01	0,1
Dieldrin	0,01	0,1
Endrin	0,01	2
Dioxins and furans		
Sum of PCDD, PCDF (conversion T.E.)	$1x10^{-5}$	$1x10^{-4}$
PCB	0,001 (0,06*)	5
Hydrocarbons		
Hydrocarbons C<12 (light) (Hydrocarbons C≤12*) *Revision proposed by National Institute of Health (ISS)	10	250
Hydrocarbons C>12 (heavy)	50	750
Others		
Asbestos (free fibers***) ***This sentence has to be excluded, according to proposal of National Institute of Health (ISS)	1000	1000
Phthalic acid esters	10	60

Compounds	Residential/ Public (green) use mg/Kg on dry	Industrial/ Commercial use mg/Kg on dry
Aliphatic halogenated compounds (carcinogens)		
Carbon tetrachloride	0,1	5
1,1,1,2-Tetrachloroethane	0,5	10
Pentachloroetane	0,5	10
Hexachloroetane	0,5	10
Hexachlorobutane	0,5	10
Aliphatic halogenated compounds (not carcinogens)		
Hexachlorobutadiene	0,5	10
Freon 11 (Fluorotrichloromethane)	0,1	5
Tetrachlorobutadienes	0,5	10
Freon 113 (1,1,2-Trichlorotrifluoroethane)	1	15
Pentachlorobutadienes	0,5	10
Chlorobenzenic compounds		
1,3 Dichlorobenzene		
1,2,3-Trichlorobenzene	1	50
1,3,5-Trichlorobenzene	1	50
1,2,3,5-Tetrachlorobenzene	1	25
Pentachloronitrobenzene	0,1	50
Nitrobenzene		
2,5-Dichloronitrobenzene	0,1	10
3,4-Dichloronitrobenzene	0,1	10
Aromatic amine		
o-Toluidine	0,05	5
2,6-Diethylaniline	0,05	5
□-naphtylamine	0,05	5
o-Nitroaniline	0,05	5
m-Nitroaniline	0,05	5
p-Nitroaniline	0,05	5
o-Chloroaniline	0,05	5
m-Chloroaniline	0,05	5
p-Chloroaniline	0,05	5
3,5-Dichloroaniline	0,05	5
2,6-Dichloroaniline	0,05	5
2,3-Dichloroaniline	0,05	5
3,4-Dichloroaniline	0,05	5
5-Chloro-2-toluidine	0,05	5
4-Chloro-2-anisidine	0,1	10
2-Nitro-4-chloroaniline	0,05	5
4-Nitro-2-chloroaniline	0,05	5
2,6-Dichloro-4-nitroaniline	0,05	5
2-Aminobiphenyl	0,1	10
4-Aminobiphenyl	0,05	5
Benzidine	0,05	5
2-Chloro-4-methylaniline	0,05	5
2-Chloro-5-methylaniline	0,05	5
2-Chloro-6-methylaniline	0,05	5
3-Chloro-4-methylaniline	0,05	5
4-Chloro-n-methylaniline	0,05	5
4-Chloro-5-methylaniline	0,05	5
2-Chloro-5-nitroaniline	0,05	5
4-Chloro-3-nitroaniline	0,05	5
5-Chloro-2-nitroaniline	0,05	5
N,N-Dimethylaniline	0,05	5
2,3-Dimethylaniline	0,05	5
2,4-Dimethylaniline	0,05	5
2,5-Dimethylaniline	0,05	5
2,6-Dimethylaniline	0,05	5
3,4-Dimethylaniline	0,05	5
3,5-Dimethylaniline	0,05	5
3,3'-Dimethylbenzidine	0,05	5
2,4-Dimethoxyaniline	0,1	10
2,5-Dimethoxyaniline	0,1	10
3,4-Dimethoxyaniline	0,1	10
3,5-Dimethoxyaniline	0,1	10
2,4-Dichloroaniline	0,05	5
2,5-Dichloroaniline	0,05	5
3,3’-Dimethoxybenzidine	0,05	5

Compounds	Residential/ Public (green) use mg/Kg on dry	Industrial/ Commercial use mg/Kg on dry
3,3'-Dichlorobenzidine	0,05	5
2,4-Dinitroaniline	0,05	5
N-ethylaniline	0,05	5
2-Ethylaniline	0,05	5
3-Ethylaniline	0,05	5
4-Ethylaniline	0,05	5
2-Ethoxyaniline	0,1	10
N-Ethyl-3-methylaniline	0,05	5
4-Phenylazoaniline	0,05	5
1,2-Phenylendiamine	0,05	5
1,3-Phenylendiamine	0,05	5
N-Methylaniline	0,05	5
3-Methylaniline	0,05	5
N-Methyl-2-nitroaniline	0,05	5
N-Methyl-4-nitroaniline	0,05	5
2-Methyl-3-nitroaniline	0,05	5
2-Methyl-4-nitroaniline	0,05	5
2-Methyl-5-nitroaniline	0,05	5
2-Methyl-6-nitroaniline	0,05	5
3-Methyl-2-nitroaniline	0,05	5
4-Methyl-2-nitroaniline	0,05	5
4-Methyl-3-nitroaniline	0,05	5
2,4,6-Trimethylaniline	0,05	5
2,3,4-Trichloroaniline	0,05	5
2,4,5-Trichloroaniline	0,05	5
2,4,6-Trichloroaniline	0,05	5
3,4,5-Trichloroaniline	0,05	5
1-Naphthylamine	0,1	10
3-Chloro-2-methylaniline	0,05	5
4-Methylaniline	0,05	5
Sum of aromatic amines in this table + Sum of aromatic amines D.M. 471/99	0,5	25
Not chlorinated phenols		
2,4-Dimethylphenol	0,1	25
2,4,6-Trimethylphenol	0,1	25
o-Ethylphenol	0,1	25
2-Nitrophenol	0,5	30
4-Nitrophenol	0,5	30
2,4-Dinitrophenol	0,1	25
Chlorinated phenols		
m-chlorophenol	0,1	25
p-chlorophenol	0,1	25
4-chloro, 3-methylphenol	0,1	25
2,3,4,5-tetrachlorophenol	0,01	5
Polycyclic aromatic compounds		
Naphthalene	5	50
Acenaphthylene	5	50
Acenaphthene	5	50
Fluorene	5	50
Phenanthrene	5	50
Anthracene	5	50
Fluoranthene	5	50
Benzo(j)fluoranthene	0,5	10
Dibenzo(ae)pyrene	0,5	10
Sum of polycyclic aromatic compounds in this table + Sum of polycyclic aromatic compounds D.M. 471/99	10	100
Naphthalensulfonic compounds of thioaminic		
Meta-aminophenol (3-aminophenol)	0,1	10
2-amino-8-hydroxy-6-naphthalensulfonic acid (gamma acid)	0,1	10
2-amino-5-hydroxy-7-naphthalensulfonic acid (isogamma acid)	0,1	10
2-naphthylamino-5,7-disulfonic acid (aminoisogamma acid)	0,1	10
2-naphthylamino-6,8-disulfonic acid (amino g acid)	0,1	10
2-amino-8-naphthalensulfonic acid	0,1	10
2-naphthylamino-1-sulfonic acid (tobias acid)	0,1	10
Para-anilinesulfonic acid (acido sulphanilic)	0,1	10
Meta-anilinesulfonic acid (metanilic acid)	0,1	10
Ortho-anilinesulfonic acid (orthanilic acid)	0,1	10
Sum of naphthalensulfonic compounds of thioaminic	0,5	25

Compounds	**Residential/ Public (green) use mg/Kg on dry**	**Industrial/ Commercial use mg/Kg on dry**
Naphthalensulfonic compounds		
Meta-nitrobenzenesulfonic acid	0,5	10
Betanaphthol (2-naphthol)	0,5	10
1,5-naphthalendisulfonic acid	0,5	10
1,6-naphthalendisulfonic acid	0,5	10
2,6-naphthalendisulfonic	0,5	10
2,7-naphthalendisulfonic acid	0,5	10
2-hydroxy-1-naphthalensulfonic (stebbins acid)	0,5	10
2-hydroxy-4-naphthalensulfonic acid	0,5	10
2-hydroxy-5-naphthalensulfonic acid	0,5	10
2-hydroxy-6-naphthalensulfonic acid (schaeffer acid)	0,5	10
2-hydroxy-7-naphthalensulfonic acid	0,5	10
2-hydorxy-8-naphthalensulfonic acid (croceic acid)	0,5	10
2-hydroxy-1,6-naphthalendisulfonic acid	0,5	10
2-hydroxy-1,5-naphthalendisulfonic acid	0,5	10
2-hydroxy-3,6-naphthalendisulfonic acid (r acid)	0,5	10
2-hydroxy-6,8-naphthalendisulfonic acid (g acid)	0,5	10
2-hydroxy-3,6,8-naphthalentrisulfonic acid	0,5	10
1-anthrachinonsulfonic acid	0,5	10
2-anthrachinonsulfonic acid	0,5	10
1,5-anthrachinondisulfonic acid	0,5	10
1,6-anthrachinondisulfonic acid	0,5	10
Other		
Dichloroisopropylether	0,3	15
MethylTertButylEther (MTBE)	10	250
EthylTertButylEther (ETBE)	10	250
Dioxalane	0,1	0,1
Dicyclopentadiene	0,1	0,1
Diphenylether	0,5	50
Ditertbutyldisulfide	10	250
Dibutyldisulfide	10	250
Diisopropylenedisulfide	10	250
Dipropyledisulfide	10	250
Diallylphtalate	10	60
Tetraethyl lead	0,01	0,068
Thioanisole	1	25
1,2,3-Trimethylbenzene	50	250
1,2,4-Trimethilbenzene	50	250
1,3,5-Trimethilbenzene	50	250
Cellulose xanthate	50	750
(1) according to toxicological similitude with compounds regulated by DM 471/99		

ITALY

Limit values for Groundwater

Compounds	Upper limit µg/L	Compounds	Upper limit µg/L
Metals		**Aliphatic chlorinated compounds (not carcinogens)**	
Aluminium	200	1,1-Dichloroethane	810
Antimony	5	1,2-Dichloroethylene	60
Silver	10	**Aliphatic halogenated compounds (carcinogens)**	
Arsenic	10	Tribromomethane (bromoforme)	0,3
Berylium	4	1,2-Dibromoehtane	0,001
Cadmium	5	Dibromochloromethane	0,13
Cobalt	50	Bromodichloromethane	0,17
Total Chromium	50	**Nitrobenzene**	
Chromium (VI)	5	Nitrobenzene	3,5
Iron	200	1,2-Dinitrobenzene	15
Mercury	1	1,3-Dinitrobenzene	3,7
Nickel	20	Chloronitrobenzenes (each)	0,5
Lead	10	**Chlorobenzenic compounds**	
Copper	1000	Monochlorobenzene	40
Selenium	10	1,2-Dichlorobenzene (not carcinogenic)	270
Manganese	50	1,4-Dichlorobenzene (carcinogenic)	0,5
Thallium	2	1,2,4-Trichlorobenzene	190
Zinc	3000	1,2,4,5-Tetrachlorobenzene	1,8
Inorganic contaminants		Pentachlorobenzene	5
Boron	1000	Hexachlorobenzene	0,01
Free Cyanides (Total Cyanides*) *Revsion proposed by the National Institute of Health (ISS)	50	**Phenols and chlorinated phenols**	
Fioride	1500	2-Chlorophenol	180
Nitrite	500	2,4-Dichlorophenol	110
Sulfate (mg/L)	250	2,4,6-Trichlorophenol	5
Organic aromatic compounds		Pentachlorophenol	0,5
Benzene	1	**Aromatic amine**	
Ethyl benzene	50	Aniline	10
Styrene	25	Diphenylamine	910
Toluene	15	p-Toluidine	0,35
para-Xylene	10	**Pesticides**	
Polycyclic aromatic compounds		Alachlor	0,1
Benzo(a)anthracene	0,1	Aldrin	0,03
Benzo(a)pyrene	0,01	Atrazine	0,3
Benzo(b)fluoranthene	0,1	A -hexachlorohexane	0,1
Benzo(k)fluoranthene	0,05	B -hexachlorohexane	0,1
Benzo(g,h,i)perylene	0,01	G -hexachlorohexane (Lindane)	0,1
Chrysene	5	Chlordane	0,1
Dibenzo(a,h)anthracene	0,01	DDD,DDT, DDE	0,1
Indeno(1,2,3-c,d)pyrene	0,1	Dieldrin	0,03
Pyrene	50	Endrin	0,1
Sum of polycyclic aromatic compounds (31, 32, 33, 36)	0,1	Sum of pesticides	0,5
Aliphatic chlorinated compounds (carcinogens)		**Dioxins and furans**	
Chloromethane	1,5	Sum of PCDD, PCDF (conversion T.E.)	$4x\ 10^{-6}$
Trichloromethane	0,15	**Others**	
Vinyl chloride	0,5	PCB	0,01
1,2-Dichloroetane	3	Acrylamide	0,1
1,1-Dichloroethylene	0,05	N-hexane (Total hydrocarbons expressed as n-hexane**)	350 (10**)
1,2-Dichloropropane	0,15	Para-phtalic acid	37000
1,1,2-Trichloroethane	0,2	Asbestos (fiber A > 10 mm)	to be defined
Trichloroethylene	1,5		
1,2,3-Trichloropropane	0,001		
1,1,2,2-Tetrachloroethane	0,05		
Tetrachloroethylene (PCE)	1,1		
Hexachlorobutadiene	0,15		
Sum of aliphatic chlorinated compounds	10		

LITHUANIA

Table 1. Maximum admissible and background concentrations of dangerous substances in soil

1 lentelė. Pavojingų cheminių medžiagų didžiausios leidžiamos koncentracijos ir jų foniniai kiekiai dirvožemyje				
Substance	CAS Nr.	MAC in soil, mg/kg	Background concentration, mg/kg	
			sand, loamy sand	loam, clay
1	2	3	4	5
Metalai ir neorganiniai junginiai (metals and inorganic substances)				
1. Alavas (Sn)	7440-31-5	10	2,1	2,3
2. Arsenas (As)	7440-38-2	10	2,5	3,6
3. Baris (Ba)	7440-39-3	600	345	426
4. Berilis (Be)	7440-41-7	10	1	1,5
5. Boras	7440-42-8	50	26	34
6. Chromas (Cr)	7440-47-3	100	30	44
7. Cinkas (Zn)	7440-66-6	300	26	36
8. Gyvsidabris (Hg)	7439-97-6	1,5	0,075	0,1
9. Kadmis (Cd)	7440-43-9	3	0,15	0,2
10. Kobaltas (Co)	7440-48-4	30	4,3	6,4
11. Manganas (Mn)	7439-96-5	1500	427	451
12. Manganas (Mn) + vanadis (V)	-	1000+100	-	-
13. Molibdenas (Mo)	7439-38-7	5	0,64	0,71
14. Nikelis (Ni)	7440-02-0	75	12	18
15. Selenas (Se)	7782-49-2	5	0,2	0,3
16. Sidabras (Ag)	7440-22-4	2	0,071	0,069
17. Stibis (Sb)	7440-36-0	10	1	1,5
18. Švinas (Pb)	7439-92-1	100	15	15
19. Uranas (U)	7440-61-1	20	2,2	3
20. Vanadis (V)	7440-62-2	150	32	49
21. Varis (Cu)	7470-50-8	100	8,1	11
22. Siera, S	7704-34-9	160	-	-
23. Cianidai (bendras), CN	-	5	0,5	0,5
24. Fluoridai, F	-	200	20	20
25. Kalio chloridas, KCl	7447-40-7	500	150	150
26. Nitratai, NO3	-	130	-	-

Table 1. Continuation

Aromatiniai angliavandeniliai (Aromatic hydrocarbons)				
27. Anilinas	62-53-3	5	-	-
28. Benzenas	71-43-2	0,5	-	-
29. Bifenilas	92-52-4	10	-	-
30. 2,3-dimetilfenolis	526-75-0	1	-	-
31. 2,4-dimetilfenolis	105-67-9	1	-	-
32. 2,5-dimetilfenolis	95-87-4	1	-	-
33. 2,6-dimetilfenolis	576-26-1	1	-	-
34. 3,4-dimetilfenolis	95-65-8	1	-	-
35. 3,5-dimetilfenolis	108-68-9	1	-	-
36. Etilbenzenas	100-41-4	5	-	-
37. Fenolis	108-95-2	10	-	-
38. Hidrohinonas	123-31-9	1	-	-
39. Izopropilbenzenas	98-82-8	0,5	-	-
40. Ksilenas	1330-20-7	0,1	-	-
41. 2-naftolis	135-19-3	1	-	-
42. Naftos produktai: lengvieji angliavandeniliai (C6-C28) sunkieji angliavandeniliai (C>28)	- -	30 50	- -	- -
43. Nitrobenzenas	98-95-3	2	-	-
44. 3-nitrofenolis	554-84-7	1	-	-
45. 4-nitrofenolis	100-02-7	0,5	-	-
46. Pentachlorbenzenas	608-93-5	1	-	-
47. Stirenas	100-42-5	5	-	-
48. Toluenas	108-88-3	0,1	-	-
Policikliniai aromatiniai angliavandeniliai (PAH)				
49. Antracenas	120-12-7	5	-	-
50. Benzo(a)pirenas	50-32-8	0,1	-	-
51. Chrizenas	218-01-9	2	-	-
52. Fenantrenas	08/01/1985	5	-	-
53. Naftalenas	91-20-3	5	-	-
54. 1-metilnaftalenas	90-12-0	4	-	-
55. 2-metilnaftalenas	91-57-6	4	-	-
56. PAH (bendras)	-	5	-	-
57. Pirenas	129-00-0	5	-	-
Halogeninti angliavandeniliai (Chlorinated hydrocarbons)				
58. Anglies tetrachloridas	56-23-5	1	-	-
59. 2-chloretilvinileteris	110-75-8	5	-	-
60. Chloroformas	67-66-3	1	-	-
61. 1,2-dichloretanas	107-06-2	2	-	-
62. Dichlormetanas	02/09/1975	2	-	-
63. 1,2-dichlorpropanas	78-87-5	10	-	-
64. Heksachloretanas	67-72-1	1	-	-
65. Polichlorintieji bifenilai (PCB)	-	0,1	-	-
66. Tetrachloretilenas	127-18-4	0,5	-	-
67. Trichloretilenas	06/01/1979	2	-	-
Pesticidai (pesticides)				
68. Aldrinas	309-00-2	0,1	-	-
69. Chlordanas	57-47-9	0,1	-	-
70. 2,4 D (dichlorfenoksiacto rūgštis)	94-75-7	0,1	-	-
71. DDT (dichlordifeniltrichloretanas)	50-29-3	0,1	-	-
72. Dieldrinas	60-57-1	0,05	-	-
73. Endrinas	72-20-8	0,1	-	-
74. Heksachlorbenzenas	118-74-1	0,5	-	-
75. Heksachlorcikloheksanas	319-84-6	0,02	-	-
76. Heptachloras	76-44-8	0,05	-	-
77. Pesticidai (bendras)	-	0,1	-	-

COMMENT: This is table from Lithuanian Hygienic norm HN 60:2004. Requirements of legislatve document applied to soils of living, recreational and agricultural areas. It sets requirement what action should be taken if values exceeds MAC.

Table 2. Maximum admissible and background concentrations of dangerous substances in water

Substance	CAS	MAC(portable)	MAC (non-portable)
Benzenas	CAS 71-43-2	0,001	0,01
Metilenchloridas,(Dichlormetanas)	CAS 75-09-2	0,05	50
1,2-Dichloretanas	CAS 107-06-2	0,003	0,03
Heksachlorbutadienas	CAS 87-68-3	0,00045	0,0009
Trichlormetanas,(chloroformas)	CAS 67-66-3	0,06	0,2
Heksachlorbenzenas	CAS 118-74-1	0,001	0,001
Trichlorbenzenai	CAS 12002-48-1	0,07	0,5
Pentachlorbenzenas	CAS 608-93-5	0,0024	0,0024
Švinas ir jo junginiai	CAS 7439-92-1	0,025	0,032
Nikelis ir jo junginiai	CAS 7440-02-0	0,02	0,04
Gyvsidabris ir jo junginiai, Hg	CAS 7439-97-6	0,001	0,001
Kadmis ir jo junginiai, Cd	CAS 7440-43-9	0,005	0,01
Poliaromatiniai angliavandeniliai, PAH		0,0001	0,01
Antracenas	CAS 120-12-7	0,012	0,012
Benz (a)pirenas	CAS 50-32-8	0,00001	0,00005
Benz (b)fluoroantenas	CAS 205-99-2	0,0002	0,0005
Benz (g.h.i.)perilinas	CAS 191-24-2	0,0002	0,0002
Benz (k)fluoroantenas	CAS 207-08-9	0,0002	0,0005
Fluoroantenas	CAS 206-44-0	0,0005	0,0005
Inden (1,2,3-cd)pirenas	CAS 193-39-5	0,00005	0,0002
Naftalenas	CAS 91-20-3	0,021	0,12
Alachloras	CAS 15972-60-8	0,002	0,002
Atrazinas	CAS 1912-24-9	0,002	0,002
Chlorfenvinfosas	CAS 470-90-6	0,0001	0,0001
Chlorpyrifosas	CAS 2921-88-2	0,0001	0,0001
Heksachlorcikloheksanas, (Lindanas)	58-89-9	0,002	0,002
Diuronas	CAS 330-54-1	0,0001	0,0001
Endosulfanas	CAS 115-29-7	0,0001	0,00056
Izoproturonas	CAS 34123-59-6	0,09	0,09
Simazinas	CAS 122-34-9	0,002	0,002
Trifluralinas	CAS 1582-09-8	0,02	0,02
Pentachlorfenolis	CAS 87-86-5	0,01	0,13
Cianidai, CN		0,05	0,1
Naftos angliavandeniliai (hydrocarbons)		0,3	1
Chromas-bendras (Cr total)	CAS 7440-47-3	0,05	0,5
Varis, Cu	CAS 7440-50-8	0,1	0,1
Alavas, Sn	CAS 2406-52-2	0,02	1
Cinkas, Zn	CAS 7440-66-6	3	3
Vanadis, V	CAS 7440-62-2	0,1	0,2
Arsenas, As	CAS 7440-38-2	0,05	0,05
Nitritai (NO_2)		0,5	1
Nitratai (NO_3)		50	50
Amonio azotas (NH_4-N)		2	10
Fosfatai (PO_4)		0,7	3,3
Chloridai, Cl		350	500
Fluoridai, F		1,5	8
Sulfatai, SO4		450	1000
Fenoliai, Phenols		0,005	0,2

Comment: Apendix from legislative act which transposed requirements of directives 80/68/EEC and 2000/60/EC annex VIII and X
If values exeeded risk evaluation procedure aplicable and actions as monitoring or clean up required

Table 3. MAC of hydrocarbons in top soil (to1,0 m.), mg/kg

lentelė. Žemės paviršiaus grunto (iki 1,0 m gylio) užteršimo angliavandeniliais DLL						
Kate-gorija, Category	**Jautrumo lygis, Sensitivity**	**Land use**	**benzino eilės C_6-C_{10}**	**dyzelino eilės C_{10}-C_{28}**	**mišinys C_6-C_{28}**	**Sunkieji angliavan-deniliai C>28**
A	Very sensitive	Geriamojo požeminio vandens šaltinių sanitarinės apsaugos zonos (SAZ) griežto režimo juostos.	0,01	0,05	**0,03**	0,05
B	Sensitive	Žemės ūkio kultūrų auginimo teritorijos, geriamojo požeminio vandens šaltinių SAZ bakteriologinės taršos apribojimo ir paviršinio vandens telkinių pakrantės apsaugos juostos.				
C	Moderate sensitive	Gyvenamosios paskirties, rekreacinės, miško teritorijos, karjerai, geriamojo požeminio vandens šaltinių SAZ cheminės taršos apribojimo juostos, paviršinio vandens telkinių apsaugos zonos ir kt. saugomos teritorijos	0,2	0,3	**0,25**	1
D	Litle sensitive	Komercinės ir industrinės paskirties teritorijos; automobilių keliai, kuriems yra nustatytos apsaugos juostos; naftos gavybos (naftos gręžinių aikštelės) ir kt.	1,5	2	**1,7**	10
E	Not sensitive	Naftos ir skystų NP sandėliavimo, perdirbimo ir krovos vietos (saugyklos, degalinės, terminalai ir kt.), geležinkelio keliai sankasos ribose, naftotiekio siurblinių teritorijos.	5	8	**6**	20

Comment: This information from Environment legislative act LAND 9-2002 which regulates soil and groundwater contamination by oil hydrocarbons

Table 4. MAC of hydrocarbons in groundwater, mg/l

lentelė. Požeminio vandens užteršimo naftos angliavandeniliais DLL						
Kate-go-rija (category)	**Jautrumo lygis (Sensitivity)**	**Land use**	**benzinoeilės C_6-C_{10}**	**dyzelino eilės C_{10}-C_{28}**	**mišinys C_6-C_{28}**	**Sunkieji angliavan-deniliai C>28**
A	Very sensitive	Geriamojo požeminio vandens šaltinių (taip pat išžvalgytų požeminio vandens telkinių) SAZ griežto režimo juostos vandens gavybos tikslais nenaudojamuose vandeninguose sluoksniuose.	0,1	0,3	**0,3**	0,3
B	Sensitive	Žemės ūkio kultūrų auginimo teritorijos, geriamojo požeminio vandens šaltinių SAZ bakteriologinės taršos apribojimo (nenaudojamuose vandeninguose sluoksniuose) ir paviršinio vandens telkinių pakrantės apsaugos juostos.	1	1	**1**	1
C	Moderate sensitive	Gyvenamosios paskirties, rekreacinės, miško teritorijos, karjerai, geriamojo požeminio vandens šaltinių SAZ cheminės taršos apribojimo juostos (nenaudojamamuose vandeninguose sluoksniuose), paviršinio vandens telkinių apsaugos zonos ir kt. saugomos teritorijos.	10	5	**10**	1
D	Litle sensitive	Komercinės ir industrinės paskirties teritorijos; automobilių keliai, kuriems yra nustatytos apsaugos juostos; naftos gavybos (naftos gręžinių aikštelės) ir kt.	30	10	**30**	1
E	Not sensitive	Naftos ir skystų NP sandėliavimo, perdirbimo ir krovos vietos (saugyklos, degalinės, terminalai ir kt.), geležinkelio keliai sankasos ribose, naftotiekio siurblinių teritorijos.	50	15	**50**	1

Comment: This information from Environment legislative act LAND 9-2002 which regulates soil and groundwater contamination by oil hydrocarbons
Actions: (1) if floating oil present - to remove it (2) groundwater monitoring to prove that plume not expanding, not present risk to water uses

Table 5. MAC of hydrocarbons in top soil (more 1,0 m.), mg/kg

lentelė. Gilesniųjų žemės sluoksnių (nuo 1,0 m gylio) grunto užteršimo angliavandeniliais DLL							
Kate-gorija (Category)	Jautru-mo lygis (sensitivity	Teritorijos naudojimo pobūdis	Lithology	benzino eilės C_6-C_{10}	dyzelino eilėsC_{10}-C_{28}	mišinys C_6-C_{28}	Sunkieji angliava-ndeniliai C>28
A	very sensitive	Geriamojo požeminio vandens šaltinių SAZ griežto režimo juostos.	mixture	0,01	0,01	**0,01**	0,05
B	sensitive	Žemės ūkio kultūrų auginimo teritorijos, geriamojo požeminio vandens šaltinių SAZ bakteriologinės taršos apribojimo ir paviršinio vandens telkinių pakrantės apsaugos juostos.	coarse sand fine sand clay	0,2 0,7 2,1	0,3 1 3	**0,25** **0,8** **2,5**	10
C	Moderate sensitive	Gyvenamosios paskirties, rekreacinės, miško teritorijos, karjerai, geriamojo požeminio vandens šaltinių SAZ cheminės taršos apribojimo juostos, paviršinio vandens telkinių apsaugos zonos ir kt. saugomos teritorijos.	coarse sand fine sand clay	1,5 4 10	2 6 15	**1,7** **5** **12**	35
D	litle sensitive	Komercinės ir industrinės paskirties teritorijos; automobiliniai keliai, kuriems yra nustatytos apsaugos juostos; naftos gavybos (naftos gręžinių aikštelės) ir kt.	coarse sand	5	8	**6**	35
E	Non sensitive	Naftos ir skystų NP sandėliavimo, perdirbimo ir krovos vietos (saugyklos, degalinės, terminalai ir kt.), geležinkelio keliai sankasos ribose, naftotiekio siurblinių teritorijos	fine sand clay	8 12	15 25	12 20	

Comment: This information from Environment legislative act LAND 9-2002 which regulates soil and groundwater contamination by oil hydrocarbons

POLAND

Land groups

Group A – land located in areas under protection pursuant to the Water Act 2001 and the nature protection laws. The regulations provide that unless the contamination constitutes a threat to human health or to the environment, no special action is required. Such land will however also fall under Group B or C and will be subject to the provisions thereof;

Group B – agricultural land except land under water in ponds and ditches, forest land and which is tree-covered and shrub-covered, wasteland, and developed and urbanised land except industrial land, mining land and land used for transportation;

Group C – industrial, mining and transportation land.

Permissible concentrations in soil [mg/kg d.m.]
(Ordinance of the Ministry of Environment on soil quality standards, 9/9/2002)

Item	Contaminant	Group A	Group B					Group C		
			Depth [m bgl]							
			0-0.3	0.3-15.0		>15		0-2	2-15	
				Saturated hydraulic conductivity [m/s]						
				up to	below	up to	below		up to	below
				$1 \cdot 10^{-7}$		$1 \cdot 10^{-7}$			$1 \cdot 10^{-7}$	
1	2	3	4	5	6	7	8	9	10	11
I. METALS										
1	Arsenic	20	20	20	25	25	55	60	25	100
2	Barium	200	200	250	320	300	650	1000	300	3000
3	Chromium	50	150	150	190	150	380	500	150	800
4	Tin	20	20	30	50	40	300	350	40	300
5	Zinc	100	300	350	300	300	720	1000	300	3000
6	Cadmium	1	4	5	6	4	10	15	6	20
7	Cobalt	20	20	30	60	50	120	200	50	300
8	Copper	30	150	100	100	100	200	600	200	1000
9	Molybdenum	10	10	10	40	30	210	250	30	200
10	Nickel	35	100	50	100	70	210	300	70	500
11	Lead	50	100	100	200	100	200	600	200	1000
12	Mercury	0,5	2	3	5	4	10	30	4	50
II. INORGANIC										
1	Free cyanides	1	1	5	6	5	12	40	5	100
2	Cyanides - Complex compounds	5	5	5	6	5	12	40	5	500
III. HYDROCARBONS										
III/A	**Light petrol - sum (-hydrocarbons C6-12)**	1	1	5	375	50	750	500	50	750
III/B	**Mineral oil (hydrocarbons C12-C35)**	30	50	200	1000	1000	3000	3000	1000	3000
III/C. **Aromatic hydrocarbons**										
1	Benzene	0.05d	0.1	0.2	25	3	50	100	3	150
2	Ethylbenzene	0.05d	0.1	1	75	10	150	200	10	250
3	Toluene	0.05d	0.1	1	75	5	150	200	5	230
4	Xylene	0.05d	0.1	1	35	5	75	100	5	150
5	Styrene	0.1	0.1	1	5	2	100	60	2	100
6	Sum of aromatic hydrocarbons	0.1	0.1	1	75	10	150	200	10	250
III/D. **Polycyclic aromatic hydrocarbons**										
1	Naphthalene	0.1	0.1	5	20	10	40	50	10	40
2	Phenanthrene	0.1	0.1	5	20	10	40	50	10	40
3	Anthracene	0.1	0.1	5	20	10	40	50	10	40
4	Fluoranthene	0.1	0.1	5	20	10	40	50	10	40
5	Chrysene	0.1	0.1	5	20	10	40	50	10	40
6	Benzo(a)anthracene	0.1	0.1	5	20	10	40	50	10	40
7	Benzo(a)pyrene	0,02	0,03	5	10	5	40	50	5	40
8	Benzo(a)fluoranthene	0.1	0.1	5	10	5	40	50	5	40
9	Benzo(ghi)perylene	0.1	0.1	10	10	5	40	50	5	100
10	Sum of PAHs	1	1	20	40	20	200	250	20	200

Permissible concentrations in soil [mg/kg d.m.] (Ordinance of the Ministry of Environment on soil quality standards, 9/9/2002)										
			Group B					Group C		
			Depth [m bgl]							
			0-0.3	0.3-15.0		>15		0-2	2-15	
				Saturated hydraulic conductivity [m/s]						
				up to	below	up to	below		up to	below
Item	Contaminant	Group A		$1 \cdot 10^{-7}$		$1 \cdot 10^{-7}$			$1 \cdot 10^{-7}$	
1	2	3	4	5	6	7	8	9	10	11
IV. CHLORINATED HYDROCARBONS										
1	Aliphatic chlorinated (volatile) - individual	0.01	0.01	0.1	5	1	10	5	1	20
2	Aliphatic chlorinated - sum	0.01	0.01	0.15	7	3	40	60	2	40
3	Chlorobenzens - individual	0.01	0.01	0.1	1	0.5	10	15	0.5	10
4	Chlorobenzens - sum	0.01	0.01	0.1	2	0.8	20	25	0.8	20
5	Chlorophenols - individual	0.001	0.001	0.01	0.5	0.2	1	1	0.2	5
6	Chlorophenols - sum	0.001	0.001	0.001	1	0.5	10	10	0.5	10
7	PCB	0.02	0.02	0.1	1	0.5	5	2	0.5	5
V. PESTICIDES										
V/A	**Chlorinated pesticides**									
1	DDT/DDE/DDD	0.0025	0.025	0.025	4	0.025	4	0.25	0.025	4
3	Aldrin	0.0025	0.025	0.025	4	0.025	4	0.25	0.025	4
4	Dieldrin	0.0005	0.005	0.005	4	0.005	4	0.5	0.005	4
5	Endrin	0.001	0.01	0.01	4	0.01	4	0.1	0.01	4
6	a-HCH	0.0025	0.025	0.025	2	0.025	2	0.25	0.025	2
7	b-HCH	0.001	0.01	0.01	2	0.01	2	0.1	0.01	2
8	g-HCH	0.000005	0.0005	0.0005	0.5	0.0005	0.5	0.005	0.0005	0.5
V/B	**Pesticides - not chlorinated compounds**									
1	Carbaryl	0.01	0.2	0.1	5	0.1		0.2	0.1	5
2	Carbofuran	0.01	0.2	0.1	2	0.1	2	0.2	0.1	2
3	Maneb	0.01	0.2	0.1	35	0.1	35	0.2	0.1	35
4	Atrazin	0.00005	0.05	0.005	6	0.005	6	0.05	0.005	6
VI. OTHER CONTAMINANTS										
1	Tetrahydrofuran	0.1	0.1	1	4	2	40	50	2	40
2	Pyridine	0.1	0.1	0.5	2	1	20	30	1	20
3	Tetrahydrothiophene	0.1	0.1	1	5	2	50	60	2	50
4	Cyclohexane	0.1	0.1	1	6	5	60	80	5	80
5	Phenol	0.05	0.1	0.5	20	3	40	50	3	100
6	Cresols (sum)	0.05	0.1	0.5	20	3	40	50	3	100
7	Phthalates (sum)	0.1	0.1	5	60	5	60	60	10	60

Notes:
d - detection limit
depth [m bgl] – value of depth below ground level, in meters
1•10-7 m/s – value of saturated hydraulic conductivity

Permissible concentrations in soil [mg/kg d.m.] (Ordinance of the Ministry of Environment on soil quality standards, 9/9/2002)										
			Group B					Group C		
			Depth [m bgl]							
			0-0.3	0.3-15.0		>15		0-2	2-15	
				Saturated hydraulic conductivity [m/s]						
				up to	below	up to	below		up to	below
Item	Contaminant	Group A		$1 \cdot 10^{-7}$		$1 \cdot 10^{-7}$			$1 \cdot 10^{-7}$	
1	2	3	4	5	6	7	8	9	10	11

Limit values for groundwater quality indicators in Poland

(Ordinance of the Ministry of Environment, 11/02/2004 - expired on the 1st of January 2005)

Item	Indicator	Unit	Limit values in classes I-V				
			I	II	III	IV	V
1	Temperature	^{0}C	6-10	12	16	25	>25
2	Conductivity in 20^{0}C	uS/cm	400	2,500	2,500	3,000	>3,000
3	Reaction	pH	6.5-9.5			<6.5 or >9.5	
4	Dissolved oxygen	mg O_2/l	1	0.5	0.5	0.1	<0.1
5	Organic carbon	mg C/l	2	10	10	20	>20
6	Ammonia	mg NH_4/l	0.1	0.5	0.65	3	>3
7	Nitrates	mg NO_3/l	10	25	50	100	>100
8	Nitrites	mg NO_2/l	0.01	0.05	0.10	0.25	>0.25
9	Phosphates	mg PO_4/l	0.05	0.2	1	5	>5
10	Fluorides	mg F/l	0.5	1	1.5	2	>2
11	Chlorides	mg Cl/l	25	250	300	500	>500
12	Free cyanides	mg CN/l	0.01	0.02	0.02	0.02	>0.02
				75-100	50-75	25-50	<25
13	Hydrogen carbonates	mg HCO_3/l	100-300	300-350	350-400	>400	>400
14	Sulfates	mg SO_4/l	25	250	250	500	>500
15	Silica	mg SiO_2/l	15	30	50	100	>100
16	Sodium	mg Na/l	60	200	200	300	>300
17	Potassium	mg K/l	10	10	15	20	>20
18	Calcium	mg Ca/l	50	100	200	300	>300
19	Magnesium	mg Mg/l	30	50	100	150	>150
20	Iron	mg Fe/l	0.1	0.3	0.5	5	>5
21	Arsenic	mg As/l	0.01	0.01	0.1	0.2	>0.2
22	Boron	mg B/l	0.5	1	1	2	>2
23	Chromium	mg Cr/l	0.01	0.05	0.05	0.1	>0.1
24	Zinc	mg Zn/l	0.5	3	5	10	>10
25	Aluminium	mg Al/l	0.1	0.2	0.5	1	>1
26	Cadmium	mg Cd/l	0.001	0.003	0.005	0.01	>0.01
27	Manganese	mg Mn/l	0.05	0.2	1	1	>1
28	Copper	mg Cu/l	0.01	0.03	0.05	0.1	>0.1
29	Nickel	mg Ni/l	0.01	0.02	0.05	0.1	>0.1
30	Mercury	mg Hg/l	0.001	0.001	0.001	0.005	>0.005
31	Lead	mg Pb/l	0.01	0.05	0.05	>0.05	>0.05
32	Phenols (Phenol index)	mg/l	0.001	0.005	0.01	0.05	>0.05
33	Pesticides[2)]	ug/l	0.1	1	2.5	5	>5
34	Anion surface-active substances	mg/l	0.1	0.2	0.5	1	>1
35	Mineral oils (Mineral oil index)	mg/l	0.01	0.01	0.03	0.05	>0.05
36	Polycyclic aromatic hydrocarbons[3)]	ug/l	0.01	0.02	0.03	0.05	>0.05

1) Limit values for metals are related to their dissolved forms
2) Pesticides include a sum of lindane and dieldrin
3) Polycyclic aromatic hydrycarbons include a sum of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene

SLOVAKIA

Table 1a. Limit values for risk elements in agricultural soils according to ASP (2004) (in mg/kg dry weight, fine soil, aqua regia-decomposition, Hg total content)

Soil texture	As	Cd	Co	Cr	Cu	Hg	Ni	Pb	Se	Zn	F
Sand, loamy-sand	10	0,4	15	50	30	0,15	40	25	0,25	100	400
Sandy-loam, loam	25	0,7	15	70	60	0,5	50	70	0,4	150	550
Clay-loam, clay	30	1	20	90	70	0,75	60	115	0,6	200	600

1. Evaluation of soil texture

Soil texture	Content of particles < 0, 01 mm
Sand, loamy-sand	pod 20 %
Sandy-loam, loam	20 45 %
Clay-loam, clay	nad 45 %

2. For the limit values (Tab. 1a) the soil pH must be considered as follows:

a) For soil texture clay-loam, clay, with pH < 6.0 the limit values for sandy-loam, loam texture must be applied to cadmium, nickel a zinc.
b) For soil texture sand, loamy-sand, with pH < 6.0 the limit values for sand, loamy-sand texture must be applied to cadmium, nickel a zinc.
c) For soil with pH < 5.0 the limit values for sandy-loam, loam texture must be applied to lead.
When a limit value is exceeded, critical value of pollution must be determined (but the Law does not establish methods or standards for derivation of such value).

Table 1b. Limit values according to ASP (2004) for risk elements for pathway agricultural soil - food plant (in mg/kg dry weight, fine soil, in 1mol/l ammonium nitrate extract)

Element	Trigger value
Arsenic (As)	0,4
Copper (Cu)	1
Nickel (Ni)	1,5
Zinc (Zn)	2
Cadmium (Cd)	0,1
Lead (Pb)	0,1
Fluorine (F) (water-soluble)	5

Table 1c. Limit values for organic substances in agricultural soils according to ASP (2004) (in mg/kg dry weight, fine soil)

Substance	Limit value	Substance	Limit value
Polycyclic aromatic hydrocarbons	1	**Chlorinated hydrocarbons**	
Naphtalene	0,05	Polychlorinated biphenyls	0,05
Phenanthrene	0,15	Chlorinated pesticides (individually)	0,5
Anthracene	0,05	HCB	0,02
Fluoranthene	0,3	DDT	0,015
Pyrene	0,2	DDE, DDD	0,01
Benzo(a)anthracene	0,1	**Other pesticides**	
Chrysene	0,1	Non-chlorinated (individually)	1
Benzo(b)fluoranthene	0,1	**Non-polar hydrocarbons**	
Benzo(k)fluoranthene	0,05	Non-polar substances (NEL)	0,1
Benzo(a)pyrene	0,1		
Indeno(1,2,3-cd)pyrene	0,1		
Benzo(g,h,i)perylene	0,05		

Table 2a. Reference values for selected harmful substances in soils according to LVRC (1994)

Substances	Unit	A	A_1
1. Metals			
As	mg/kg	(29)	5
Ba	mg/kg	500	
Be	mg/kg	3	
Cd	mg/kg	(0.8)	0,3
Co	mg/kg	20	
Cr	mg/kg	(130)	10
Cu	mg/kg	(36)	20
Hg	mg/kg	(0.3)	
Mo	mg/kg	1	
Ni	mg/kg	(35)	10
Pb	mg/kg	(85)	30
Se	mg/kg	0,8	
Sn	mg/kg	20	
V	mg/kg	120	
Zn	mg/kg	(140)	40
2. Inorganic substances			
F (total)	mg/kg	(500)	
S (sulphidic)	mg/kg	2	
Br (total)	mg/kg	20	
3. Halogenated hydrocarbons			
Hexachlorocyclohexanone, tetrachloroethane	µg/kg	(10)	
Tetrachloromethane, trichloroethane, trichloroethylene, trichloromethane	µg/kg	(10)	
PCB IUPAC No. 28 and 52, chloropropene, tetrachloroethylene, hexachloroethane, hexachlorobutadiene, heptachloroperoxide, dichlorobenzene, trichlorobenzene, tetrachlorobenzene, hexachlorobenzene, monochloronitrobenzene, dichlorobenzene, chlordane, endosulphane, trifluraline	µg/kg	(10)	
PCB IUPAC No. 101, 118, 138, 153 and 180, DDD, DDE, pentachlorophenol	µg/kg	(100)	
4. Polycyclic aromatic hydrocarbons			
Naphtalene, chryzene	µg/kg	(10)	
Phenantrene, anthracene, fluoranthene, benzo(a)pyrene	µg/kg	(100)	
Benzo(a)anthracene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene	mg/kg	(1)	
Benzo(ghi)perylene	mg/kg	(10)	
5. Mineral oils			
Total	mg/kg	(50)	
Octane, heptane	mg/kg	(1)	

The reference value (A) is not a constant of a harmful substance for all soil types. The authors of this system provide mathematical formulae to determine the reference values specific to each sample, taking into account also the content of organic matter and clay less than 0.002 mm

Table 2b. Limit values for selected harmful substances in soils according to LVRC (1994

Substances	Unit	B	C
1. Metals			
As	mg/kg	30	50
Ba	mg/kg	1000	2000
Be	mg/kg	20	30
Cd	mg/kg	5	20
Co	mg/kg	50	300
Cr	mg/kg	250	800
Cu	mg/kg	100	500
Hg	mg/kg	2	10
Mo	mg/kg	40	200
Ni	mg/kg	100	500
Pb	mg/kg	150	600
Se	mg/kg	5	20
Sn	mg/kg	50	300
V	mg/kg	200	500
Zn	mg/kg	500	3000
2. Inorganic substances			
F (total)	mg/kg	1000	2000
S (sulphidic)	mg/kg	20	200
Br (total)	mg/kg	50	300
3. Aromatic substances			
Benzene	mg/kg	0,5	5
Ethylbenzene	mg/kg	5	50
Toluene	mg/kg	3	30
Xylene	mg/kg	5	50
Phenols	mg/kg	1	10
Aromatics (total)	mg/kg	7	70
4. Polycyclic aromatic hydrocarbons			
Naphtalene	mg/kg	5	50
Phenantrene	mg/kg	10	100
Anthracene	mg/kg	10	100
Fluoranthene	mg/kg	10	100
Chryzene	mg/kg	5	50
Benzo(a)anthracene	mg/kg	5	50
Benzo(a)pyrene	mg/kg	1	10
Benzo(a)fluoranthene	mg/kg	5	50
Indeno(1,2,3-cd)pyrene	mg/kg	5	50
Benzo(ghi)perylene	mg/kg	10	100
PAU (total)	mg/kg	20	200
5. Chlorinated hydrocarbons			
Aliphatic chlorinated hydrocarbons (individual)	mg/kg	5	50
Aliphatic chlorinated hydrocarbons (total)	mg/kg	7	70
Chlorobenzenes (individual)	mg/kg	1	10
Chlorobenzenes (total)	mg/kg	2	20
Chlorophenols (individual)	mg/kg	0,5	5
Chlorophenols (total)	mg/kg	1	10
Chlorinated PAH (total)	mg/kg	1	10
PCB (total)	mg/kg	1	10
EOCl (total)	mg/kg	1	10
6. Pesticides			
Organic chlorinated (individual)	mg/kg	0,5	5
Organic chlorinated (total)	mg/kg	1	10
Non-chlorinated (individual)	mg/kg	1	10
Non-chlorinated (total)	mg/kg	2	20
7. Others			
Tetrahydrofurane	mg/kg	4	40
Pyridine	mg/kg	2	20
Tetrahydrothiophene	mg/kg	5	50
Cyclohexanone	mg/kg	6	60
Styrene	mg/kg	5	50
Phtalates (total)	mg/kg	50	500
Oxidized PAH (total)	mg/kg	200	2000
Mineral oils	mg/kg	500	1000

A, A_1 - level of the reference values (Tab. 2b)
B - level of the maximum allowable limits
C - level of the values calling for soil decontamination measures

Table 3. Hygienical limits for drinking water (DWQ, 2004) commonly used for groundwater quality evaluation

Element	Symbol	Limit		Type of limit
Antimony	Sb	0,005	mg/l	MLV
Arsene	As	0,01	mg/l	MLV
Bor	B	0,3	mg/l	MLV
Bromates	BrO_3^-	0,01	mg/l	MLV
Nitrates	NO_3^-	50	mg/l	LV
Nitrites	NO_2^-	0,1	mg/l	LV
		3,0	mg/l	MLV
Fluorine	F-	1,5	mg/l	MLV
Chromium	Cr	0,05	mg/l	MLV
Cadmium	Cd	0,003	mg/l	MLV
Cyanide	CN-	0,03	mg/l	MLV
Coper	Cu	1,0	mg/l	LV
Nickel	Ni	0,02	mg/l	MLV
Lead	Pb	0,01	mg/l	MLV
Mercury	Hg	0,001	mg/l	MLV
Selene	Se	0,01	mg/l	MLV
Silver	Ag	0,05	mg/l	MLV
Organic substances				
Acrylamide		0,1	mg/l	MLV
Benzene		1,0	mg/l	LVRR
Dichlorbenzene		0,3	mg/l	LV
		300	mg/l	MLV
1,2 dichlorethane		3,0	mg/l	MLV
Monochlorbenzene		10	mg/l	LV
		300	mg/l	MLV
Total organic carbon		5,0	mg/l	LV
Pesticides		0,1	mg/l	MLV
Pesticides total		0,5	mg/l	MLV
Polycyclic aromathic hydrocarbons		0,1	mg/l	LVRR
Benzo(a)pyrene		0,01	mg/l	LVRR
Epichlorhydrine		0,1	mg/l	LVRR
Styrene		20	mg/l	MLV
Tetrachlorethene		10	mg/l	MLV
Tetrachlormethane		2,0	mg/l	LVRR
Toluene		50	mg/l	LV
		700	mg/l	MLV
Trichlorethene		10	mg/l	MLV
Vinylchloride		0,5	mg/l	MLV
Xylenes		100	mg/l	LV
		500	mg/l	MLV

Abbreviations:
MLV - maximal limit value
LV - limit value
LVRR - limit value of reference risk

SPAIN

List of contaminants and GVRs derivated for the protection of the Human Health and each Environmental Receptor, taking into account the three uses considered (mg/kg soil dw).

		HUMAN HEALTH PROTECTION			ECOSYSTEM PROTECTION		
		Industrial	Urban	Natural	Natural Use		
SUBSTANCE	CAS N				Soil orgs.	Aquatic orgs.	Terrest verts
1,1-Dichloroethane	75-34-3	100**	70***	7	-	0.06	4.18
1,1,2,2-Tetrachloroethane	79-34-5	3***	0,3***	0.03	-	0.02	0.04
1,1,2-Trichloroethane	79-00-5	10***	1***	0.1	-	0.16	0.3
1,1-dichloroethylene	75-35-4	1	0,1***	0.01	-	-	-
1,2,4-Trichlorobenzene	120-82-1	90***	9***	0.9	0.05	0.79	0.94
1,2-Dichlorobenzene	95-50-1	100**	70**	7	-	0.11	3.15
1,2-Dichloroethane	107-06-2	5***	0,5***	0.05	-	0.16	0.24
1,2-Dichloropropane	78-87-5	4	0,5***	0.05	4.24	0.07	0.43
1,3-Dichloropropene	42-75-6	7***	0,7***	0.07	-	0,01*	0.58
1,4-Dichlorobenzene	106-46-7	40***	4***	0.4	0.1	0.16	0.53
1,4-dioxane	123-91-1	-	-	-	1.45	13.9	-
2,4,5-Trichlorophenol	95-95-4	100**	100**	10	0.05	0.09	3.3
2,4,6-Trichlorophenol	88-06-2	90***	9***	0.9	0.4	0.012	0.03
2,4-Dichlorophenol	120-83-2	10***	1***	0.1	0.2	0.06	0.02
2-Chlorophenol	95-57-8	100**	10***	1	0.04	0,01*	0.12
Acenaphthene	83-32-9	100**	60***	6	-	0.02	4.85
Acetone	67-64-1	100**	10***	1	-	0.54	6.71
Aldrin	309-00-2	1***	0,1***	0.01	0,01*	0.01	0,01*
Anthracene	120-12-7	100***	100**	45	-	0,01*	22
Benz(a) anthracene	56-55-3	20***	2***	0.2	3.8	0.01	-
Benzene	71-43-2	10***	1***	0.1	1	0.2	0.11
Benzo(a)pyrene	50-32-8	2***	0,2***	0.02	0.15	0,01*	-
Benzo(b)fluoranthene	205-99-2	20***	2***	0.2	-	-	-
Benzo(k)fluoranthene	207-08-9	100**	20***	2	-	-	-
Carbon tetrachloride	56-23-5	1	0.5***	0.05	-	0.12	-
chlordane	57-74-9	1***	0,1***	0.01	0.04	0.01*	0,01*
Chlorobenzene	108-90-7	35	10***	1	1	0.03	7.66
Chloroethylene	75-01-4	1***	0,1***	0,01*	-	-	-
Chloroform	67-66-3	5	3	0.7	-	0.01	0.01
Chrysene	218-01-9	100**	100**	20	-	-	-
Decabromodiphenyl ether	1163-19-5	-	-	-	-	2.66	59.7
Dibenz(a,h)anthracene	53-70-3	3***	0,3***	0.03	-	-	-
dichloromethane	75-09-2	60***	6***	0.6	-	-	-
Dieldrin	60-57-1	1***	0,1***	0,01*	0.13	0,01*	0.01*
Endosulfan	115-29-7	60***	6***	0.6	0.01	0,01*	0.04
Endrin	72-20-8	1***	0,1***	0,01*	-	0,01*	0,01*
Ethylbenzene	100-41-4	100**	20***	2	-	0.08	4.6
Fluoranthene	206-44-0	100**	80***	8	1	0.03	1.96
Fluorene	86-73-7	100**	50***	5	0.22	0.02	2.84
Fluoride	7664-39-3	-	-	-	11	0.29	3.7
Heptachlor epoxide	1024-57-3	1***	0,1***	0.01	-	-	-
Hexachloro-1,3-butadiene	87-68-3	10***	1***	0.1	-	0,01*	-
Hexachlorobenzene	118-74-1	1***	0,1***	0,01*	5.7	0.01	0,01*
Hexachlorocyclohexane-alfa	319-84-6	1***	0,1***	0,01*	-	0.25	0.05
Hexachlorocyclohexane-beta	319-85-7	1***	0,1***	0,01*	-	0.38	0,01*
Hexachlorocyclohexane-gamma	58-89-9	1***	0,1***	0,01*	0,01*	0,01*	0.23
Hexachloroethane	67-72-1	9***	0,9***	0.09	-	0.03	0.03
Indeno(1,2,3-cd) Pyrene	193-39-5	30***	3***	0.3	-	-	-
naphthalene	91-20-3	10	8	1	0.1	0.05	0.06
nonyl phenol	25154-52-3	-	-	-	0.34	0.031	0.78
o-cresol	95-48-7	100**	40***	4	-	-	-
p,p´-DDE	72-55-9	60***	6***	0.6	0.14	0,01*	0,01*
p,p´-DDT	50-29-3	20***	2	0.2	-	0.01	0,01*
p,p-DDD	72-54-8	70***	7***	0.7	-	-	-
PCBs	1336-36-3	0.8	0.08	0,01*	-	-	-
p-chloroaniline	106-47-8	30***	3***	0.3	0.14	0,01*	0.09
Pentabromodiphenyl ether	32534-81-9	-	-	-	0.32	5.18	0,01*
pentachlorophenol	87-86-5	1***	0,1***	0.01*	0.02	0,01*	0,01*
Phenol	108-95-2	100**	70**	7	0.27	0.03	23.7
Pyrene	129-00-0	100**	60***	6		0,01*	1.2
Styrene	100-42-5	100**	100**	20	0.68	0.25	100**
Tetrachloroethylene	127-18-4	10***	1***	0.1	0.01*	0.06	0.15
toluene	108-88-3	100***	30***	3	0.3	0.24	13.5
Trichloroethylene	79-01-6	70***	7***	0.7	-	0.21	0.45
Xylene	1330-20-7	100***	100**	35	-	0.07	-

(*) Detection Rule (**) Reduction Principle (***) Continuity Principle
(-) No values derivated

SWEDEN

Swedish guideline values for contaminated soils

The table below shows the guideline values for soil given in the Swedish EPA report 4639, (SEPA, 1996). Newer values have been calculated but as yet they have only been circulated in a preliminary version for comments and have not been issued as a final version.

Substance	Sensitive land use	Less sensitive land use, groundwater protection	Less sensitive land use
Arsenic	15	15	40
Lead	80	300	300
Cadmium	0.4	1	12
Cobalt	30	60	250
Copper	100	200	200
Chrome (III)	120	250	250
Chrome (VI)	5	15	20
Mercury	1	5	7
Nickel	35	150	200
Vanadiium	120	200	200
Zinc	350	700	700
Cyanide total	30	80	1000
Cyanide free	1	2	20
Phenol and Cresol	4	10	40
Sum of chlorophenols except pentachlorophenol	2	10	10
Pentachlorophenol	0.1	3	5
Sum of mono- and dichlorobenzenes	15	30	30
Sum of tri-, tetra, and pentachlorobenzenes	1	20	30
Hexachlorobenzene	0.05	20	30
Dibromochloromethane	2	4	100
Bromodichloromethane	0.5	2	8
Carbon tetrachloride	0.1	0.2	3
Trichloromethane	2	8	50
Trichloroethene	5	30	60
Tetrachloroethene	3	20	60
1,1,1-trichloroethane	40	90	90
Dichloromethane	0.1	0.3	60
Nitrotoluene (2,4-di)	0.5	2	20
PCB total	0.02	4	7
Dioxin (TCDD-ekv)	0.00001	0.00025	0.00025
PAH carcinogenic*	0.3	7	7
PAH others*	20	40	40
Benzene	0.06	0.2	0.4
Toluene	10	35	35
Ethylbenzene	12	50	60
Xylene	15	60	70

* Sum of carcinogenic PAH (benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene and dibenzo(a,h)anthracene)

Sum of other PAH (naphthalene, acenapthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene and benzo(ghi)perylene)

NETHERLAND

SSV	Target Value		Intervention Value	
Compartment Dimension	**soil [mg.kg-1]**	**groundwater [µg.l-1]**	**soil [mg.kg-1]**	**groundwater [µg.l-1]**
Contaminant				
I Metals and trace elements		<10m >10m		
Antimony	3.0	- 0.15	15	20
Arsenic	29	10 7.2	55	60
Barium	160	50 200	625	625
Beryllium	1.1	- 0.05	(30)*1	(15)*1
Cadmium	0.8	0.4 0.06	12	6.0
Chromium*2	100	1.0 2.5	380	30
Cobalt	9.0	20 0.7	240	100
Copper	36	15 1.3	190	75
Mercury	0.3	0.05 0.01	10	0.3
Lead	85	15 1.7	530	75
Molybdenum	3.0	5.0 3.6	200	300
Nickel	35	15 2.1	210	75
Selenium	0.7	- 0.07	(100)*1	(160)*1
Silver	-	- -	(15)*1	(40)*1
Tellurium	-	- -	(600)*1	(70)*1
Thallium	1.0	- 2.0	(15)*1	(7.0)*1
Tin	-	- 2.2	(900)*1	(50)*1
Vanadium	42	- 1.2	(250)*1	(70)*1
Zinc	140	65 24	720	800
II Inorganic contaminants				
Cyanides (free)	1.0	5.0	20	1500
Cyanides (complex, pH<5)	5.0	10	650	1500
Cyanides (complex, pH≥5)	5.0	10	50	1500
Thiocyanates (sum)	1.0	-	20	1500
III Aromatic contaminants				
Benzene	0.01	0.2	1.0	30
Ethyl benzene	0.03	4.0	50	150
Phenol	0.05	0.2	40	2000
Cresoles (sum)	0.05	0.2	5.0	200
Toluene	0.01	7.0	130	1000
Xylene	0.1	0.2	25	70
Styrene	0.3	6.0	100	300
Catechol	0.05	0.2	20	1250
Resorcinol	0.05	0.2	10	600
Hydrochinon	0.05	0.2	10	800
Dodecylbenzene	-	-	(1000)*1	(0.02)*1
Aromatic solvents	-	-	(200)*1	(150)*1
Monochloroanilines	0.005	-	50	30
Dichloroanilines	0.005	-	(50)*1	(100)*1
Trichloroanilines	-	-	(10)*1	(10)*1
Tetrachloroanilines	-	-	(30)*1	(10)*1
Pentachloroanilines	-	-	(10)*1	(1.0)*1
4-Chloro-2-methylphenol	-	-	(15)*1	(350)*1
4-Chloro-3-methylphenol	-	-	(15)*1	(350)*1

SSV	Target Value		Intervention Value	
Compartment Dimension	**soil [mg.kg-1]**	**groundwater [µg.l-1]**	**soil [mg.kg-1]**	**groundwater [µg.l-1]**
Contaminant				
IV Polycyclic aromatic hydrocarbons				
Naphthalene	-	0.01	-	70
Anthracene	-	0.0007	-	5.0
Phenantrene	-	0.003	-	5.0
Fluoranthene	-	0.003	-	1.0
Benzo(a)anthracene	-	0.0001	-	0.5
Chrysene	-	0.003	-	0.2
Benzo(a)pyrene	-	0.0005	-	0.05
Benzo(*ghi*)peryleen	-	0.0003	-	0.05
Benzo(k)fluorantheen	-	0.0004	-	0.05
Indeno(1,2,3-cd)pyrene	-	0.0004	-	0.05
Total PAHs (10)	1	-	40	-
V Chlorinated hydrocarbons				
Vinylchloride	0.01	0.01	0.1	5.0
Dichloromethane	0.4	0.01	10	1000
1,1-Dichloroethane	0.02	7.0	15	900
1,2-Dichloroethane	0.02	7.0	4.0	400
1,1-Dichloroethene	0.1	0.01	0.3	10
1,2-Dichloroethene (cis)	-	-	-	-
1,2-Dichloroethene (trans)	-	-	-	-
1,2-Dichloroethene (sum)	0.2	0.01	1.0	20
Dichloropropanes	0.002	0.8	2.0	80
Trichloromethane	0.02	6.0	10	400
1,1,1-Trichloroethane	0.07	0.01	15	300
1,1,2-Trichloroethane	0.4	0.01	10	130
Trichloroethene	0.1	24	60	500
Tetrachloromethane	0.4	0.01	1.0	10
Tetrachloroethene	0.002	0.01	4.0	40
Chlorobenzenes:				
Monochlorobenzene	-	7.0	-	180
Dichlorobenzenes (sum)	-	3.0	-	50
Trichlorobenzenes (sum)	-	0.01	-	10
Tetrachlorobenzenes (sum)	-	0.01	-	2.5
Pentachlorobenzene	-	0.003	-	1.0
Hexachlorobenzene	-	0.00009	-	0.5
Total Chlorobenzenes	0.03	-	30	-
Chlorophenols:				
Monochlorophenols (sum)	-	0.3	-	100
Dichlorophenols (sum)	-	0.2	-	30
Trichlorophenols (sum)	-	0.03	-	10
Tetrachlorophenols (sum)	-	0.01	-	10
Pentachlorophenol	-	0.04	-	3.0
Total chlorophenols	0.01	-	10	-
Chloronaphthalene	-	-	10	6.0
Polychlorobiphenyls:				
Trichlorobiphenyl	-	-	-	-
Hexachlorobiphenyl	-	-	-	-
Total polychlorobiphenyls	0.02	0.01	1.0	0.01
Dioxins*5	-	-	(0.001)*1	(0.000001)*1

SSV	Target Value		Intervention Value	
Compartment Dimension	**soil [mg.kg-1]**	**groundwater [µg.l-1]**	**soil [mg.kg-1]**	**groundwater [µg.l-1]**
Contaminant				
VI Pesticides				
Organochlorine pesticides:				
DDT	-	-	-	-
DDE	-	-	-	-
Total DDT/DDD/DDE	10 µg.kg-1	0.004 ng.l-1	4.0	0.01
Aldrin	0.06 µg.kg-1	0.009 ng.l-1	-	-
Dieldrin	0.5 µg.kg-1	0.1 ng.l-1	-	-
Endrin	0.04 µg.kg-1	0.04 ng.l-1	-	-
Total drins	5.0 µg.kg-1	-	4.0	0.1
□-HCH	3.0 µg.kg-1	33 ng.l-1	-	-
□-HCH	9.0 µg.kg-1	8.0 ng.l-1	-	-
□-HCH	0.05 µg.kg-1	9.0 ng.l-1	-	-
Total HCHs	10 µg.kg-1	50 ng.l-1	2.0	1.0
Other pesticides:				
Atrazin	0.2 µg.kg-1	29 ng.l-1	6.0	150
Azinphosmethyl	0.005 µg.kg-1	0.1 ng.l-1	(2.0)*1	(2.0)*1
Carbaryl	0.03 µg.kg-1	2.0 ng.l-1	5.0	50
Carbofuran	0.02 µg.kg-1	9.0 ng.l-1	2.0	100
Chlordane	0.03 µg.kg-1	0.02 ng.l-1	4.0	0.2
Endosulfan	0.01 µg.kg-1	0.2 ng.l-1	4.0	5.0
Heptachlor	0.7 µg.kg-1	0.005 ng.l-1	4.0	0.3
Heptachoro epoxide	0.0002 µg.kg-1	0.005 ng.l-1	4.0	3.0
Maneb	2.0 µg.kg-1	0.05 ng.l-1	35	0.1
MCPA	0.05 µg.kg-1	20 ng.l-1	4.0	50
Tributyltinoxide	-	-	-	-
Triphenyltin compounds	-	-	-	-
Total organotin compounds (sum)	1.0 µg.kg-1	0.05-16 ng.l-1	2.5	0.7
VII Other pollutants				
Acrylonitrile	0.000007	0.08	(0.1)*1	(5.0)*1
Butanol	-	-	(30)*1	(5600)*1
Butylacetate	-	-	(200)*1	(6300)*1
Cyclohexanone	0.1	0.5	45	15000
Diethylene-glycol	-	-	(270)*1	(13000)*1
Ehtylacetate	-	-	(75)*1	(15000)*1
Ethyleneglycol	-	-	(100)*1	(5500)*1
Formaldehyde	-	-	(0.1)*1	(50)*1
Isopropanol	-	-	(220)*1	(31000)*1
Methanol	-	-	(30)*1	(24000)*1
Methyl-*tert*-butyl ether (MTBE)	-	-	(100)*1	(9200)*1
Methylethylketone	-	-	(35)*1	(6000)*1
Mineral oil	50	50	5000	600
Butyl benzylphthalate	-	-	-	-
Di(2-ethylhexyl)phthalate	-	-	-	-
Total phthalates	0.1	0.5	60	5.0
Pyridine	0.1	0.5	0.5	30
Tetrahydrofuran	0.1	0.5	2.0	300
Tetrahydrothiophene	0.1	0.5	90	5000
Tribromomethane	-	-	75	630

-: not available

*1: no reliable value could be derived; in the Ministerial Circular this value (in between brackets) is called *Indicative Level for serious soil contamination*

European Commission

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Title: **Working title Derivation Methods of Soil Screening Values in Europe: a Review of National Procedures Towards Harmonisation**

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Abstract

Soil Screening Values (SVs) are quality standards that are used to regulate contaminated sites. Derivation methods of SVs have scientific and political bases; they differ from country to country, and SVs numerical values vary consequently. In relation to the common environmental policies in Europe, this variability has raised concern among both regulators and risk assessors. As reported in the Soil Thematic Strategy discussion documents (Van Camp et al., 2004), a further alignment of European SVs derivation methods is generally supported. The idea of a toolbox approach, which addresses the harmonization of specific building blocks of SVs derivation procedures while giving wide room for national diversities, was already discussed in an expert meeting in Ispra on February 2005. Nevertheless, it was also clear at that time that a detailed analysis of commonalities and differences among European national approaches, was lacking. In particular, besides the identification of differences, a further insight was necessary on the reasons for the differences. Based on this consideration, the idea of the present review was launched.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

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