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DESIRE FOR LEVELS

Background study for the policy document "Setting Environmental Quality Standards for Water and Soil"

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This study was commissioned by the Directorate General for the Environment, Drinking Water, Water and Soil Department, Water Section and the Substances and Risk Management Department. Previously this project was registered under project number 718922. Originally, this work has been published in Dutch, as RIVM-report no. 670101.001: "STREVEN NAAR WAARDEN".

FOREWORD

As commissioned by the Directorate-General for Environmental Protection, RIVM has proposed a procedure to derive a coordinated set of environmental quality standards for water and soil from single species toxicity test results; the procedure was then applied to derive risk limits for water, sediment and soil for 45 chemicals. The present report is a translation of the original report of this study: "STREVEN NAAR WAARDEN". Many names and titles have been left untranslated. Translations in square brackets have been provided only in cases where proper understanding of the text demanded this.

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33	Projecten- en Rapportenregistratie
34 - 35	Bibliotheek RIVM
36	Bibliotheek RIVM, depot EMD
37 - 75	Reserve Exemplaren

TABLE OF CONTENTS

SUMMARY

This report is meant to provide scientific support for setting environmental quality objectives for water, sediment and soil.
No quality criteria are being set in this report. Only options for decisions are given. Starting point is the policy document *"Omgaan met risico's"* [Premises for Risk Management], in which long term quality objectives are chosen to be set equal to the *"Verwaarloosbaar Risico"* [Negligible Risk] levels which, in turn, are chosen to be set equal to 1/100th of the *"Maximaal Aanvaardbaar Risico"* [Maximum Acceptable Risk] levels. This report is restricted to the derivation of the maximum acceptable risk levels for 45 chemicals.

Maximum acceptable risk levels for water are primarily derived from available chronic toxicity data, following an extrapolation procedure recommended by the *"Gezondheidsraad"* [Health Council]. This procedure has been modified in two ways:

- a revised statistical technique has been used
- input data are grouped according to taxonomical classes

For those chemicals for which insufficient toxicity data are available to use the extrapolation procedure recommended by the Health Council, a modified EPA-procedure that produces indicative values only, is used.
In addition to this toxicological approach, an ecological approach has been taken to assess the possible effects on ecosystems. This ecological approach uses a mathematical description of a model ecosystem, consisting of algae, Daphnia and fish. The results are used to indicate the occurrence of effects at the ecosystem-level.

For sediment no toxicity data are available. Maximum acceptable risk levels for sediment are derived indirectly from maximum acceptable risk levels for water, using the equilibrium partitioning method.

To derive maximum acceptable risk levels for soil, ecotoxicological extrapolation methods similar to those used for water are used. In addition, maximum acceptable risk levels for soil are derived from maximum acceptable risk levels for water with the equilibrium partitioning method.

The results for water, sediment and soil are given in the tables 9, 10 and 11, respectively. It appears that the differences between the results obtained with different extrapolation procedures for deriving maximum acceptable risk levels for water are small. For soil too little toxicity data are available to properly derive maximum acceptable risk levels directly. In absence of reliable soil-pore water partition coefficients, application of the equilibrium partitioning method is not a suitable alternative.

Maximum acceptable risk levels and negligible risk levels for water and sediment are compared with natural background concentrations in the tables 14 and 15. Natural background concentrations for soil are not known. Therefore risk levels for soil are compared to the *"Referentiewaarden Bodemkwaliteit"* [Reference Values for Soil Quality]. It appears that for metals negligible risk levels are lower than the natural background concentrations in water sediment. This is not the case for polycyclic aromatic hydrocarbons. The negligible risk levels for metals in soil are well below the reference values for soil quality.

In this report a number of recommendations are made. The most important of these are:

- It is not necessary to set long term quality objectives for sediments, since sediment quality is determined by water quality.
- Long term quality objectives for naturally occurring chemicals are not to be set automatically equal to the negligible risk levels; long term quality objectives for man-made chemicals are.
- Effects at higher trophic levels, resulting from bioconcentration, are to be considered systematically in deriving maximum acceptable risk levels from laboratory toxicity data.
- In addition to chemical parameters, toxicological response parameters are to be considered as a base for setting environmental quality objectives.

Furthermore research is being recommended

- into the natural background levels of chemicals
- to further develop toxicity testing methods for terrestrial organisms
- to obtain reliable partition coefficients
- to improve and optimize extrapolation methods

1 INTRODUCTION

1.1 Objective and Framework

This report is intended to provide a scientific basis to the policy document *"Milieukwaliteitsnormering voor bodem en water"* [Setting Environmental Quality Standards for Water and the Soil] (MILBOWA) to be written by the MILBOWA project group of the Directorate-General of Environmental Protection (DGM). This policy document will have two focal points:

- Quality objectives will be defined against the backdrop of the expected effects on ecosystems.
- Quality objectives for different compartments of the environment (water, sediment, soil) will be coordinated.

The following approach was set in consultation with the client:

- Scientific and policy aspects will be kept separate whenever possible. This report is limited to the discussion of different ways of setting quality objectives and to demonstrate the quantitative consequences thereof.
- In principle the ecotoxicologically supported negligible risk provides the basis when defining *"streefwaarden"* [desirable levels]. For naturally occurring substances the natural background levels will be considered as an additional factor; for substances that do not occur naturally ecotoxicologically supported negligible risk provides the only basis.
- This report focuses on the quantitative expression of "natural background concentrations" and "maximum acceptable risk" levels. Deriving *"streefwaarden"* [desirable levels] and *"grenswaarden"* [maximum tolerable levels] is considered to be a policy matter and not discussed in this report.
- If due to a lack of ecotoxicological data it is not possible to derive maximum acceptable risk levels directly for soil and sediment, then these values will be derived from those for water, using the equilibrium partition concept.
- Coordination of the quality objectives will be limited to a minimum and will comprise retrospective assessment. When drawing up quality objectives it will be considered how reasonable it is to assume that the derived concentrations in water, sediment and the soil will simultaneously occur in the environment. The criteria for this will be the concentration ratios sediment-water and soil-water, to be based on a theoretical or empirical basis.
- Maximum acceptable risk levels will not be derived for groundwater. The drinking water function of groundwater should be protected by protecting the soil.

The report covers 45 substances:

Cadmium, mercury, copper, chromium, arsenic, lead, zinc, nickel, polycyclic aromatic hydrocarbons (10 components), atrazin, lindane, azinphos-methyl, malathion, parathion-ethyl, tributyl tinoxide, dieldrin, diazinon, chlorophenols (19 components).

1.2 Approach

Given the short history of "coordinated effects based standards" special attention was given to the strength of the scientific premises to be used. To a large extent this was based on the, often personal, opinion of a number of specialists. A deliberate decision was made to give this report the character of a discussion document.
The following documents were used as the initial documentation to promote continuity with knowledge obtained through other frameworks and positions taken earlier:

- *"Discussienota Bodemkwaliteit"* [Soil Quality Discussion Document] (VROM, 1986)
- *"Rapport Werkgroep Normering"* [Report of the Working Group on Setting Standards] (RWS-DGMH, 1986)
- Policy Document *"Omgaan met Risico's"* [Premises for Risk Management] (DGM, 1989a)
- Health Council Report *"Advies inzake ecotoxicologische risico-evaluatie van stoffen"* [Assessing the Risk of Toxic Chemicals for Ecosystems] (Gezondheidsraad, 1988b)
- Policy Document *"Kansen voor Waterorganismen"* [Opportunities for Aquatic Organisms] (DBW/RIZA, 1989)

To obtain the data required easily accessible sources were used whenever possible, generally with assistance from the experts consulted:

- *Basisdocumenten* [Integrated Criteria Documents] and underlying data
- Data available at the RIVM *Adviescentrum Toxicologie* [Toxicology Consultancy Department]
- Data collected by the consultancy Bureau BKH, commissioned by *DBW/RIZA* [Institute for Inland Water Management and Waste Water Treatment], which provided the foundation for the policy document *"Kansen voor Waterorganismen"* [Opportunities for Aquatic Organisms]
- Provisional results of the *Herziening Leidraad Bodemsanering* [Revision of the Guidelines for Soil Remediation] and underlying data
- Provisional raw data from initial measurements during the period the *Meetnet Bodemkwaliteit* [Soil Quality measuring network] was being set up
- Recent, partly unpublished, work by Van Straalen c.s., commissioned by the *Technische Commissie Bodembescherming* [Technical Soil Protection Committee]

Additionally an extensive literature study was made with assistance from the Bureau BKH (which was commissioned by DGM) of available toxicity data related to water and soil organisms.

1.3 Limitations

This report does not consider the marine environment. The derived maximum acceptable risk levels only apply to the freshwater environment.

This report does not consider the effects which may occur due to the effects of biomagnification. Consequently the maximum acceptable risk may be underestimated, particularly for substances which accumulate greatly. Risks to predators should be estimated by processing oral chronic toxicity data for higher organisms (rats, guinea pigs, etc.) combined with food consumption by predators and bioconcentration in aquatic organisms. Bioaccumulation was included in "Opportunities for Aquatic Organisms"

(DBW/RIZA, 1989), in that product standards were used when determining the *"ecotoxicologische waarden"* [ecotoxicological values].

In this report the maximum acceptable risk levels for individual substances are derived. According to generally accepted views the most chemicals have an aspecific (narcotic) effect and it should be assumed that they will generally have additive effects. In the environment, however, substances occur in varying combinations and quantities. It is therefore impossible to consider combined toxicity in general terms. In the risks policy (DGM, 1989a) the aspect of combined toxicity is included by using the safety factor 100 when deriving the negligible risk from the maximum acceptable risk. This is an explicit policy choice. DBW/RIZA (1989) has made an attempt in "Opportunities for Aquatic Organisms" to consider the combined toxicity of groups of substances when deriving ecotoxicological values for water.

2 METHODOLOGY

2.1 Background levels

There are a number of ways to determine the "normal" or "background" concentrations of substances in the environment:

a. **Determining the concentrations in "relatively clean" areas.** This a disputable method as it is hard to establish criteria for "relatively clean". This method was used when determining the *"referentiewaarden bodemkwaliteit"* [reference values for soil quality] (Edelman, 1984; VTCB, 1986) and the *"algemene milieukwaliteit waterbodems"* [general environmental quality standard for sediments] (RWS-DGMH, 1986; DGM, 1989b).
b. **Determining the concentrations in preanthropgenic deposits.** The absence of anthropogenic influences is generally easier to determine for old deposits than for recent ones. Obviously this method can only be used for soil and sediment. This method was used by Salomons (1983) when determining the naturally occurring mineral content of Rhine sediments and by Geochem-Research (1989) when determining the naturally occurring levels of polycyclic aromatic hydrocarbons in Rhine water and sediment.
c. **Scientific deduction.** When large river systems are concerned it may be assumed that the natural levels of major and minor components resulting from hinterland erosion reflect the average known mineral composition of the soil in the catchment area. In this way the natural background levels in water and soil can be calculated. Schuiling and Van der Weijden (1974) made such a calculation for the Rhine in the past. This calculation was recently repeated (Van der Weijden and Middelburg, 1989).

Numerical values of background concentrations of naturally occurring substances (metals, arsenic, polycyclic aromatic hydrocarbons) are listed in table 1.

Water
Background levels of metals and arsenic in water are based on a calculation by Middelburg (1990) according to method c (Schuiling and Van der Weijden, 1974; Van der Weijden and Middelburg, 1989). The erosion rate was determined by measuring the total quantity of major river components (Si, Al, Fe, Mg, Ca) and comparing this with the average soil composition. As the average level of trace elements in the soil is also known the corresponding quantities of trace elements in the Rhine could be estimated. The naturally occurring quantities thus derived were converted to total contents (dissolved and bound to particles). The corresponding concentrations of dissolved matter were derived from this using the ratios between total and dissolved matter for the period 1975-1984 (Van der Weijden and Middelburg, 1989), it was assumed that the ratio between total and dissolved matter was the same in the natural situation.
The background levels of polycyclic aromatic hydrocarbons were derived from a literature study recently undertaken by Geochem-Research (1989). On the basis of PAH contents reported in the literature in pre-anthropogenic Rhine basin sediments (method b) the corresponding equilibrium concentrations in Rhine water were calculated using sediment-water partition coefficients estimated on the basis of the K_{ow} and an f_{oc} value for Rhine sediment of 0.025.

Table 1 Background concentrations and concentrations in "relatively clean areas" of naturally occurring substances

	Water ($\mu g.l^{-1}$)		Sediment ($mg.kg^{-1}$)		Soil ($mg.kg^{-1}$)
	Total[1]	Dissolved[1]	Old sediment[2]	GEQS Sediments[3]	Reference value soil quality[3]
Cadmium	0.0063	0.002	0.25	0.8	0.8
Zinc	2.6	1	68	140	140
Nickel	1.8	1	29	35	35
Lead	2.0	0.1	21	85	85
Mercury	0.3	0.3			
Chromium	4.8	0.9	72	100	100
Copper	1.3	0.4	13	36	36
Arsenic				29	29
Naphthalene					
Anthracene	0.004	0.002			
Phenanthrene	0.06	0.05	0.03		
Fluoranthene	0.009	0.009	0.01	1.2	
Benzo[a]anthracene	0.0003	0.0002	0.001		
Chrysene	0.001	0.001	0.005		
Benzo[k]fluoranthene	0.0007	0.0004	0.005	0.55	
Benzo[a]pyrene	0.0005	0.0003	0.004	0.2	
Benzo[ghi]perylene	0.0002	0.00006	0.003	0.2	
Indeno[1,2,3-cd]pyrene					0.2

[1] Metals: Middelburg, 1990; PAH: Geochem-Research, 1989
[2] Metals and arsenic: Salomons, 1983; PAK: Geochem-Research, 1989
[3] DGM (1989b)

Sediment

For metals in sediments both the values reported by Salomons (1983) as the "provisional base line" for sediment in the Netherlands (method b) as well as the values laid down in the "general environmental quality standards" for sediments (GEQS-sediments: method a; DGM, 1989b) have been included. For polycyclic aromatic hydrocarbons both the values reported by Geochem-Research as well as those in the GEQS-sediments have been included. The differences, particularly for PAH, are striking. This is due in part to the differences in the way the values were derived. Salomons and Geochem-Research report averages of a series of measurements of pre-anthropogenic sediments. The GEQS-sediments were determined in a different way (DBW/RIZA, 1988). For the latter values a concentration was determined which exceeded almost all concentrations (mean + 2 x standard deviation) measured in Markermeer and Oosterschelde sediments. The values obtained in this manner were little different from the "soil quality reference values". It was then decided to set the GEQS-sediments and the "soil quality reference values" to the same level. This accounts for part of the discrepancy between the values according to Salomons and Geochem and those according to GEQS-sediments. This is not a complete explanation: the average metal content of Markermeer and Oosterschelde sediments was 1.5 to 2 times the average metal content of Dollard sediment (DBW/RIZA, 1988). These differences are due to the differences in contamination of the samples.

The PAH levels reported by Geochem-Research are considerably lower than those according to GEQS-sediments. This suggests that the Markermeer and Oosterschelde sediments suffer from considerable PAH pollution.

Where metals are concerned the "provisional base line" suggested by Salomons is interpreted as the natural background for Netherlands' sediments. Where PAH are concerned the values supplied by Geochem-Research will be considered as the natural background.

Soil
Naturally occurring background levels are not known for terrestrial soil. However, concentrations in relatively unpolluted areas are available (Edelman, 1984). For comparison the reference values for soil quality for metals and arsenic have been included in table 1, although these should not be considered as the natural background levels.

2.2 Risk levels

It is a historical fact that ecotoxicological studies are undertaken in analogy with animal experiments undertaken for human toxicology. In human toxicology observations are rightly made at the individual level; the intention is to protect humans at the individual level. Primarily, extrapolation need only be undertaken from one species to another. Secondarily the difference in sensitivity between humans needs to be considered. Matters are rather different where ecosystems are concerned. Although the protection level is not described in detail (see the NMP) it is reasonable to assume that protection at the individual level is not intended. Furthermore, a limited reduction in the number of species might be acceptable (EPA, 1984; DGM, 1989a). The current problem is that ecotoxicological tests have been developed and internationally accepted whereas the objectives have not yet been defined. At present ecological objectives are still being proposed, whereby for the aquatic environment the following indicators of ecosystem performance have been designated: salmon for the Rhine, seals for the Wadden Sea and herring for the North Sea. However in an advice on ecological standards for water management the Health Council (1988a) does not mention such indicators.

In scientific circles a number of methods have been proposed during the last few years which may be suitable to derive environmental quality objectives from ecotoxicological data. We will limit ourselves to indicating different approaches recently suggested in the Netherlands which have been used to determine maximum acceptable risk levels. The Health Council (1988b) recently evaluated several extrapolation methods (Blanck, 1984; EPA, 1984; Erickson and Stephan, 1984; Slooff et al., 1986; Kooijman, 1987; Van Straalen and Denneman, 1989). On the basis of available information a procedure was proposed to derive scientifically sound standards, comprising a combination of the methods proposed by Kooijman (1987), Van Straalen and Denneman (1989) and Slooff et al. (1986). The results of this procedure, i.e. the concentration at which 95% of all possible species is protected, have become accepted as a basis for setting the maximum acceptable risk level; the negligible risk level will in principle be set at 1% of this upper limit (DGM, 1989a)[1].

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[1] Traditionally the toxic influence of substances on organisms is only considered as an undesirable effect. The use of the terms "protection", "maximum acceptable", "negligible" and "risk" illustrates this. This is obvious where substances which do not occur naturally in the environment are concerned. However, toxic influences are not necessarily undesirable when naturally occurring substances are concerned. It is possible that the presence of a particular substance in a given ecosystem fulfils a regulating function in that ecosystem by virtue of its toxic effect. In

2.2.1 Objects to be protected

Where the ecotoxicological assessment of substances is concerned this report has been based on appropriate elements from the procedures discussed earlier. The discussions on this subject in the inter-ministerial *"Werkgroep Risicomanagement Ecosystemen"* [Working Group Risk Management of Ecosystems] will also be considered.

The primary question concerns the level of biological integration at which the ecosystems have to be protected against adverse effects. Broadly speaking a choice has to be made between the levels of the individual, the species and the ecosystem. Generally the protection level will decrease with an increase in integration level (Slooff, 1989). It is not possible to make quantitative statements about this given the lack of knowledge of ecosystem-wide effects. Pragmatic considerations therefore require that the sensitivity of species is used as the basis for protecting species. The premise that by protecting species the functioning of the ecosystem will also be guaranteed (Health Council, 1988b) is also accepted. It should also be noted that the extent to which a species is protected also determines the extent of protection given to individuals.
Implicitly this choice means that the interactions between species and operating mechanisms of the substances are not studied and as such are not included in the assessment. This is considered undesirable. To meet this objection to some extent the RIVM is considering the development of methods which may be used for this.

2.2.2 Unacceptable effects

When assessing to what extent, possibly unacceptable, effects occur the following may be distinguished:

a. Nature of the effects
   Selecting the species as the object to be protected means that only those toxicological criteria will be considered which are directly relevant to the survival of the species: survival, reproduction and growth. Primarily this concerns parameters to be interpreted directly: deaths/survivors, number of offspring, biomass/length/weight. Teratogenic effects also have to be included in so far as these affect growth and survival. There are also parameters which indirectly affect the survival of a species. For example, the occurrence of histopathological defects of the reproductive organs. Although other effects may be observed these are not considered to affect the survival of the species.
   The following should be considered with respect to special effects. Carcinogenic effects are only relevant at the individual protection level and should not be assessed differently from the toxic effects with respect to the above criteria. Mutagenic effects may be relevant to the survival of the species but the chance that congenital genetic defects occur is so much lower than the chance of

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that event the presence of the substance would be desired. It would therefore be better to use neutral terms to identify toxic influences. For example the term **"5% effect level"** could be used instead of "95% protection level", similarly **"maximum desired influence level"** could be used instead of "maximum acceptable risk level".

non-congenital defects such as tumours that the relevance of this will be considered as limited.

b. The extent of the effects (in terms of intensity, scope and duration).

With respect to the extent of the effects the following may be distinguished:

- no harmful effect on the species (effect without consequences to the size and structure of the population)
- no harmful effect on the ecosystem (effect without consequences to the chances of maintenance, recovery and development) (similar to the Nature Policy plan)

The question also arises whether all species should be given equal protection or if there should be differentiation.

Setting the acceptable degree of influence is a social choice. It should be assumed that society will choose the ecosystem protection level provided that there will not be an unacceptable adverse effect on species which are relevant on economic or recreational grounds.

The following questions arise:

i. What percentage of species in an ecosystem may suffer effects concerning survival, reproduction and/or growth without decreasing the ecosystem's opportunities for maintenance, recovery and development?

This question was posed to a number of biologists, ecotoxicologists, ecologists and bio-mathematicians in the Netherlands. It was decided that there is currently no scientific basis to provide an adequate answer to this question. It is doubtful that the question can actually be answered. The critical percentage depends on the ecological relevance of the species (keystone species) and may be different in different ecosystems. For pragmatic reasons (consistency with EPA, acceptance at the national level) an arbitrary level of 5% has been chosen.

ii. What species are relevant on economic and recreational grounds?

An RIVM report is currently being prepared (Kwadijk et al., 1990) which will include a list of ecological indicators as positive objectives of the environmental policy, selected for example on the basis of their caressing factor or because they represent an ecodistrict. The species included on the list on the basis of these criteria are limited to higher plants (water and land based plants) and animals (fish, amphibians, reptiles, mammals). In connection with economically significant species consideration should be given to crops, forestry, cattle breeding, mink farms, fish farms, mussel and oyster culture, etc. This generally concerns higher organisms. Given their area/volume ratio these higher organisms may be less sensitive to toxic substances than the smaller, less organised organisms. However, they are more vulnerable given their smaller numbers, longer generation periods and limited number of offspring. In other words, the chance that these higher species are included in the 5% which may suffer damage is relatively low, but the damage will be relatively large if it occurs.

2.3 Maximum acceptable risk levels for water

The maximum acceptable risk level of a substance is the concentration of that substance in the environment above which species or ecological equilibriums are unacceptably affected, either quantitatively or qualitatively. A number of methods to determine a maximum acceptable risk level for aquatic ecosystems will be discussed in this section. Two approaches will be followed. The first approach stresses toxicology, and ecological information, e.g. about interactions between species or compensation mechanisms, is not included. This approach forms the basis to deriving the maximum acceptable risk level. The other approach puts the stress on ecology: ecological interaction mechanisms (Aldenberg and Knoop, 1990) are considered as well as single species toxicological data. At present such a method has only been developed for the aquatic environment. This method should be considered as supplementary to the first method, whereby, on the grounds of this interaction, it may suggest a decrease of the maximum acceptable risk levels. The method as such mainly fulfils a signalling function.

2.3.1 Toxicological method

In the second half of the 80's various methods were developed and proposed to derive "acceptable" concentrations of substances in the environment on the basis of experimental aquatic and terrestrial single species toxicological data. At approximately the same time the Health Council (1988b) and DBW/RIZA (1989) independently published recommendations. The Health Council (1988b) evaluated the scientific merits of the existing methods in the Netherlands and abroad to derive concentration limits, above which particular effects will occur with increasing certainty in at least one species. The Health Council (1988b) recommended a procedure in which three extrapolation methods (Slooff et al., 1986; Kooijman, 1987; Van Straalen and Denneman, 1989) each had their own place and function. The last method mentioned would provide the basis for the derivation of risk limit values. At the same time the committee identified some major gaps in our knowledge, e.g. concerning biological availability, combined toxicity and biomagnification and possibly related effects of bioaccumulation in the food chain.
In contrast with the Health Council, DBW/RIZA (1989) did not start with the existing extrapolation methods, but rather by supporting a general protection level exclusively for aquatic ecosystems based on ecotoxicological data. This was based on the description of the basic quality: offering opportunities for life to aquatic communities including higher organisms and also protecting ecological interests outside the water (such as birds and mammals which consume aquatic organisms).

The above leads to the conclusion that the premises and therefore the protection levels used by the Health Council (1988b) and DBW/RIZA (1989) differ. Both approaches are based on experimentally derived NOEC values for various taxonomical groups. In the approach taken by the Health Council all reliable NOEC values are used to determine a risk limit. This limit protects a selected percentage of the species in an ecosystem against unacceptable effects, on the basis of an assumed sensitivity range of all species in an ecosystem. The method used by DBW/RIZA however, is only based on NOEC values derived for a limited number of taxonomical groups (algae, molluscs, crustaceans, fish) without extrapolation to other species and without providing an understanding of the degree of protection provided. However, when determining the desired environmental quality the possible effects of poisoning along the food chain are considered, an aspect not included in the Health Council procedure. It has also been attempted to include the issue of combined toxicity in numerical form in the ecotoxicological value which provides the desired protection.

In accordance with the advice of the Health Council this report stresses the method of Van Straalen and Denneman (1989). This method was further discussed according to the recommendations of the Health Council. Eventually this resulted in two modifications to the method of Van Straalen and Denneman (1989). The advice of the Health Council was not adhered to if very little ecotoxicological information was available.

Modification 1

According to the extrapolation method followed by Van Straalen and Denneman (1989) the safe level is defined as the concentration at which a randomly selected species or group of species will have a higher NOEC in 95% of the cases. The same definition is used in this report although a different statistical method is used to estimate these concentrations. Van Straalen and Denneman (1989) calculate a number, depending on the chosen reliability, which appears to be intended as the lower limit of the reliability interval of the 95% protection level. However, the RIVM has found major discrepancies with the reliability defined in this manner, particular if few NOEC values are used (Slob, 1989)[2].

An alternative method is proposed in this report to calculate the 95% protection levels and associated reliability intervals. This method is based on Bayesian statistics using non-informative priors (Box and Tiao, 1973) for the parameters of the distribution of NOEC data among the species and within a species. A report is being prepared about the use of this method (Aldenberg and Knoop, 1990).

This method can be summarised as follows: it is assumed that the available set of toxicity data can be described with an infinite number of logistic curves, which provide the best fit in the dispersion of the toxicity data. The 95% protection level can be determined for each of these curves; this is indicated by "5%" in the upper half of figure 1. The 50% value (median) is calculated from the 95% protection level as well as the 5% value. This is indicated in the lower half of figure 1. The advantage of this approach is that the uncertainty in the forecast of the operationally defined safe concentration is fully defined, on the basis of limited toxicity data. Unlike the original method of Van Straalen and Denneman (1989) more than 3 input data are required. This agrees with the advice being prepared by Okkerman et al. (1990) which advocates a larger number of input data to obtain a better estimate of the "safe" value. Unlike the method of Van Straalen and Denneman (1989) in which the 95% protection level is determined with 95% certainty, it is now proposed to determine the 95% protection level with 50% certainty. The reason for this is that this is the most likely value. The ratio between the 50% value and the 5% value can serve as an indicator of the accuracy of the estimate of the 95% protection level (see figure 1.)

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[2] These findings were discussed with Professor Kooijman. An unambiguous conclusion could not be made. This may be a difference in interpretation between author and reader. However, it cannot yet be excluded that the calculation methods chosen by Kooijman are not entirely correct. This is subject of further investigation. The results were not yet available at the time of publication of this report.

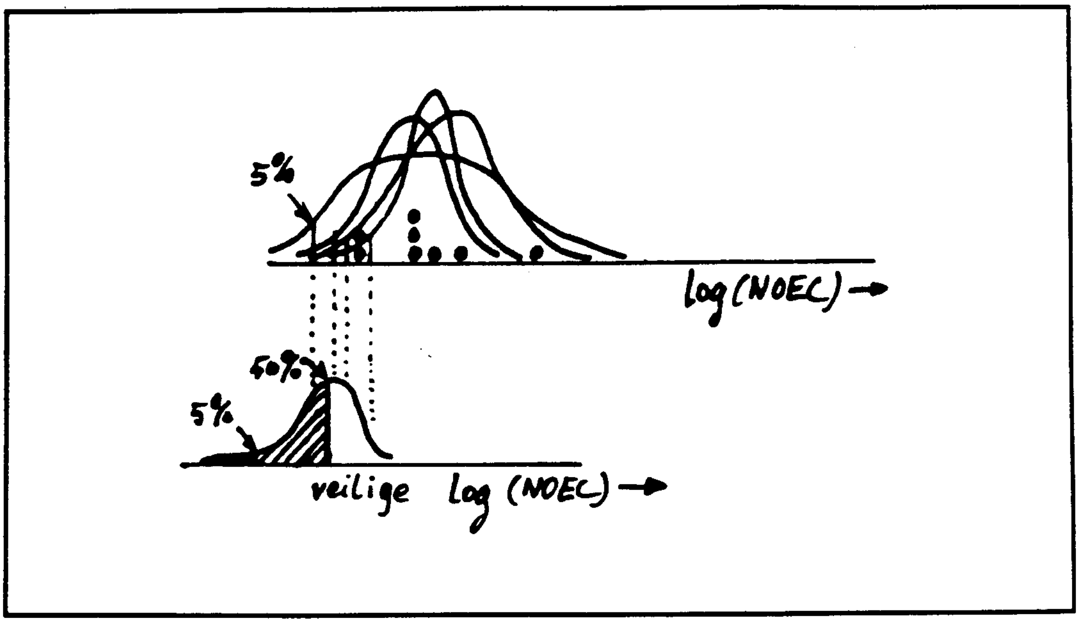

Figure 1 A posteriori distribution of the NOEC values defined as "safe" based on the uncertainty of the parameters best suited to the data. The 5- and 50-percentiles are shown (see text for further explanation)

Modification 2

In this modification, besides the statistical changes, the toxicity data to be used are grouped in taxonomic classes. In the method of Van Straalen and Denneman (1989) all reliable NOEC values obtained from single species tests are included. Theoretically the input data should be a random sample from the species in an ecosystem. This assumption is not fulfilled in practice as the available data determine the content of the sample. It should be assumed that the variation in sensitivity within a taxonomic group is smaller than that between different taxonomic groups. This assumption is based on the fact that the toxicity of a substance depends on the structure, way of life, chemokinetics and other characteristics, which are often typical for certain taxonomic groups. This assumption is supported by observations:

- Canton and Adema (1978) found hardly any difference in the sensitivity of three Daphnia species to a number of substances. This provides an indication that species with the same structure, way of life and chemokinetics react similarly.
- Jop et al. (1986) compared the sensitivity of 2 crustaceans (Daphnia and shrimp) with the sensitivity of 4 species of fish to chromium; Daphnia was shown to be the most sensitive. The shrimp's sensitivity was 15 times lower, that of the fish on average 200 times, the spread in sensitivity between the fish varied from 1.3 to 6.5.
- LeBlanc (1984) did not find a correlation ($r = 0.02$) between the sensitivity of fish and water fleas to pesticides; a correlation was observed for metals ($r = 0.79 - 0.95$), however the toxicity varied by a factor of 10.
- Slooff et al. (1986) compared the sensitivity of 35 species of 11 taxonomic classes to 15 substances. This study also showed that the correlation coefficients within a class are better than those between different taxonomic classes, although the differences were small.

Further consideration of earlier research (Slooff et al. 1983), however, showed that the differences between non-related species are considerably larger than those between related species, dependent on the nature of the substance.

On the basis of the above the application of all available toxicity data may lead to a bias: the over-representation of a species or group of species (e.g. fish) in the available set of data may lead to an incorrect impression (i.e. it only indicates the protection level for fish). To meet this objection to some extent one NOEC value has been chosen or derived per taxonomic group. The disadvantage of this is that the number of input data is reduced and that therefore information is lost and the statistical uncertainty increases. The following method was used to evaluate reliable NOEC values:

- if several studies were made of one species with different toxicological parameters the lowest relevant (see above) NOEC value was used;
- if several studies were made of one species with the same toxicological parameter the geometric average NOEC value for this species was used;
- if several studies were made of different species of one genus (e.g. Daphnia magna and Daphnia Pulex) the geometric average NOEC value for this genus was used (e.g. NOEC for Daphnia);
- Per taxonomic class (groups of genera, i.e. crustaceans: Daphnia/ Asellus/Gammarus) the lowest NOEC value or the lowest geometric average NOEC value was then used. These values were the input data for the calculations. This introduces a slight change in the definition of the maximum acceptable risk level according to the Health Council: the concentration at which a randomly drawn group of species has a higher NOEC value in 95% of the cases.
- For the aquatic environment the following groups have provisionally been used as taxonomic classes: bacteria, fungi, green algae, blue-green algae, diatoms (Streble and Krauter, 1988), protozoa, water plants, coelenterates, worms, molluscs, crustaceans, insects, fish and amphibians.
- If the NOEC value for a taxonomic class was considerably higher than that for other classes (in the case of pesticides this may concern non-target species) this value was not included in the calculations. The reason for this was that the risk limit is partly determined by the variation in sensitivity between the classes: an extremely insensitive class would then, wrongly, decrease the maximum acceptable risk level. In these cases it was acceptable to use only the NOEC values for the target species and sensitive non-target species as the sensitivity of these species has its own frequency distribution. This procedure was followed if the ratio between the 50% value and the 5% value of the estimated risk limit was a factor 500 or higher.

EPA method
In this report it was attempted to make an indicative value judgement of the ecotoxicological properties of a substance even if only one acute toxicity datum or value derived on the basis of a QSAR was available, in contrast with the advice of the Health Council. For the time being (see Okkerman et al., 1990) the modified Health Council method will be used if there are at least 4 toxicity data, obtained from chronic toxicity studies. If there are only 3 values, or only acute toxicity data or a QSAR then the

Table 2. Extrapolation factors (modified according to EPA, 1984) to determine maximum acceptable risk levels if insufficient data are available to apply the modified Health Council procedure

Required Information	Extrapolation factor
Lowest acute L(E)C50 or QSAR for acute toxicity	1000
Lowest of L(E)C50s for at least algae/crustaceans/fish	100
Lowest NOEC-value or QSAR for chronic toxicity to the most sensitive species	10

method described by the EPA (1984) will be used in principle.
The EPA method does not have a scientific basis (Health Council, 1988b). This should not, however, be considered as a great disadvantage. If there is very little data available there will be no scientific basis to use advanced mathematical methods; the inaccuracies in the estimates will be too great for this. In such a situation it will only be possible to give an indication of harmful and harmless concentrations. These indicative values can be derived by various methods. A method was selected which provides clearly indicative information: the method is based on the assumption that there is a constant and identical difference between acute and chronic toxicity, and between the sensitivity of species and ecosystems for all chemical substances: a factor of 10 is used for each step. Table 2 lists the extrapolation factors to be used.
This includes the following changes with respect to the EPA method (1984):

- A factor of 100 was applied to the lowest L(E)C50 for at least algae, crustaceans and fish, instead of the lowest of five L(E)C50 values for crustaceans and fish. The reasons for this are: (a) as primary producers algae are considered essential and (b) five L(E)C50 values are not always available.
- The lowest NOEC value is not necessarily dependent on the L(E)C50 values referred to, in contrast with the EPA method in which the determination of the NOEC should be preceded by acute toxicity tests, in principle the most sensitive species is then used for the chronic tests.
- If both acute and chronic toxicity data were available the lowest value obtained was in principle be used, after applying the extrapolation factors.
- For groups of substances with aspecific effects QSARs for chronic toxicity were prefered in cases where few or no toxicity data were available.
- The values obtained are considered as indicative or provisional maximum acceptable risk levels, unlike the EPA which considers these values as concentrations at which populations may still be adversely affected under field conditions (concern levels).

2.3.2 Ecological method

This approach is based on a mathematical model calculation concerning a greatly simplified reflection of aquatic ecosystems. This aquatic model has three trophic levels: algae, zooplankton and fish. This limitation is imposed by the knowledge of the functioning of species and groups of species in aquatic ecosystems, also providing a link to the toxicity data which are most commonly available. The algorithm was developed on the basis of existing expertise in the field of modelling aquatic ecosystems on an ad-hoc basis to support the considerations discussed in this report. A report on this is being prepared (Aldenberg and Knoop, 1990). In anticipation of this the background of this method will be outlined below. The biomass of the groups to be included in the model are expressed in mass units of carbon per volume unit of water [mg C/l]. Conversion rates (processes) are shown as daily changes in the carbon concentration. The model could be considered as consisting of three biotic compartments between which carbon is exchanged. For each trophic compartment (functional group) the nett balance of incoming and outgoing carbon flows is zero (equilibrium). The processes concerned are growth, sedimentation, respiration, mortality, grazing, defecation, predation and fishing. These are described by 11 parameters defining a particular situation (an aquatic ecosystem). Limits have been set for each parameter on the basis of practical experience and knowledge of aquatic ecosystems in the Netherlands. Realistic values will be found between these limits. Model calculations were undertaken using a large number (5000) of computer generated sets of parameters, all of which describe an aquatic ecosystem which might be found in the Netherlands. The lowest NOEC values for each functional group were entered as toxicity data. It is assumed that:

- at these concentrations (NOEC values) 1% growth reduction may still occur (NOEC = EC1, population growth) (this is a provisional arbitrary choice, the mathematics necessitate a level causing an effect greater than zero), and
- that in the concentration range concerned the growth inhibition will be linear with the concentration of the substance. This concerns the reduced population growth (vitality); mortality, sedimentation, etc. in this model are not influenced at EC1.

For each of these 5000 imaginary ecosystems the equilibrium value of the biomass of each group is calculated in the absence of the toxic substance. The addition of the toxic substance is then simulated by assuming (i) the lowest NOEC values for the individual components of the ecosystems (algae, Daphnia, fish) and (ii) the interaction between the components of the ecosystem such that the concentration is determined at which a difference of a maximum of 2% occurs in one of the biomasses, relative to the calculated reference level. The 2% value was selected such that the critical concentrations of the various substances are, on average, not much different from the 95% protection levels obtained with the modified Health Council methods. Discrepancies are interpreted as an indication of ecological interaction. Using the 5000 combinations of parameter values (ecosystems) this results in 5000 critical concentrations. The 5% and 50% values of this distribution are obtained.

The advantage of the ecological approach is firstly that field information is included in the extrapolation as well as indirect effects at the functional level. Secondly, the three most readily available NOEC values are sufficient for this method. Also, a large spread between the three NOEC values e.g. for insecticides will not result in a large spread in the final distribution of the critical concentrations, unlike extrapolation on a purely toxicological basis. In the latter case, an excessively high NOEC will result in a great spread (i.e. uncertainty of the final forecast); in the ecological model a high NOEC does not affect the spread in critical concentrations.

2.4 Maximum acceptable risk levels for sediment and soil

In principle the methods used to derive the maximum acceptable risk level for water can also be applied to soil and sediment. The ecological approach is an exception to this as it is specific to aquatic ecosystems. A similar ecological approach cannot yet be undertaken for soil given the present knowledge of soil ecosystems and the more complex interactions between soil dwelling organisms. The application of toxicological extrapolation methods to sediment and soil is also more problematic than to water. The reasons for this are as follows:

a. Exposure to substances in the sediment and the soil is more complex than in water. The following points are particularly relevant to this:
    - Uptake occurs both from pore water and from particles (soil, food). Some experiments with soil are difficult to interpret with regard to the significance of the concentrations of the substances in the soil (exposure through food, etc.). Experiments with sediments are often undertaken without the sediment, in which case it is actually the toxicity of the pore water which is measured.
    - The availability of substances added for ecotoxicological test and substances which occur naturally or were already present for other reasons may vary. It is generally assumed that the availability, and therefore the toxicity, of added substances is greater. This particularly applies to metals. In these cases the toxicity will be overestimated. It should also be noted that on the basis of the test results the effect concentration is often calculated using the added quantity, ignoring the fact that soil naturally contains a certain quantity of that metal.
    - The availability of a substance to soil organisms also depends on the distribution between water and particles. This depends on the physical-chemical characteristics of the soil. These are generally not sufficiently described in tests. In some cases even basic information such as the pH and the percentage of organic carbon (OC) and clay is not specified.
    - For studies of organic compounds it should also be noted that these generally concern static test systems and that it is implicitly assumed that the nominal added concentration will remain constant. This will lead to an underestimate of the toxicity of substances which are quickly removed from the soil by degradation or volatilization.

b. There is relatively little ecotoxicological data, most of which concerns acute effects, available on soil and sediment dwelling organisms.

In concrete terms this means that the methods discussed for water can only be applied to the soil with great reservations. There is so little ecotoxicological data available on sediment dwelling organisms that they are not further considered in this report. To enable the application of methods used for water it is necessary to unify the available soil ecotoxicological data. Conversion of the data for the different soils used to a standard soil (using standardisation by clay content and organic carbon content as used for the differentiation of the reference values for soil quality) is the most appropriate method. It is doubtful however, whether the relationships described by the *TCB* [Technical Soil Protection

Committee] between the percentage of OC and/or the percentage of clay in the soil and the presence of metals may be associated with the biological availability and toxic effects; this is not done by the *TCB*. If data for soil animals are exclusively used, the percentages of OC and clay appear to be reasonably effective descriptive parameters; this descriptive value is greatly reduced when data on micro-organisms are added. It appears that other parameters such as pH, O_2, Fe and P play a significant role. However, as there are no alternatives and despite these objections, the conversion factors for soil reference values have been used. In cases where organisms are exposed through their food it has been assumed, analogous with the method used in the *TCB* reports (Schobben et al, 1989), that this corresponds with soil containing 95% organic matter and 0% clay. When making the conversion for soils with less than 2% organic matter, it was assumed that the minimum of 2% organic matter was present. This is specified by the conversion methods for organic compounds. This may lead to a slight underestimation of the toxicity. Similarly, with soils containing over 30% organic matter this value was used as the maximum. Given these limitations in the available toxicity data for soil organisms it was decided to use several methods to derive the maximum acceptable risk level.

2.4.1 Toxicological method

The method recommended by the Health Council (1988b) and modification 1 were used if chronic toxicity data (NOEC values) for at least 4 different species of soil animals and/or plants were available. Modification 2 was only used if the above mentioned conditions were met. The soil organisms were grouped according to the classification of annex D (plants, Collembola, Isopoda, Acari, Oligochaeta and Mollusca). The results of this approach were assessed using the available toxicity data for micro-organisms and enzyme activity. As these data refer to functional parameters they cannot as such be included in the methods according to Van Straalen and Denneman (1989) and the modifications thereof. As these methods could only be used for a few substances the modified EPA method (2.3.1) was used for all substances for which toxicity data for soil organisms were available. If less than 3 acute toxicity data were available an extrapolation factor of 1000 was applied to the lowest L(E)C50 when deriving the maximum acceptable risk level. The lowest L(E)C50 was divided by 100 if data was available for at least 3 groups of organisms: micro-organisms, enzyme activity (although not an organism this parameter was given a separate place, partly on the basis of its specific character), earthworms, arthropods or plants. A factor of 10 was applied to the lowest NOEC.

2.4.2 Indirect method

It has been suggested by the USEPA to derive quality objectives for sediments from the objectives for water with the equilibrium partition method (EPA, 1989; Shea, 1988). This EP method is based on the assumption that toxic effects are largely caused by exposure to pore water and hardly or not at all by uptake from particles. Those opposing the EP method stress that this assumption is not always valid (Landrum and Robbins, 1989). In this report the EP method is used to derive maximum acceptable risk levels for sediment from the maximum acceptable risk levels for water.

For soil the maximum acceptable risk levels calculated with the EP method are compared with the values obtained by the toxicological approach. Only when toxicological data are not available will the maximum acceptable risk level for soil be set to the level calculated with the EP method. The equilibrium partition method is based on the assumption that there is a thermodynamical equilibrium between the concentration of a substance in water (surface water or pore water) and the concentration in the non-aqueous media in contact with it (suspended particles, sediment, soil, organisms). It is generally assumed that sorption is a reversible equilibrium phenomenon that can be characterised by a sorption isotherm. Sorption isotherms may take various mathematical forms. It is generally assumed however, that the most basic isotherm expression may be used: the linear sortion isotherm. If these, generally implicit, conditions have been fulfilled the distribution of a substance over the various media can be described with an equilibrium constant: the partition constant. Using the equilibrium partition concept the concentration of a substance in the soil and sediment can be calculated if the concentration in the pore water is known.
The limitations of this method are twofold:

a. The implicit assumptions are not always fulfilled. It is feasible that the relationship between the concentration of a substance in the water phase and in the solid phase cannot be described by a simple linear sorption isotherm. This obviously also applies if the existence of an equilibrium may not be assumed.
Even if there is an equilibrium the relationship between the concentrations in water and particles is not always straightforward. For example, this applies if the solubility of metal salts is exceeded. This is assumed to occur in anaerobic sediments where metals may be precipitated as sulphides with a very low solubility. In that case there will not be a direct relationship between the concentrations in the water phase and in the particles: a wide range of concentrations may occur in the sediment at a given concentration in the water phase.

b. A numerical approach to the partition coefficients is not always possible. It would be desirable to have a method to express the partition coefficient of any given substance as a function of the physical-chemical properties of that substance and the characteristics of the environment. Such a universal method is not available.

Hydrophobic organic substances
For the group of hydrophobic organic substances there is the general rule that the partition coefficient K_p can be described by the octanol-water partition coefficient K_{ow} of the substance and the organic carbon content f_{oc} of the soil or sediment. The following simple formula is preferred for general purposes:

$$K_p = f_{oc} * K_{oc} = 0.5 * f_{oc} * K_{ow}$$

It is generally assumed that organic anions are poorly adsorbed relative to their protonated, uncharged form. The reason for this is that ions are far less hydrophobic than their uncharged equivalents. To estimate the partition coefficient the product of the K_{ow} of the non-dissociated substance and the fraction of the non-dissociated substance is used:

$$K_p = f_{oc} * K_{oc} = 0.5 * f_{oc} * K_{ow}\ fr_{nd}$$

The fraction of the non-dissociated substance can be calculated using the dissociation constant K_a and the pH.

A similar argument applies to organic cations. Again it is assumed that the ionic form is less hydrophobic and less strongly adsorbed than the uncharged form. However, this argument is not as strong, as specific sorption of cations should not be ignored. Information about this is generally not available.

Metals

Considerable research has been undertaken on metals. Recently a model has been proposed to generally describe sorption equilibria for metals, in analogy with the sorption model for hydrophobic organic substances. This three-phase model (DiToro et al., 1987; Shea, 1988), at present hardly tested, reflects the general assumption that iron and manganese oxides, as well as organic matter, provide the major sorptive surfaces of sediment particles. The extent to which a metal is adsorbed by sediment or soil can be expressed as a function of the contents of these sorbents. The pH greatly influences the extent of sorption as it determines the surface condition (degree of protonation, surface charge) of the sorption surfaces. This explains the differences in partition coefficients for a given metal between different sediments and soils. Metals which occur as anionic oxo-compounds (this is the dominant form of arsenic, chromium partly occurs in this form) are considered to be largely adsorbed to the positively charged surfaces. As there are no tested general rules the numerical values for partition coefficients of metals to sediment will have to be based on experimental findings, which in principle only apply to the substance and soil type investigated.

A complication occurs when setting numerical values for partition coefficients as they should apply to all imaginable environmental conditions, including those to be expected in the future. This is a consequence of the multi-functionality principle. For example, if an aquatic sediment becomes terrestrial soil, the partition coefficient will generally be reduced due to changes in the composition of the solid phase (pH, organic carbon content, etc.). In anticipation of the toxic effects of the presently sediment-associated substances on the terrestrial organisms after the sediment has become soil, the expected low partition coefficient will have to be considered.

As metals are not degraded the quality objectives for metals should be set in anticipation of the future situation. In future the concentrations in the pore water may be greater than at present and the toxic effects may increase.

This does not apply to organic substances as it is expected that the degradation of organic substances will take place at a higher rate than the weathering of the sediment.

Partition coefficients

The experimental partition coefficients listed in table 4 were used to derive the maximum acceptable risk levels for organic substances in sediment and soil from those for water through the equilibrium partition. These refer to standard soil and standard sediment with an organic carbon content f_{oc} of 0.05 and pH 6. The dissociation at this pH value of acidic and basic compounds (indicated in table 3) was included. The chlorophenols were combined to 1, 2, 3, 4, 5-chloro products by mathematically averaging the individual components. Strictly speaking the numbers related to metals are not equilibrium partition coefficients, rather they are numerical

Table 3 Partition coefficients for acidic and basic organic compounds, as a basis for deriving maximum acceptable risk levels using the equilibrium partition method; CP = chlorophenol.

	log K_{ow}[1]	pK_a[1]	fr_{nd} pH=6	Kp (l.kg^{-1})	
				Calc.[2]	Exper.[1]
Atrazin	2.60	12.3	0.00	0.0	6.9
2-CP	2.17	8.48			
3-CP	2.50	9.37			6-12
4-CP	2.60	8.97			
mono-CP (mean)	2.42	8.94	1.00	7	9
2,3-diCP	3.19	7.58			
2,4-diCP	2.75	7.85			440
2,5-diCP	3.20	7.59			
2,6-diCP	2.80	6.89			20
3,4-diCP	3.37	8.62			15-30
3,5-diCP	3.52	8.27			
di-CP (mean)	3.14	7.80	0.98	34	22
2,3,4-triCP	4.07	7.04			
2,3,5-triCP	4.21	6.75			
2,3,6-triCP	3.88	6.06			
2,4,5-triCP	3.72	7.04			43-78
2,4,6-triCP	3.69	6.35			15
3,4,5-triCP	4.39	7.73			24
tri-CP (mean)	3.99	6.83	0.87	214	40
2,3,4,5-tetraCP	4.95	6.22			
2,3,4,6-tetraCP	4.10	5.22			24/85-95
2,3,5,6-tetraCP	4.90	5.24			140
tetra-CP (mean)	4.65	5.56	0.27	297	86
PCP	4.74	4.75	0.05	73	20/120-125
PCP (mean)					88

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[1] Sources: RIVM-ACT, 1989 (atrazin); Slooff et al., 1989d; Wegman and Van den Broek, 1983; Van Gestel and Ma, 1988 (chlorophenols)

[2] $K_p = 0.5*f_{oc}*K_{ow}*fr_{nd}$ where $f_{oc} = 0.05$

values derived from routine measurements of the metal content of surface water, before and after filtration, which do not necessarily relate to the equilibrium. A calculated value was used if experimental partition coefficients were not available.

2.5 Coordination

2.5.1 Desired method

The starting point for the coordination of quality objectives will always be the progressive effects of the presence of a substance from one compartment of the environment to another and the progressive effect of these concentrations in the environment on product quality. This can be further defined in two steps:

a. Listing all relevant pathways through which the progressive effects may occur ("protection paths")

Table 4 Partition coefficients for standard soil and standard sediment, as a basis to derive the maximum acceptable risk levels for soil and sediment using the equilibrium partition method. The values shown for atrazin and chlorophenols (CP) are the calculated[1] values from table 3.

	log K_{ow}[1]	K_p (l.kg^{-1}) Calculated[2]	Experimental[1,3]
Cadmium			85000
Zinc			75000
Nickel			5300
Lead			430000
Mercury			110000
Chromium			190000
Copper			35000
Arsenic			6500
Tributyl Tinoxide (TBTO)	3.85	177	1000[4]
Atrazin	2.60	0.0	6.9
Lindane	3.75	141	250
Azinphos-methyl	2.29	5	86
Diazinon	3.95	223	80
Malathion	2.89	19	400
Parathion-ethyl	3.81	161	880
Dieldrin	6.2	39622	37500
Naphthalene	3.5	79	129
Anthracene	4.5	791	2630
Phenanthrene	4.5	791	2291
Fluoranthene	5.1	3147	
Benzo[a]anthracene	5.6	9953	
Chrysene	5.6	9953	
Benzo[k]fluoranthene	6.0	25000	
Benzo[a]pyrene	6.0	25000	
Benzo[ghi]perylene	6.6	99527	
Indeno[1,2,3-cd]pyrene	6.4	62797	
mono-CP (mean)	2.42	7	9
di-CP (mean)	3.14	34	22
tri-CP (mean)	3.99	214	40
tetra-CP (mean)	4.65	297	86
PCP	4.74	73	88

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[1] Sources: RIVM-ACT, 1989 (pesticides); Slooff et al., 1989a,d, Van Gestel and Ma, 1988; Wegman and Van den Broek, 1983 (chlorophenols)

[2] $K_p = 0.5*f_{oc}*K_{ow}*fr_{nd}$ where $f_{oc} = 0.05$

[3] Metals: derived from the values for suspended particles in surface water in the Netherlands as reported by DBW/RIZA (1989), divided by a factor of 1.5; PAK: Sabljic (1984)

[4] Estimate by the authors of this report.

b. Quantitative formulation of the relationships between the concentrations in the compartments of origin and the concentrations in the targets ("progressive effect factors").

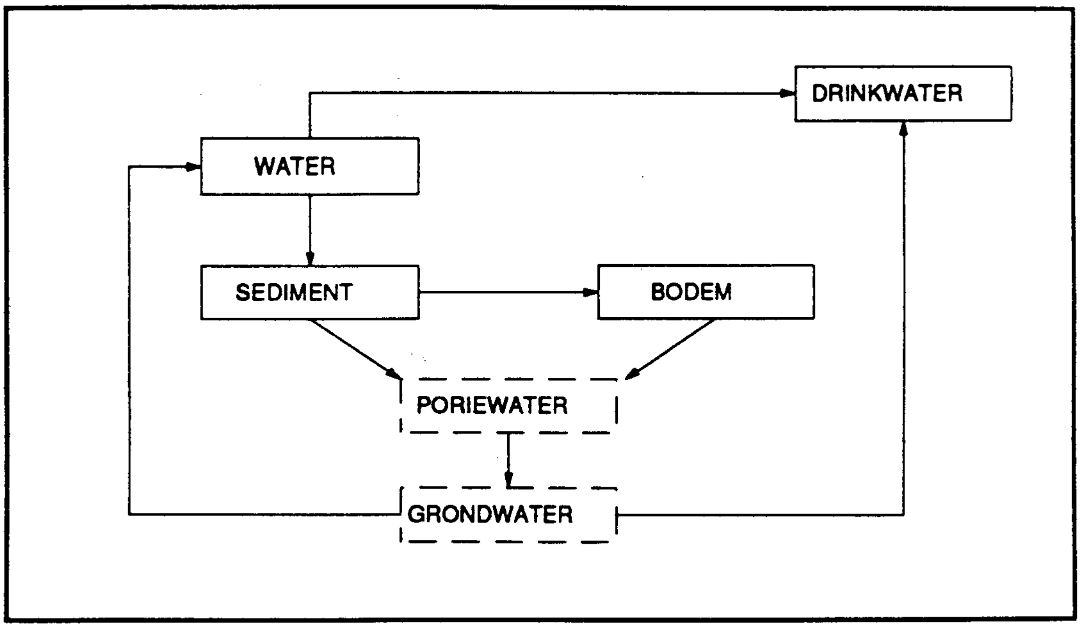

Figure 2 Schematic representation of the considered protection paths.

Protection paths

Figure 2 shows how the progressive effects of the concentrations may occur. This diagram can be used to describe the following protection paths:

i. **Starting from surface water**
   - Protection of aquatic organisms (*protection path: direct*). The water should be sufficiently clean to offer good opportunities to the aquatic organisms living in it.
   - Protection of sediment organisms (*protection path: water → sediment*). The water should be sufficiently clean, so that the sediment is clean enough for sediment dwelling organisms.
   - Protection of soil organisms (*protection path: water → soil*). The water should be sufficiently clean to be used as irrigation water for agricultural land.
   - Protection of soil organisms (*protection path: water → sediment → soil*). The water should be sufficiently clean so that the sediment, after reclaiming, will be clean enough for soil organisms.
   - Protection of aquatic organisms (*protection path: water → soil → pore water → groundwater → water*). The water should be sufficiently clean so that water flowing from dry soil formed from the underlying sediment is sufficiently clean for aquatic organisms.
   - Protection of the role of surface water in the supply of drinking water (*protection path: water → drinking water*). The water should be sufficiently clean to be potable without treatment.
   - Protection of the role of groundwater in the supply of drinking water (*protection path: water → sediment → soil → pore water → groundwater → drinking water*). The water should be sufficiently clean so that the water from the soil formed from the underlying sediment would be potable without treatment.

ii. Starting from sediment

- Protection of sediment dwelling organisms (*protection path: direct*). The water should be clean enough to offer good opportunities to the sediment dwelling organisms.
- Protection of aquatic organisms (*protection path: sediment → water*). The sediment should be so clean that the water above it is clean enough for aquatic organisms.
- Protection of soil organisms (*protection path: sediment → soil*). The sediment should be so clean that after reclamation it would be clean enough for soil dwelling organisms.
- Protection of aquatic organisms (*protection path: sediment → soil → pore water → groundwater → water*). The sediment should be so clean that water emerging from soil formed from underlying sediment would be clean enough for aquatic organisms.
- Protection of the role of groundwater in the supply of drinking water (*protection path: sediment → soil → pore water → groundwater → drinking water*). The sediment should be so clean that the water above it would be potable without treatment.
- Protection of the role of surface water in the supply of drinking water (*protection path: sediment → soil → pore water → groundwater → drinking water*). The sediment should be so clean that the water emerging from the dry soil which would be formed from it after reclaiming would be potable without treatment.

iii. Starting from soil

- Protection of soil organisms (*protection path: direct*). The soil should be sufficiently clean to provide good opportunities to organisms in and on the soil.
- Protection of aquatic organisms (*protection path: soil → pore water → groundwater → water*). The soil should be so clean that water emerging from it is clean enough for aquatic organisms.
- Protection of the role of surface water in the supply of drinking water (*protection path: soil → pore water → groundwater → water → drinking water*). The soil should be so clean that surface water emerging from it would be potable without treatment.
- Protection of the role of groundwater in the supply of drinking water (*protection path: soil → pore water → groundwater → drinking water*). The soil should be so clean that its groundwater would be potable without treatment.

Progression factors

Each of the protection paths referred to above can be divided into a number of steps. The progression factor for the whole protection path is the cumulation of these steps. Each of the steps can be represented by a step factor; the overall progression factor is the product of these step factors. The steps can be classified in two groups:

- Treatment factors. For the progression of surface water and groundwater to drinking water.
- Concentration ratios. For the progression of surface water to sediment, from pore water to groundwater and from pore water to surface water.

Treatment factors

If the required product quality of the drinking water sets the standard for the quality objectives for surface water and soil then an estimate will have to be made for each substance of the extent to which that substance will be removed by "simple treatment". There is no general method to derive treatment factors from a substance's properties. Other forms of progression of environmental quality to product quality which were not included in the diagram such as agricultural crops and fish could be considered in a similar way.

Concentration ratios
The ratios between the concentrations of the substances in different compartments of the environment are controlled by the relative rates at which substances are transported between the compartments and the rates at which substances are degraded in the different compartments. The overall results of the different processes can be calculated with multi-compartment models. The required concentration ratios are the result of such calculations. The process rates, and therefore the concentration ratios between compartments of the environment are basically a function of:

- the substance: substances behave in different ways
- the location: environmental characteristics which determine the effects of a substance vary, depending on the location
- the time: the environment needs time to develop to a stable situation in which the concentration ratios no longer change. This may take many years, particularly for soil and sediment.

The consequences of the above are that the progression factors to be defined for each substance are also location and time dependent. Coordination is generally only valid if the concentration ratios can be quantitatively related to environmental parameters which can easily be measured. Generally, this will not be the case. Only when there are stable concentration ratios which have developed to a stable situation in which there is also an equilibrium between the environmental compartments (equilibrium is the exception rather than the rule) is it possible to associate numerical values with the progression factors (EP method). The limitations to the application of the equilibrium compartment method were discussed in section 2.4.2.
There are perspectives for the coordination of desirable levels. The reason for this is that it is feasible that equilibrium will be reached within the period required to obtain the desirable levels. Additionally relatively large uncertainty margins for the compartment coefficients will suffice for the desirable levels.

2.5.2 Practical method

As this report is limited to the quantitative definition of maximum acceptable risk levels the coordination of quality objectives for the different environmental compartments is not yet relevant. However, when quality objectives for water and soil are quantitatively defined it will have to be decided how to obtain the coordination between these. In the light of the considerations of the previous section it can be asserted that assuming the existence of an equilibrium between particles and water or pore water is presently the only practical basis for coordination, however uncertain and limited for application it is. Coordination could take place by testing afterwards. After the quality objectives have been determined for the various compartments the partition coefficient can be used to check if the ratio of these represents an equilibrium situation. If not then it could be considered to use the most critical of the objectives as a guide.

The following possibilities should be anticipated:

a. **Quality objectives for water, sediment and soil are all derived from the maximum acceptable risk level for water by applying the equilibrium partitioning method. In that case the quality objectives are coordinated by the method to set them.**
b. **Quality objectives for water, sediment and soil are derived from the maximum acceptable risk levels which have been derived separately for the compartments from toxicity data. In this case it is possible that the quality objectives do not match. The method suggested above using the assumption of an equilibrium might then provide a solution.**
c. **This also applies when the quality objectives are based on the functions of the compartments to be protected. This applies in particular to the role of drinking water production of groundwater and surface water.**
d. **Quality objectives for water, sediment and soil are derived from concentrations observed in the field (e.g. desirable levels from background concentrations, maximum tolerable levels from present concentrations). In that case it may be expected that the quality objectives will match reasonably well.**

2.6 Summary

Maximum acceptable risk levels

For water the maximum acceptable risk levels were primarily derived from the available chronic toxicity data using the method of Van Straalen and Denneman (1989), recommended by the Health Council (1988b). Given the comments made on this method two modifications were made to implement a different statistical method and to group data by taxonomic classes. The modified EPA method was used for substances for which insufficient toxicity data was available.

In addition to these toxicological methods an ecological method was also used. Starting point for this ecological method was the predicted effect on the model-ecosystem algae/Daphnia/fish. Final proposals for maximum acceptable risk levels were made upon comparing the results of these different methods.

For soil only the toxicological approach was taken to determine the maximum acceptable risk levels. For all chemicals maximum acceptable risk levels were also derived indirectly from the values obtained for water using the equilibrium partitioning method (partition coefficients). Also in this case the maximum acceptable risk levels obtained by using the different methods were compared to arrive at a final proposal.

No toxicity data were available for sediment. The equilibrium partitioning method is the only method to derive the maximum acceptable risk for sediment.

Quality objectives

Quality objectives (desirable levels and maximum tolerable levels) are not derived in this report. This report only indicates the various options from which a selection can be made on policy grounds. The premise defined in the report "Premises for Risk Management" (DGM, 1989a), i.e. that desirable levels should be set to negligible risk levels and therefore to 1/100 of the maximum acceptable risk level, is also used in this report. For substances which occur naturally, for which the negligible risks levels are often lower than the background levels, it might be considered basing the final desirable levels on these background concentrations. Desirable levels are beyond the scope of this report. The coordination of quality objectives between water, sediment and soil can be attained by assessing the results using the partition coefficients. In the event that quality objectives for the different compartments are all directly or indirectly based on the maximum acceptable risk level for water, coordination will be attained as well.

3 CALCULATIONS AND COMPARISONS

3.1 Maximum acceptable risk levels

3.1.1 Water

Basic information was obtained from the Integrated Criteria Documents on cadmium (Ros and Slooff, 1987), copper and HCH (Slooff et al., 1987; Slooff and Matthijsen, 1987), PAH, chromium and arsenic (Slooff et al., 1989a, b, c) and chlorophenols (Slooff et al., 1989d); additional literature studies were made for the other substances (see annex B). When assessing toxicity data for which only the upper limits of the NOECs were given ("<"), half of those upper limits were used as the NOEC values to be adopted.

In accordance with the (modified) Health Council (1988b) procedure it was not possible to calculate a risk limit for the chlorophenols and most PAH compounds due to a lack of data. Table 5 lists the results of the calculations according to (a) the Health Council advice, (b) the statistical modifications and (c) as (b) however using grouped NOEC values. The last data is included in annex A.
The numerical differences between the derived risk levels were generally small. The difference between the values obtained with the Health Council procedure and those obtained with the statistical changes to this method (Health Council modification 1) on average amounted to a factor of 3.1 (minimum 1, maximum 9.2). The use of the original method consistently resulted in lower values. This difference is similar if, in addition to a statistical modification, other input data (Health Council modification 2: grouped NOEC values instead of individual NOEC values) are used (a factor of 4.8; minimum 0.1, maximum 22). This could partly be attributed to differences in the algorithms used. The original method provided a statement with a reliability of 95% about the 95% protection level; the modified method provided a 50% reliable statement about the 95% protection level.
When Health Council modifications 1 and 2 were used, a higher value was obtained for the ratio 50%-value : 5%-value for malathion and dieldrin (250) respectively TBTO (2,750). For malathion and TBTO this discrepancy was mainly due to the great difference in sensitivity of the species (factor > 100). For dieldrin this discrepancy could be attributed to the limited number of NOEC values available for this substance.

Table 5 shows that the uncertainty increases as the number of input data decreases. This is also illustrated in figure 3.

Therefore a choice had to be made between:
- relatively accurately estimated risk limits for species which may not have been randomly selected, whereby it is likely that these values are biased, e.g. towards one taxonomic class;
- relatively less accurately estimated risk limits which aim to protect all groups of species.
  For example the uncertainty (r, expressed as the mean ratio of 50% and 5% values) for the top 12 substances in table 5, as calculated from all NOEC values is approximately 10 (2 - 48). On the basis of NOEC values grouped by taxonomic/functional class the uncertainty is approximately 300 (11 - 1,750). It should be noted that, incorrectly, all NOEC values were used in the first method, instead of one NOEC value per species,

Table 5 Comparison of possible maximum acceptable risk levels ($\mu g.l^{-1}$) obtained by applying the extrapolation method of the Health Council (1988b) and modifications thereof on one data set of aquatic toxicity data. Where applicable the number of input data (n) and the ratio 50%/5% (r) have been included in the table.

Substance	HC method	HC-modification 1			HC-modification 2		
		5%	50%	(n/r)	5%	50%	(n/r)
Cadmium	0.09	0.023	0.09	(41/4)	0.0044	0.16	(9/36)
Zinc	2.0 *	0.83	3.6	(37/4)	0.013	1.6	(9/123)
Nickel	0.31	0.10	1.2	(20/12)	0.022	1.4	(6/64)
Lead	2.3	1.1	3.3	(33/3)	0.18	2.0	(10/11)
Mercury	0.0028	0.001	0.010	(19/9)	0.0001	0.010	(6/100)
Chromium	8.2 *	4.5	9.2	(68/2)	0.12	2.0	(11/17)
Copper	3.3	2.2	3.4	(41/2)	0.22	1.7	(6/77)
Arsenic	16 *	16	51	(27/3)	0.70	8.6	(10/12)
TBTO	0.006	0.0005	0.024	(7/48)	***	0.011	(4/2750)
Atrazin	1.5	0.70	4.5	(11/6)	0.0032	0.75	(4/234)
Lindane	0.21	0.028	0.50	(10/18)	0.0046	0.55	(7/120)
PCP	1.2	0.59	2.2	(26/4)	0.11	2.0	(10/18)
Azinphos-methyl	0.033	0.01	0.07	(10/7)	0.01	0.069	**
Diazinon	0.0053	0.0013	0.023	(11/18)	0.011	0.087	**
Malathion	0.0002	***	0.0012	(13/250)	***	0.0043	**
Parathion-ethyl	0.0005	0.0001	0.0025	(13/25)	0.0001	0.0046	**
Dieldrin	0.0035	***	0.045	(4/250)	***	0.045	**
Naphthalene	14	3.5	40	(7/11)			
Phenanthrene	0.8						

* For these substances the methods of Van Straalen and Denneman (1989) and of Slooff et al. (1986) diverge by more than a factor of 10 (see Health Council, 1988b); the differences are 158 for chromium, 32 for arsenic and 19 for zinc. It is likely that in all these cases the differences are due to one extremely low NOEC value.

** For these pesticides only the NOEC values for aquatic target organisms and sensitive non-target organisms were used; the data for insensitive groups of species (bacteria, algae and protozoa) are not included here. Annex C lists the lowest NOEC values.

*** Values < 0.0001.

while too many species may have been grouped together in the second method, due to a lack of biological knowledge. In other words, in the first case too much data was entered while too little data was entered in the second case. This resulted in an overestimate of the differences. On the basis of this information it was estimated that the introduction of one NOEC value per species would decrease the number of input data by approx. 5% - 25%. If the classification in groups of species was based on careful analysis (considering ecological function, life, structure, etc.) the number of groups would be increased by at least 50%. This would reduce the difference in uncertainty from a factor of 30 to a factor of approximately 10. It should therefore be concluded that the reliability of Health Council modification 1 is probably estimated too high by this method and the reliability of Health

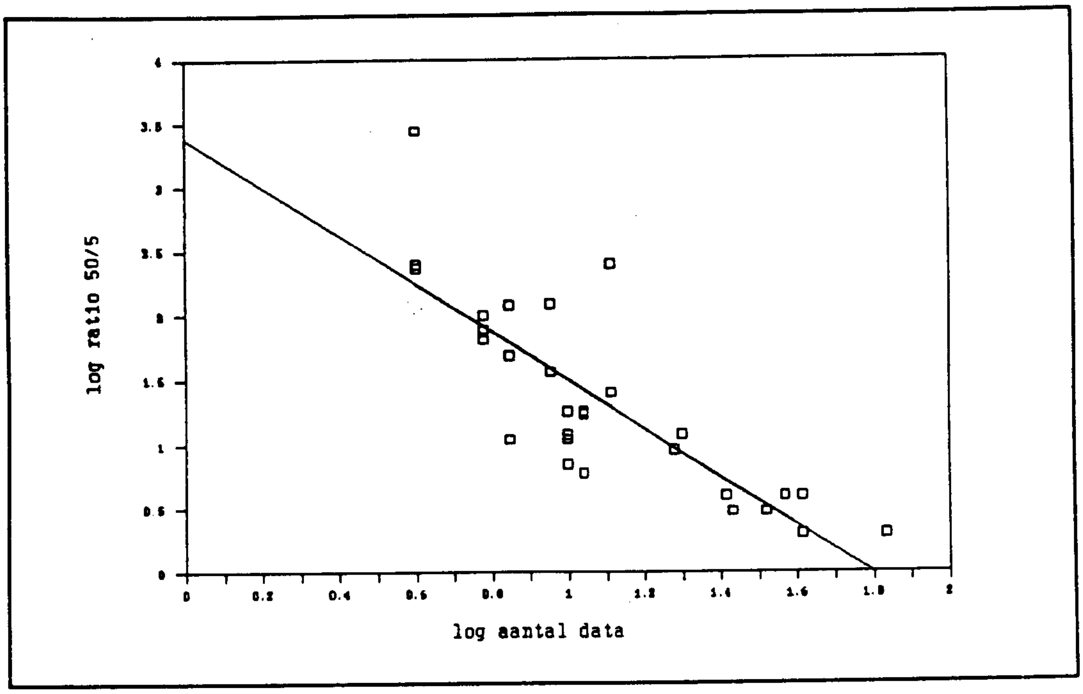

Figure 3 Relation between the number of input data in the modified Health Council method and the uncertainty in the estimate of the risk limit: $\log r = -1.88 \log n + 3.38$; $r = 0.82$

Council modification 2 too low. Further research will be needed to improve reliability.

Table 6 lists the indicative maximum acceptable risk levels (MAR values) obtained with the modified EPA procedure (table 2). This procedure was applied to all substances. For metals and pesticides the EPA method was only applied to the available toxicity data. For the chlorophenols the EPA method was applied to available acute and/or chronic toxicity data. Subsequently, assuming that toxicity depends on the extent of chlorination, the derived risk limit was adapted such that the same value was obtained for each group of chlorophenols.

For the PAH, laboratory toxicity data (table 6) were combined with recent data about QSARs for chronic toxicity (table 7). De Wolf et al. (1988) derived a QSAR for the water flea:

$$\log \text{NOEC (mmol/l)} = -0.99 \log K + 4.16 \ (r=0.97;\ s=0.50;\ n=10)$$

Van Leeuwen et al. (1990) derived a QSAR for fish:

$$\log \text{NOEC (mmol/l)} = -0.90 \log K + 3.80 \ (r=0.96;\ s=0.33;\ n=30)$$

It is generally accepted that this type of QSAR is reliable up to a log K_{ow} value of 5 to 6. Table 7 lists the NOEC values determined on the basis of the above QSARs for water fleas and fish, as well as the maximum acceptable risk levels derived there from.
The NOEC values in table 7, calculated with the QSARs, do not necessarily represent the lowest NOEC values observed. A comparison with the NOEC values obtained in laboratory tests (table 6) showed that for substances for which NOEC values are available the lowest NOEC values observed were a

Table 6 Indicative maximum acceptable risk levels MAR ($\mu g.l^{-1}$) derived according to the modified EPA method (see text) and adapted on the basis of the assumed analogy between congeners.

Substance	Acute data		Chronic data		MAR	
	genera	lowest L(E)C50	genera	lowest NOEC	EPA	Adapted
Metals						
Cadmium			27 (a,b,w, p,mo,c,f,am)	0.15	0.015	0.015
Zinc			19 (b,a,d, p,mo,c,f)	0.75	0.075	0.075
Nickel			15 (b,a,p, c,f)	2.5	0.25	0.25
Lead			23 (b,a,d, m,p,mo,c,i,f)	10	1.0	1.0
Mercury			14 (b,a,p, c,f)	0.002	0.0002	0.0002
Chromium			32 (a,d,m, p,co,mo,c,i,f,am)	0.35	0.035	0.035
Copper			27 (a,mo,c, i,f)	3	0.3	0.3
Arsenic			20 (b,a,d, m,p,mo,c,i,f)	10	1.0	1.0
Pesticides						
TBTO			6 (a,mo,c, f)	0.16	0.016	0.016
Atrazin			9 (a,c,f)	1.5	0.15	0.15
Lindane			10 (a,mo,c, i,f,am)	2.2	0.22	0.22
Azinphos-methyl			10 (c,i,f)	0.1	0.01	0.01
Diazinon			9 (a,c,i,f)	0.2	0.02	0.02
Malathion			11 (a,p,c, i,f)	0.008	0.0008	0.0008
Parathion-ethyl			11 (b,a,c, i,f)	0.002	0.0002	0.0002
Dieldrin			4 (mo,c,f)	0.12	0.012	0.012
Chlorophenols						
2-CP	7 (a,p,c,f)	2600	1 (c)	500	26	25
3-CP	2 (a,f*)	5500			5.5	25
4-CP	5 (a,c,f)	2500	1 (c)	630	25	25
2,3-diCP	3 (a,c,f*)	3100			31	15
2,4-diCP	7 (a,p,c,f)	1400	2 (c,f)	290	14	15
2,5-diCP	1 (f*)	2800			2.8	15
2,6-diCP	4 (a,c,f)	3400			34	15
3,4-diCP	2 (a,f*)	1100			1.1	15
3,5-diCP	2 (a,f*)	1800			1.8	15
2,3,4-triCP	2 (a,f*)	1200			1.2	2.5
2,3,5-triCP	1 (f*)	600			0.6	2.5
2,3,6-triCP	1 (f*)	2900			2.9	2.5

Table 6 Continued

Substance	Acute data		Chronic data		MAR	
	genera	lowest L(E)C50	genera	lowest NOEC	EPA	Adapted
2,4,5-triCP	3 (c,f)	450			0.45	2.5
2,4,6-triCP	7 (a,p,c,f)	320			3.2	2.5
3,4,5-triCP	1 (f**)	2400			2.4	2.5
2,3,4,5-tetraCP	2 (p,f)	410			0.41	1
2,3,4,6-tetraCP	5 (a,c,f)	140			1.4	1
2,3,5,6-tetraCP	3 (p,c,f)	170			0.17	1
PCP			13 (b,a,m, co,mo,c,i,f,am)	3.2	0.32	0.32
PAH						
naphthalene	19 (a,p,mo, c,i,f,am)	1600	5 (c,f)	40	4	10#
anthracene	7 (a,c,i, f,am)	1			0.01	2#
phenanthrene	12 (a,p,w , c,i,f,am)	500	3 (a,c,f)	30	3	2#
fluoranthene	8 (a,c,i, f,am)	4	1 (a)	50	0.04	0.5#
benz[a]anthr.	3 (a,c)	10	1 (a)	3	0.01	0.2#
chrysene	3 (c,i,am)	1700	1 (a)	1	0.1	0.2#
benzo[a]pyrene	5 (a,c,i, f,am)	2			0.02	0.1#
benz[k]fluoranth.						0.1#
benzo[ghi]peryl.						0.02#
indeno[1,2,3-c,d]pyrene						0.04#

* LC50 48 h; report incomplete
** LC50 1 wk
a: algae; b: bacteria; d: diatoms; m: macrophytes; co: coelanterates;
p: protozoa; mo: molluscs; w: worms; c: crustaceans; i: insects
f: fish; am: amphibians
\# QSAR: see text and table 7

factor of 3 to 10 lower than the values calculated with the QSAR. The QSARs were selected as the basis for determining the maximum acceptable risk levels. Given the lower NOEC values observed in practice the MARs derived from the QSARs were divided by 5 (see table 6).

Table 8 shows the results of the application of the ecological model, using as the criterion a deviation of 2% relative to the steady state when deriving the risk limit (the 50% value). The ratio 50%/5% (r) was also included as a measure of the uncertainty of the estimates. The statistical certainty with which the risk limit was estimated is quite high (r is approximately 10) and reasonably constant (minimum 8; maximum 12).

Table 7 Indicative maximum acceptable risk levels MAR ($\mu g.l^{-1}$) for PAH, derived on the basis of QSARs for chronic toxicity.

Substance	Log Kow	NOEC		MAR
		Water flea	Fish	
Naphthalene	3.5	634	572	57
Anthracene	4.5	90	100	9
Phenanthrene	4.5	90	100	9
Fluoranthene	5.1	26	33	2.6
Benz[a]anthracene	5.6	9.4	13	0.9
Chrysene	5.6	9.4	13	0.9
Benzo[a]pyrene	6.0	4.2	6.3	0.4
Benzo[k]fluoranthene	6.0	4.2	6.3	0.4
Benzo[ghi]perylene	6.6	1.2	2.0	0.1
Indeno[123cd]pyrene	6.4	1.8	3.0	0.2

Table 8 Indicative maximum acceptable risk levels ($\mu g.l^{-1}$), obtained from an ecological model based on the interactions between algae, zooplankton and fish

Substance	5%	50%	r
Cadmium	0.017	0.16	9
Zinc	0.13	1.5	12
Nickel	0.072	0.83	12
Lead	0.18	2.1	12
Mercury	0.0015	0.013	9
Chromium	0.010	0.12	12
Copper	0.092	1.0	11
Arsenic	0.27	3.1	11
TBTO	0.0072	0.072	10
Atrazin	0.044	0.51	12
Lindane	0.19	1.9	10
Diazinon	0.018	0.15	8
Malathion	0.0008	0.0064	8
Parathion-ethyl	0.0019	0.016	8
PCP	0.38	4.4	12
Phenanthrene	1.1	11	10

Table 9 shows the results of the application of the various extrapolation methods on toxicity data for the aquatic environment. These values were obtained by:

a. applying the original procedure according to the Health Council (HC);
b. as a., with the proposed statistical modification (HC-modl);
c. as b., with the proposed modification of the input data (HC-mod2);
d. application of the modified EPA method, possibly adapted on the basis of an assumed analogy in toxicity in group of chlorophenols (EPA);
e. application of the ecological method (ECO);
f. lowest NOEC for all species;

Table 9 Comparison of possible maximum acceptable risk levels for aquatic ecosystems obtained by applying the various extrapolation methods; a proposal for a definitive risk level (MAR) ($\mu g.l^{-1}$).

Substance	HC	HC-mod1	HC-mod2	EPA	lowest NOEC	ECO	"DBW/RIZA"a procedure	Ecotoxicological value&	Recommended MAR	Derivation procedure
Cadmium	0.09	0.09	0.16	0.015	0.15	0.16	0.15	0.025	0.16	HC-mod2
Zinc	2.0 *	3.6	1.6	0.075	0.75	1.5	5	6.5	1.6	HC-mod2
Nickel	0.31	1.2	1.4	0.25	2.5	0.83	2.5 #	7.5	1.4	HC-mod2
Lead	2.3	3.3	2.0	1.0	10	2.1	10	1.3	2.0	HC-mod2
Mercury	0.0028	0.01	0.01	0.0002	0.002	0.013	0.002 #	0.005	0.01	HC-mod2
Chromium	8.2 *	9.2	2.0	0.035	0.35	0.12	5	2.5	2.0	HC-mod2
Copper	3.3	3.4	1.7	0.3	3	1.0	3	1.3	1.7	HC-mod2
Arsenic	16 *	51	8.6	1.0	10	3.1	10	12.5	8.6	HC-mod2
TBTO	0.006	0.024	0.011	0.016	0.16	0.072	0.16	0.003	0.011	HC-mod2
Atrazin	1.5	4.5	0.75	0.15	1.5	0.51	1.5 #	0.075	0.75	HC-mod2
Lindane	0.21	0.50	0.55	0.22	2.2	1.9	2.2	0.099	0.55	HC-mod2
PCP	1.2	2.2	2.0	0.32	3.2	4.4	3.2	0.4	2.0	HC-mod2
Azinphos-methyl	0.033	0.07	0.069	0.01	0.1		0.1 #	0.015	0.069	HC-mod2
Diazinon	0.005	0.023	0.087	0.02	0.2	0.15	0.2 #	0.03	0.087	HC-mod2
Malathion	0.0002	0.0012	0.0043	0.0008	0.008	0.0064	0.008 #	0.02	0.0043	HC-mod2
Parathion-ethyl	0.0005	0.0025	0.0046	0.0002	0.002	0.016	0.002 #	0.02	0.0046	HC-mod2
Dieldrin	0.0035	0.045	0.045	0.012	0.12		0.12 #	0.0005	0.045	HC-mod2
mono-CP				25	500			9.0	25	EPA
di-CP				15	290			0.08	15	EPA
tri-CP				2.5				10	2.5	EPA
tetra-CP				1	1				1	EPA
Naphthalene	14	40		10	40		40 #		10	EPA
Anthracene				2				0.031	2	EPA
Phenanthrene	0.8			2	30	11	30 #	0.029	2	EPA
Fluoranthene				0.5	50			0.058	0.5	EPA
Benzo[a]anthracene				0.2	3			0.0034	0.2	EPA
Chrysene				0.2	1			0.0034	0.2	EPA
Benzo[k]fluoranthene				0.1				0.0041	0.1	EPA
Benzo[a]pyrene				0.1				0.0015	0.1	EPA
Benzo[ghi]perylene				0.02				0.00043	0.02	EPA
Indeno[123-cd]pyrene				0.04				0.00067	0.04	EPA

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* For these substances the differences between the methods of Van Straalen and Denneman (1989) and the method used by Slooff et al. (1986) amount to a factor of 10; the differences are 158 for chromium, 32 for arsenic and 19 for zinc. In all cases the discrepancy is probably due to one extremely low NOEC value.

\# Calculated on the basis of 3 instead of 4 groups, or even 2 groups in the case of azinphos-methyl.

a NW3 method based on the lowest NOEC for fish, Daphnia, algae and mollusca, without considering effects of bioaccumulation and combined toxicity.

& Ecotoxicological value from "Opportunities for Aquatic Organisms" (DBW/RIZA, 1989).

g. lowest NOEC for algae, molluscs, crustaceans and fish, in analogy with the method used by DBW/RIZA;
h. ecotoxicological value as reported in "Opportunities for Aquatic Organisms"; when determining this ecotoxicological value DBW/RIZA used a different data set.

When comparing the results of the advanced derivation methods with those obtained by rules of thumb with only a limited scientific basis in accordance with the modified EPA method it is striking that the numerical differences are only limited. The difference is approximately a factor of 13. If the differences for chromium (factor of 57) and mercury (factor of 50) are not included the factor amounts to approximately 7.5. Barring a few exceptions the modified EPA method is the most stringent method. This is desirable as in principle an indicative method should not be less stringent than results obtained with a better foundation.
With respect to the ecological method (ECO) it should be remarked that this method hardly fulfils an indicative function for the substances considered: only for chromium was the maximum acceptable risk level over a factor 10 lower than the recommended value on the basis of the modified HC method. This deviation is probably not exclusively due to the occurrence of secondary ecological effects of chromium but was probably due to the relatively high sensitivity of diatoms to chromium (see annex A).

In addition to the maximum acceptable risk level table 9 also lists the lowest NOEC values and the ecotoxicological value which corresponds with the basis quality concept (DBW/RIZA, 1989). Given its definition the recommended maximum acceptable risk level (the 95% protection level) should generally be lower than the lowest NOEC values observed. This is confirmed by the results: the lowest NOEC is higher for 21 out of 25 substances and groups of substances. This is not so for cadmium, zinc, chromium and parathion-ethyl. For these substances the proposed maximum acceptable risk level is a factor 2 to 5 higher than the lowest NOEC values observed. Relatively sensitive species are protozoa (zinc), diatoms (chromium) and crustaceans (parathion-ethyl). As mentioned above DBW/RIZA (1989), when deriving ecotoxicological values corresponding to the basic quality, only considers the lowest NOEC values obtained for algae, molluscs, crustaceans and fish. These values are also included in table 9. A comparison with the lowest NOEC values for all species shows that in most cases (17 out of 19) the DBW/RIZA method is based on the same toxicity values. However, this does not necessarily mean that the groups of organisms selected by DBW/RIZA are the most sensitive; rather there is a lack of reliable NOEC values for species not belonging to the selected groups.

Finally the recommended MAR values are listed in table 9. When sufficient data were available these were obtained by applying Health Council modification 2. If insufficient data were available the outcome of the modified EPA method was used. It should once more be stressed that the possible effects of bioaccumulation are not included in these recommended MAR values.

It is not possible to compare the proposed maximum acceptable risk levels with the ecotoxicological values according to "Opportunities for Aquatic Organisms" (DBW/RIZA, 1989). Firstly no policy indication has yet been given of the relationship between the terms "basis quality" and "maximum acceptable risk". Secondly when calculating the ecotoxicological values for a number of substances it was attempted to include the combined presence. Furthermore the ecotoxicological value for bioaccumulating substances is partly based on existing product standards.

3.1.2 Sediment

Given the lack of toxicity data indicative maximum acceptable risk levels for sediment were derived from those for water using the EP method. The results are listed in table 10. With respect to the metals and arsenic it is stressed that the partition coefficients used were derived from measurements of the difference between filtered and nonfiltered surface water samples. The extent to which these values are representative for the distribution between sediment and pore water should be further investigated.

Table 10 Indicative maximum maximum acceptable risk levels for substances in sediment, derived from the values for water using the EP method.

Substance	Recommended MAR water ($\mu g.l^{-1}$)	Partition coefficient ($l.kg^{-1}$)	Recommended MAR sediment ($\mu g.kg^{-1}$)	Derivation procedure
Cadmium	0.16	85000	14000	HC-mod2/EP
Zinc	1.6	75000	120000	HC-mod2/EP
Nickel	1.4	5300	7400	HC-mod2/EP
Lead	2.0	430000	860000	HC-mod2/EP
Mercury	0.01	110000	1100	HC-mod2/EP
Chromium	2.0	190000	270000	HC-mod2/EP
Copper	1.7	35000	60000	HC-mod2/EP
Arsenic	8.6	6500	56000	HC-mod2/EP
TBTO	0.011	1000	11	HC-mod2/EP
Atrazin	0.75	6.9	5.2	HC-mod2/EP
Lindane	0.55	250	140	HC-mod2/EP
PCP	2.0	88	180	HC-mod2/EP
Azinphos-methyl	0.069	86	5.9	HC-mod2/EP
Diazinon	0.087	80	7.0	HC-mod2/EP
Malathion	0.004	400	1.7	HC-mod2/EP
Parathion-ethyl	0.004	880	4.0	HC-mod2/EP
Dieldrin	0.045	37500	1700	HC-mod2/EP
mono-CP	25	9	220	EPA/EP
di-CP	15	22	330	EPA/EP
tri-CP	2.5	40	100	EPA/EP
tetra-CP	1.0	86	86	EPA/EP
Naphthalene	10	129	1300	EPA/EP
Anthracene	2	2630	5200	EPA/EP
Phenanthrene	2	2291	4600	EPA/EP
Fluoranthene	0.5	3147	1600	EPA/EP
Benzo(a)anthracene	0.2	9953	2000	EPA/EP
Chrysene	0.2	9953	2000	EPA/EP
Benzo(k)fluoranthene	0.1	25000	2500	EPA/EP
Benzo(a)pyrene	0.1	25000	2500	EPA/EP
Benzo(ghi)perylene	0.02	99527	2000	EPA/EP
Indeno[1,2,3-cd]pyrene	0.04	62797	2500	EPA/EP

3.1.3 Soil

Basic information about the toxicity to soil organisms was derived from the Integrated Criteria Documents referred to above. For the other substances data were collected by the BKH consultancy. After evaluation these data were grouped by the RIVM in annex D. If NOEC values were available E(L)C50 values were generally not listed for that substance as well. In the annex the data for the various types of soil used were converted to values for standard soil. The data used to derive maximum acceptable risk levels were summarised in annex E. Data obtained from tests in which organisms were exposed other than via the soil or litter (agar, filter paper, etc.) were not included in the extrapolation.

Using the Health Council method and its modifications, estimates of the maximum acceptable risk levels for cadmium, lead and copper were made which are listed in table 11.

Table 11 Comparison of possible maximum acceptable risk levels for cadmium, lead and copper in soil (in mg.kg^{-1}, converted to standard soil) as obtained by the application of the extrapolation methods of the Health Council (1988b) and modifications thereof on the same data set of soil ecotoxicological data. The number of input data (n) and the ratio 50%/5% (r) have also been included.

Substance	HC	HC-modification 1			HC-modification 2		
		5%	50%	(n/r)	5%	50%	(n/r)
Cadmium	0.08	0.014	0.22	(8/16)	0.0071	0.17	(6/24)
Lead	13.1	4.7	33	(8/7)	0.64	22	(5/34)
Copper	1.6	0.17	5.2	(6/31)	0.0046	3.5	(4/761)

For cadmium the Health Council method results in 0.08 mg.kg^{-1}. Van Straalen and Denneman (1989) obtained a value of 0.16 mg.kg^{-1}. There are two reasons for this difference. Firstly the NOEC value for plants is also included in the calculation. Secondly Van Straalen and Denneman's work was based on the reproduction parameter instead of the most sensitive parameter. If only reproduction is considered a value of 0.26 mg.kg^{-1} is obtained.

The maximum acceptable risk level was derived for all substances on which toxicity data were available, using the modified EPA method. The results are shown in table 12.

Table 12 Indicative maximum acceptable risk levels MAR (mg.kg^{-1}) for terrestrial ecosystems derived through the modified EPA method (see text) for substances for which sufficient data were available.

Substance	Acute data		Chronic data		Recommended MAR
	groups	lowest L(E)C50	groups	lowest NOEC	
Cadmium	3 (w,mp,e)	185	6 (w,mp,c, wl,m,s)	0.75	0.08
Zinc	3 (w,mp,e)	393	3 (mp,wl,s)	7.3	0.70
Nickel	3 (w,mp,e)	596	3 (w,mp,e)	26	2.6
Lead			7 (w,mp,e,p wl,c,s)	23.4	2.3
Mercury			2 (s,mp)	2	0.2
Chromium	2 (mp,e)	188	3 (w,e,p)	24	2.4
Copper	2 (mp,e)	140	5 (w,mp,p, c,s)	12.5	1.3
Arsenic			3 (mp,e,p)	71	7.1
TBTO					
Atrazin	3 (w,c,m)	6.5	2 (mp,e)	24	0.065[2]
Azinphos-methyl	1 (c)	5	1 (c)	2.5	0.25[1]
Diazinon	3 (i,c,t)	0.7	3 (mp,e,c)	0.25	0.025[1]
Dieldrin	2 (i,c)	1.1	3 (mp,e,c)	0.5	0.05[1]
Malathion	2 (mp,e)	40	2 (mp,e)	27.6	0.04 -2.8[3]
Parathion-ethyl	3 (w,i,c)	0.7	4 (w,mp,e,c)	0.05	0.005[1]
Lindane	2 (w,c)	0.95	2 (w,c)	0.05	0.005[1]
3-CP	1 (o)	213			0.21
2,4-diCP	1 (o)	303			0.30
2,4,5-triCP	1 (o)	106			0.11
2,4,6-triCP	1 (o)	58			0.06
2,3,4,5-tetraCP	1 (o)	293			0.29
PCP	1 (o)	10	3 (w,mp,p)	1.7	0.17
Fluoranthene	1 (o)	170			0.17

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[1] The low value for these insecticides is caused by the high sensitivity of the Springtail species (which could be considered as a target organism).

[2] Plants were not tested with this herbicide; it is expected that the ecotoxicological risk limit will be lower than the value included here.

[3] Toxicity data relating to crustaceans are not available for these insecticides; it is expected that the ecotoxicological risk limit will be lower than the value included here.

p: plants; o: oligochaetes; mp: microbial processes; wl: wood lice; m: mites; e: enzyme activity; c: collemboa; i: insects; s: slugs/snails; t: threadworms

Table 13 Comparison of possible maximum acceptable risk levels (MAR) for soil obtained by applying various derivation methods; proposal for a final risk limit (in mg.kg^{-1})

Substance	HC	HC-mod1	HC-mod2	EPA	EP	Lowest NOEC	Recommended MAR	Derivation procedure
Cadmium	0.08	0.22	0.17	0.08	14	0.75	0.17	HC-mod2
Zinc				0.7	120	7.3	0.7	EPA
Nickel				2.6	7.4	26	2.6	EPA
Lead	13	33	22	2.3	860	23	22	HC-mod2
Mercury				0.2	1.1	2	0.2	EPA
Chromium				2.4	270	24	2.4	EPA
Copper	1.6	5.2	3.5	1.3	60	13	3.5	HC-mod2
Arsenic				7.1	56	71	7.1	EPA
TBTO					0.011		0.011	HC-mod2/EP
Atrazin				0.065-2.4	0.0052	24	0.065	EPA
Azinphos-methyl				0.005-0.25	0.0059	2.5	0.005	EPA
Diazinon				0.007-0.025	0.007	0.25	0.007	EPA
Dieldrin				0.001-0.05	1.7	0.5	0.001	EPA
Malathion				0.04 -2.8	0.0017	28	0.04	EPA
Parathion-ethyl				0.005-0.007	0.004	0.05	0.005	EPA
Lindane				0.001-0.005	0.14	0.05	0.001	EPA
3-CP				0.21	0.23	210*	0.21	EPA
2,4-diCP				0.30	0.33	300*	0.3	EPA
2,4,5-triCP				0.11	0.1	110*	0.11	EPA
2,4,6-triCP				0.06	0.1	60*	0.06	EPA
2,3,4,5-tetraCP				0.29	0.086	290*	0.29	EPA
PCP				0.17	0.18	1.7	0.17	EPA
Naphthalene					1.3	170*	1.3	EPA/EP
Anthracene					5.2		5.2	EPA/EP
Phenanthrene					4.6		4.6	EPA/EP
Fluoranthene				0.17	1.6		1.6	EPA
Benzo(a)anthracene					2.0		2.0	EPA/EP
Chrysene					2.0		2.0	EPA/EP
Benzo(k)fluoranthene					2.5		2.5	EPA/EP
Benzo(a)pyrene					2.5		2.5	EPA/EP
Benzo(ghi)perylene					2.0		2.0	EPA/EP
Indeno[1,2,3-cd]pyrene					2.5		2.5	EPA/EP

* Lowest L(E)C50-value

Annex D shows that there is frequently a wide variation in the sensitivity of one parameter in different soils. For example the sensitivity of microbial parameters in one soil type may be far lower than in other soils, even after conversion to standard soil. It is not clear how representative this low value actually is. Therefore, to derive the maximum acceptable risk levels using the modified EPA method, the geometric mean of the values of such a parameter in different soils was used. The indicative MAR values derived by means of the EPA method are stringent by nature.

Table 13 provides a comparison of the maximum acceptable risk levels for soil derived according to the various methods, to obtain a definitive risk level. In analogy with the procedure followed for water the modified Health Council method was used for substances on which sufficient data were available. For those substances on which little data were available the modified EPA method was used. The equilibrium partition method was used for substances for which no data were available at all. Fluoroanthene was an exception for which only one acute L(E)C50 value was available. In this case the QSAR available for chronic NOEC values was considered more reliable.
Once more it should be stressed that the possible effects of bioaccumulation are <u>not</u> included in these recommended MAR values.

As for water there was a close correspondence between the results of the Health Council method and its modifications and those of the indicative EPA method. Again the EPA method was the most stringent. The EP method provides considerably higher (factor > 100) values for metals. It is doubtful whether the partition coefficients used, which were derived from suspended particle - surface water distributions, were representative for the distribution of metals between soil and porewater.

3.2 Comparison of risk levels and background levels

The negligible risk can be derived from the maximum acceptable risk level by applying a factor to it. In "Premises for Risk Management" (DGM, 1989a) an explicit policy choice was made to use a ratio of 100 between the maximum acceptable risk level and the negligible risk. There are no objective scientific arguments in favour or against this factor of 100. The main reason for using this factor is the uncertainty of the effect of the presence of a number of substances simultaneously. As the number and ratios of the substances in an ecosystem vary widely in time and between locations it is impossible to make a general statement about the magnitude of the factors to be used.
Desirable levels are set to the negligible risk levels, this too being a choice explicitly in accordance with policy. This is an obvious choice where substances are concerned which do not naturally occur in the environment; it is not all that obvious for substances which do naturally occur in the environment. It is generally assumed, more or less intuitively and without further support, that the natural background levels will not exceed the negligible risk levels.
In the following the derived maximum acceptable risk levels and negligible risk levels are compared with the natural background levels. The resulting differences are discussed in chapter 4 "Discussion".

3.2.1 Water

As shown by table 14 the natural background levels of metals other than cadmium in Rhine water are considerably higher than the negligible risk levels. These differences may be so large that it would be more appropriate to use the MAR values for comparison. In contrast with metals the naturally occurring concentrations of PAH do not exceed the negligible risk levels.

Table 14 Comparison of maximum acceptable risk (MAR) for water with the negligible risk (MAR/100) and background levels (in $\mu g.l^{-1}$)

Substance	MAR	MAR/100	Background
Cadmium	0.16 *	0.0016	0.002
Zinc	1.6 *	0.016	1
Nickel	1.4 *	0.014	1
Lead	2.0 *	0.02	0.1
Mercury	0.01 *	0.0001	-
Chromium	2.0 *	0.02	0.9
Copper	1.7 *	0.017	0.4
Arsenic	8.6 *	0.086	-
TBTO	0.011 *	0.00011	0.0
Atrazin	0.75 *	0.0075	0.0
Lindane	0.55 *	0.0055	0.0
PCP	2.0 *	0.02	0.0
Azinphos-methyl	0.069 *	0.00069	0.0
Diazinon	0.087 *	0.00087	0.0
Malathion	0.0043 *	0.000043	0.0
Parathion-ethyl	0.0046 *	0.000046	0.0
Dieldrin	0.045 *	0.00045	0.0
mono-CP	25 **	0.25	0.0
di-CP	15 **	0.15	0.0
tri-CP	2.5 **	0.025	0.0
tetra-CP	1 **	0.01	0.0
Naphthalene	10 **	0.1	-
Anthracene	2.0 **	0.02	0.004
Phenanthrene	2.0 **	0.02	0.05
Fluoranthene	0.5 **	0.005	0.009
Benzo[a]anthracene	0.2 **	0.002	0.0002
Chrysene	0.2 **	0.002	0.001
Benzo[k]fluoranthene	0.1 **	0.001	0.0004
Benzo[a]pyrene	0.1 **	0.001	0.0003
Benzo[ghi]perylene	0.02 **	0.0002	0.00006
Indeno[123-cd]pyrene	0.04 **	0.0004	-

* Derived with the HC-mod2 method
** Derived with the modified EPA method
\- No background value available

3.2.2 Sediment

Roughly the same applies to sediment as to water. Table 15 shows that the background levels of metals are higher than the negligible risk levels derived from aquatic toxicity data. The background level of nickel actually exceeds the maximum acceptable risk level. The background levels of PAH are lower than the negligible risk levels.

Table 15 Comparison of maximum acceptable risk (MAR) for sediment with the negligible risk (MAR/100) and background levels (in mg.kg^{-1})

Substance	MAR	MAR/100	Background
Cadmium	14 *	0.14	0.25
Zinc	120 *	1.2	68
Nickel	7.4 *	0.074	29
Lead	860 *	8.6	21
Mercury	1.1 *	0.011	-
Chromium	270 *	2.7	72
Copper	60 *	0.6	13
Arsenic	56 *	0.56	-
TBTO	0.011 *	0.00011	0.0
Atrazin	0.0052 *	0.000052	0.0
Lindane	0.14 *	0.0014	0.0
PCP	0.18 *	0.0018	0.0
Azinphos-methyl	0.0059 *	0.000059	0.0
Diazinon	0.007 *	0.00007	0.0
Malathion	0.0017 *	0.000017	0.0
Parathion-ethyl	0.004 *	0.00004	0.0
Dieldrin	1.7 *	0.017	0.0
mono-CP	0.21 **	0.0021	0.0
di-CP	0.3 **	0.003	0.0
tri-CP	0.1 **	0.001	0.0
tetra-CP	0.29 **	0.0029	0.0
Naphthalene	1.3 **	0.013	-
Anthracene	5.2 **	0.052	0.02
Phenanthrene	4.6 **	0.046	0.03
Fluoranthene	1.6 **	0.016	0.01
Benzo[a]anthracene	2.0 **	0.02	0.001
Chrysene	2.0 **	0.02	0.005
Benzo[k]fluoranthene	2.5 **	0.025	0.005
Benzo[a]pyrene	2.5 **	0.025	0.004
Benzo[ghi]perylene	2.0 **	0.02	0.003
Indeno[123-cd]pyrene	2.5 **	0.025	-

* Derived from water (HC-mod20), using the EP method
** Derived with water (modified EPA-method), using the EP method
\- No background value available

3.2.3 Soil

In table 16 the risk levels for soil are compared with the reference values for soil, as there are no natural background levels available for soil. With the exception of mercury the reference values are considerably higher than the maximum acceptable risk levels.

Table 16 Comparison of maximum acceptable risk (MAR) for soil with the negligible risk (MAR/100) and reference values for soil quality (in $mg.kg^{-1}$)

Substance	MAR	MAR/100	Reference value soil
Cadmium	0.17 *	0.0017	0.8
Zinc	0.7 **	0.007	140
Nickel	2.6 **	0.026	35
Lead	22 *	0.22	85
Mercury	0.2 **	0.002	0.3
Chromium	2.4 **	0.024	100
Copper	3.5 *	0.035	36
Arsenic	7.1 **	0.071	29
TBTO	0.011 ****	0.00011	0.0
Atrazin	0.065 **	0.00065	0.0
Lindane	0.005 **	0.00005	0.0
PCP	0.17 **	0.0017	0.0
Azinphos-methyl	0.25 **	0.0025	0.0
Diazinon	0.025 **	0.00025	0.0
Malathion	0.04 **	0.0004	0.0
Parathion-ethyl	0.005 **	0.00005	0.0
Dieldrin	0.05 **	0.0005	0.0
mono-CP	0.21 **	0.0021	0.0
di-CP	0.3 **	0.003	0.0
tri-CP	0.1 **	0.001	0.0
tetra-CP	0.29 **	0.0029	0.0
Naphthalene	1.3 ***	0.013	-
Anthracene	5.2 ***	0.052	-
Phenanthrene	4.6 ***	0.046	-
Fluoranthene	1.6 **	0.016	-
Benzo[a]anthracene	2.0 ***	0.02	-
Chrysene	2.0 ***	0.02	-
Benzo[k]fluoranthene	2.5 ***	0.025	-
Benzo[a]pyrene	2.5 ***	0.025	-
Benzo[ghi]perylene	2.0 ***	0.02	-
Indeno[123-cd]pyrene	2.5 ***	0.025	-

*	Derived directly with the HC-mod2
**	Derived directly with the modified EPA-method
***	Derived from water (modified EPA), using the EP method
****	Derived from water (HC-mod2), using the EP method
-	No background value available

3.3 Present standards

Table 17 shows that the negligible risk levels for water, sediment and soil are below the present standards. The discrepancies will not be discussed here as the desirable levels still have to be set.

3.4 Present concentrations in the environment

The present concentrations in the environment, to the extent that these are available in recent reports, are described in annex F. Generally the reported concentrations span a wide range. Table 18 is an attempt to provide a reasonable representation of fairly common values.
For water and sediment the 10th and the 90th percentile of a large number of measurements made of waterways in The Netherlands was used. These values are the result of an analysis of the data available at DBW/RIZA, undertaken during the preparation of the *"3ᵉ Nota Waterhuishouding"* [3rd policy document on Water Management] (Van der Kooij, 1989). Similar material was not available for terrestrial soils. At present concentrations are not measured systematically. However, an initial, informative experimental measurement was made in 1988 by the RIVM, together with the IB [Institute of Soil Fertility] and the RIKILT [Government Institute for Quality Control of Agricultural Products]. The initial as yet unpublished results of this research have already been included here (see annex F).

The differences with the derived risk values will not be further discussed as the desirable levels still have to be set.

Table 17 Present standards and guiding values

	WATER (total; µg.l⁻¹)			SEDIMENT (mg.kg⁻¹)		SOIL (mg.kg⁻¹)			DRINKING WATER (µg.l⁻¹)
	Basic quality surface water	Surface water as source of drinking water	NW3 quality objective 2000	NW3 quality objective 2000	General Environmental Quality Standard for sediments	Reference value soil quality	LAC signal level sand	LAC signal level peat	Water supply Decree
Cadmium	2.5	1.5	0.2	2.2	0.8	0.8	0.5	1.0	5
Zinc	200	200	30	477	140	140	100	350	
Nickel	50		10	40	35	35			50
Lead	50	30	25	533	85	85	100	150	50
Mercury	0.5	0.3	0.03	0.6	0.3	0.3	2	2	1
Chromium	50	50	25	483	100	100			50
Copper	50	50	3	42	36	36	30	30	
Arsenic	50	20	15	83	29	29			50
TBTO			0.01	0.00022					0.1
Atrazin	0.1		0.1	0.0015					0.1
Lindane	0.01	0.05	0.01	0.01	0.0025	0.001	0.015		0.1
Azinphos-methyl			0.02	0.00031					0.1
Diazinon			0.03	0.0019					0.1
Malathion			0.03	0.00054					0.1
Parathion-ethyl			0.02	0.004					0.1
Dieldrin	0.01	0.05		0.04	0.0025	0.01	0.08		0.1
Naphthalene		0.2 **			0.2	variable			0.2 **
Anthracene		0.2 **		0.034	0.2	variable			0.2 **
Phenanthracene		0.2 **		0.034	0.2	variable			0.2 **
Fluoranthene	0.1 *	0.2 **	0.07	0.23	1.2	0.1			0.2 **
Benzo[a]anthracene		0.2 **		0.043	0.2	variable			0.2 **
Chrysene		0.2 **		0.043	0.2	variable			0.2 **
Benzo[k]fluoranthene	0.1 *	0.2 **		0.13	0.55	10			0.2 **
Benzo[a]pyrene	0.1 *	0.2 **		0.003	0.2	0.1			0.2 **
Benzo[ghi]perylene	0.1 *	0.2 **		0.052	0.2	10			0.2 **
Indeno[1,2,3-cd]pyrene	0.1 *	0.2 **		0.052	0.2	10			0.2 **
Mono-CP				0.069					
Di-CP			0.08	0.0042					
Tri-CP	0.05			1.7					
Tetra-CP									
PCP	0.05		0.05	0.18					

* Sum Borneff-PAK = 0.1
** Value for all PAH = 0.2

Table 18 Summary of reported concentrations in water, sediment, soil and groundwater

	WATER ($\mu g.l^{-1}$)	SEDIMENT ($mg.kg^{-1}$)	SOIL ($mg.kg^{-1}$)		GROUNDWATER ($\mu g.l^{-1}$)	
			Uncontaminated	Contaminated	Uncontaminated	Contaminated
Cadmium	0 - 1.9	0.1 - 15	0.04 - 14	- 8.8	0.05 - > 31	
Zinc	0 - 117	62 - 1331	6.4 - 2070	- 2360	1 - 1024	
Nickel	0 - 14	11 - 55	< 0.5 - 58	- 68	1 - 276	
Lead	0 - 16	12 - 255	0 - 540	- 300000	< 1 - > 50	
Mercury	0.004 - 0.5	0.06 - 2.8	0 - 31	- 12	0.002 - >1.5	
Chromium	0.2 - 27	11 - 185	0 - 164	- 530	0.5 - > 20	
Copper	0 - 14	9 - 145	0.8 - 247	- 295	0.01 - > 50	
Arsenic	0 - 4.1	2.8 - 37	0.1 - 144	- 205	0.3 - > 20	
TBTO						
Atrazin			0.3 - 0.9	< 0.1 - 0.8		
Lindane	0.0004 - 0.04	0.0003 - 0.04	0.0005 - 0.08	- 55000	0.015	0.6
Azinphos-methyl						
Diazinon						
Malathion						
Parathion-ethyl						
Dieldrin	0 - 0.01	0.0002 - 0.082	0.0005 - 0.04	- 26		
Naphthalene		0.05 - 2	0.00001 - 1		0.001 - 6.5	8000
Anthracene		0.020 - 2.6	0.00001 - 0.2	1.5 - 60	< 0.001	200
Phenanthrene	- 0.07	0.07 - 4.1	0.00001 - 0.2	2 - 154	0.001	0.08 - 31
Fluoranthene	- 92	0.15 - 7.5	0.00001 - 0.15	0.2 - 170	0.001	0.2 - 60
Benzo[a]anthracene	- 0.02	0.06 - 5.8	0.00001 - 0.5	0.1 - 60	0.001	0.04 - 12
Chrysene	- 0.02	0.07 - 4.3	0.00001 - 0.5	< 0.2 - > 1.2	0.001	0.07 - 10
Benzo[k]fluoranthene	- 41.1	0.05 - 2.5	0.00001 - 0.5	0.3 - 39	0.001	0.04 - 7
Benzo[a]pyrene		0.05 - 4.6	0.00001 - 0.02	0.06 - 45	0.001	0.08 - 8
Benzo[ghi]perylene	- 46	0.08 - 3.3	0.00001 - 1	0.04 - 26	0.001	0.04 - 10
Indeno[1,2,3-cd]pyrene	- 59	0.05 - 3.2	0.00001 - 1	0.09 - 24	0.001	0.04 - 9
Mono-CP					< 0.01 - 0.12	
Di-CP			0.02		0.06	
Tri-CP	0 - 0.08		- 20		0.02	
Tetra-CP					- 0.01	
PCP	0 - 0.08		- 0.005		- 0.04	

4 DISCUSSION

4.1 Substance based and effects based standards

The Netherlands' environmental policy follows an approach along two lines: the source related approach and the effects related approach. For the effects based approach it is necessary to have quality objectives to:

- assess the present state of the environment;
- consider the need for measures;
- evaluate the results of any measures.

The quality objectives are substantiated at various levels (STUNO, 1989). For example, there are "desirable levels" (long-term objectives), "maximum tolerable levels" (short term objectives) and "intervention levels" (alarm function). These different sorts of quality objectives need to be quantified with their own forms and accuracies. Given their nature, desirable levels (which have to be reached in the long-term) can be set in a fundamental way. Maximum tolerable levels (urgent measures are required when these are exceeded) are to be set in a more pragmatic manner. This also applies to intervention levels: remediation will generally be needed when these are exceeded. Given the associated consequences the required precision increases from desirable level to limit to intervention level.

The effects related environmental policy is based on specific substances. In this approach the quality of the environment is translated to concentrations of individual substances. In concrete terms this means that standards are based on conditioning parameters (concentrations of substances) rather than on response parameters (toxicological and ecological effects). As far as desirable levels are concerned this choice results from the preventive environmental policy (desirable levels). As far as the curative environmental policy (intervention values) is concerned however, the use of response parameters would appear to be more appropriate. Response parameters provide the information which is of greatest interest: are there any effects, and if so, what is the nature and extent of these effects? The use of toxicological cumulative parameters also has policy advantages given the increasing number of substance specific standards and the resulting costs of enforcement.

With respect to water the OECD (1985) has made proposals for the use of toxicological response parameters. A similar discussion concerning sediments is currently taking place in the US and Canada (Tetra Tech, 1989; Giesy and Hoke, 1989). Where sediment is concerned the question also arises as to what is the purpose of setting quality requirements for sediments. The quality of sediments, being directly derived from water quality, is guaranteed by the preventive water quality policy. Quality parameters will only be required in situations where pollution from the past is present and when the need for curative measures such as dredging has to be investigated. In these situations the use of response parameters will prevail.

RECOMMENDATION 1:
The use of toxicological response parameters as criterion for the assessment of, and setting standards for, the quality of the environment should be considered. The evaluation could be based on:

- *surveying all possible parameters and selecting the most useful ones (cost and time aspects)*

- *a comparative practical study of the effectiveness of chemical structure parameters and toxicological response parameters*

RECOMMENDATION 2:
It might be considered not to draw up desirable levels for sediments as the sediment quality is determined by the water quality. The desirable levels for soil could serve as a reference for the sediment quality to be obtained.

4.2 Attitude to risks and naturally occurring substances

By introducing the terms "negligible risk" and "maximum acceptable risk" the policy document "Premises for Risk Management" (DGM, 1989a) has made the risk management policy to be followed more explicit. As a continuation of this the desirable level for each substance will in principle be set equal to its negligible risk level. Limits will basically be consistent with the maximum acceptable risk levels but will not be set equal to these without further consideration. This approach to risks does not distinguish between substances which naturally occur in the environment and man-made chemicals.

However, there are reasons to consider making this distinction. It appears that for metals and arsenic the naturally occurring background levels are generally higher than the negligible risk levels, whereas for soil they even exceed the maximum acceptable risk levels. One of the implications of the risk concept is that it has to be assumed that toxic effects may occur in systems which are not exposed to outside influences. This may seem rather strange but on further consideration it is neither surprising nor necessarily undesirable. It is quite possible that the natural background concentrations, because of their toxic influence, are a factor in the selection of species in ecosystems. For this reason levels below the naturally occurring concentrations could even be undesirable. Where essential elements are concerned it is likely that a deficiency may be an ecological selection mechanism. For zinc and copper in particular it is possible that a given concentration may be toxic to one particular organism while other organisms may suffer from a lack of these elements at the same concentration. The fact that risk limits are exceeded in certain ecosystems and the occurrence of toxic influences are therefore not necessarily unacceptable or undesirable. For naturally occurring substances it is therefore not self-evident to aim for negligible risk levels. The extent of influence which is just acceptable or the minimum desired under "normal" or "natural" circumstances, and the concentrations of natural substances which should be aimed for cannot be easily determined. An area specific approach to this appears to be desirable.

The situation is much less complicated where substances occur which do not naturally occur in the environment. Where these substances are concerned any toxic influence should be considered as undesirable under all circumstances. It is therefore obvious to aim for negligible risk levels for substances which do not occur naturally.

By ignoring in the risk approach the distinction between substances which occur naturally and those which do not, this risk approach, which is very simple for substances which do not occur naturally, is made unnecessarily complicated. This also obscures discussions on this subject. Ignoring the distinction between naturally occurring and other substances may even turn complications when applying the risk concept to naturally occurring substances into an argument against the application to substances which do not occur naturally.

RECOMMENDATION 3:
When setting environmental quality objectives different approaches should be followed for substances which occur naturally and those which do not.

RECOMMENDATION 4:
For naturally occurring substances the desirable levels should not necessarily be set to the negligible risk level, however, this should be done for other substances.

According to the comparison provided by tables 14 and 15 of the risk levels for naturally occurring substances in water and sediment with the background levels it should be assumed that toxic influences naturally occur in many aquatic ecosystems in the Netherlands.

Although it is likely that toxic influence is a natural occurrence at the local and possibly even at the regional level, it is not likely that toxic influences on natural systems occur on a large scale. In other words: the derived negligible risk levels for naturally occurring substances should not be so low that there are no locations where concentrations below these levels occur. The differences between "background concentrations" and risk limits for the metals in table 16 are surprisingly large. There are two possible explanations for this:

a. The ecotoxicologically derived risk limits for soil are too low. This may be due to e.g.:
   - overestimating the toxicity due to a difference in availability of the substance between laboratory and field conditions (see 2.4)
   - overestimating the variation in sensitivity of the species as the tests made cannot be compared very well (see 2.4); a greater variation results in lower risk limits
b. The "background concentrations" are too high.
   - firstly the numbers quoted here are not background concentrations but reference values; these are the 95 percentiles of the concentrations in relatively clean areas; it is certain that the natural concentrations in the Netherlands are lower
   - it is not known to what extent the worldwide natural background concentrations are lower than those in the Netherlands

RECOMMENDATION 5:
Further research should be undertaken into the background concentrations of natural substances in the soil and a comparison should be made for cadmium, copper and lead between the background concentrations and the ecotoxicologically derived risk limits.

RECOMMENDATION 6:
More ecological and ecotoxicological research should be undertaken, particularly into soil
- *ecological research to support the selection of terrestrial indicator organisms*
- *further development of toxicity tests with soil organisms*
- *undertaking ecotoxicological research on substances for which fewer than 4 chronic NOEC values are available, derived for different taxonomic classes or functional groups*

4.3 Deriving and coordinating quality objectives

An internally consistent environmental policy aims at realising the quality objectives for air, water, soil and products in a coordinated manner. There are a number of reasons for not considering the quality requirements separately:

a. *Distribution*. The various compartments of the environment are connected to a varying extent. For this reason concentrations of substances in the different compartments of the environment are not independent of each other. Therefore the quality objectives for the various compartments of the environment, to be expressed in terms of concentrations, cannot be set independently.

b. *Toxic effects*. A logical consequence of the hypothesis that toxic effects, to aquatic organisms as well as to sediment and soil organisms, are largely related to the concentration of the substance in the water which the organism is exposed to, is that environmental quality requirements for sediment and soil should be based on the associated concentrations in pore water.

c. *Principle of multi-functionality*. One of the implications of providing protection to all possible functions is that in principle no distinction is made between aquatic sediments and dry soil, as sediments may become dry and vice-versa. Therefore quality objectives for sediment and soil are not independent. Generally the quality of the environment should be such that its products should be of high quality. For example it should be possible to prepare drinking water from groundwater and surface water.

When quality objectives for water and the soil are defined it should also be decided how the coordination should be effected. In section 2.5 it was discussed that the assumption that there is an equilibrium between the particles and the (pore) water is presently the only practical basis for coordination. As the EP method is used to derive the maximum acceptable risk level for sediment the coordination of the quality objectives for water and sediment should not provide any problems. Some doubt remains however, concerning (i) the validity of the EP approach as such and (ii) the scale of the partition coefficients to be used.

RECOMMENDATION 7:
Making general rules operational to describe the scale of the sediment - pore water partition coefficients as a function of the properties and environmental characteristics of a substance, to convert concentrations between (pore) water and sediment, through
- *further literature research into partition coefficients sediment - pore water and possible generalisation*
- *field studies of concentrations in pore water*

In table 13 the maximum acceptable risk levels derived for soil are compared with the values obtained from those for water by applying the equilibrium partition method. For metals the direct approach produces much more stringent values than the indirect approach. A possible explanation for this could be that the partition coefficients used in this study are too high and result in an overestimation of the sorption of metals to soil. Partition coefficients tailored to soil-groundwater systems are available, but not in such a form that they are directly applicable to this application (DHV, 1989). Barring some exceptions (atrazin, dieldrin, malathion, lindane) the similarity between the values derived with the EPA method and the EP method is quite good for organic compounds. However, for organic compounds the use of partition coefficients for coordination will not be without problems.

RECOMMENDATION 8:
Making general rules operational to describe the scale of the soil - pore water partition coefficients as a function of the properties of the substance and the soil, to convert concentrations between pore water and soil, through
- *further literature research into partition coefficients soil - pore water and possible generalisation of these*
- *field studies of concentrations in soil and pore water*

4.4 Effects of bioaccumulation and combined toxicity

This report does not cover the effects of bioaccumulation. Therefore the maximum acceptable risk levels of greatly accumulating substances may have been underestimated. The progressive effects of accumulation may be included in any of a number of ways:

a. Through product standards. Concentration standards in products (fish, shellfish, crops, drinking water) are converted to environmental quality requirements. Product standards are only concerned with protecting humans and may be based on considerations other than toxicity.
b. Through toxic effect data. With a view to effects progressing through the food chain, maximum acceptable concentrations in biotics are converted to environmental quality objectives. The maximum permissible concentrations in biotics derived in this way are concerned with protecting ecosystems including humans and are only based on considerations of harmful effects.

Method b, which is preferred, could be developed as follows:

- An analysis is first made of the food chain in which an a priori estimate is made of the most threatened organisms, in terms of exposure, and the associated food chains. The food intake (mass of food per mass of body weight per unit of time) of the organisms in the chain is then determined.
- Safe intake quantities of substances expressed as 95% protection levels (mass of the substance per mass of body weight per time unit) for the target organisms are estimated using an extrapolation method based on the Health Council procedure. This is based on available protection data for animal groups representative for the target organism concerned (e.g. rats, guinea pigs, etc. as models for otters), assuming that the sensitivity of the species to be protected has a log-log distribution.
- The maximum acceptable concentration in biotics is then calculated on the basis of the acceptable intake quantity of the substance and the food intake of the target organism.
- The maximum acceptable concentration in the compartment of the environment concerned is then determined on the basis of the bioconcentration factors.

RECOMMENDATION 9:
Developing the above relationship for the substances discussed in this report

In section 1.3 it was stated that there is no scientific basis to consider the combined presence of several substances when deriving maximum acceptable risks in general terms. However, for some groups of substances it may be possible to draw up quality objectives for the whole group. For example, this applies to PAH: the PAH distribution in the environment generally does not show a wide spread.

4.5 Scientific basis of quality objectives

The method to extrapolate laboratory data to acceptable risk levels in the field is an important link in the process of deriving desirable levels. The developments in this field are rapid, given the content of the Health Council report and the present report. Given the importance of a well-founded environmental policy on an ecological basis further activity in this field is desired.

> *RECOMMENDATION 10:*
> *Further development of the scientific basis to deriving quality objectives:*
> - *system analysis of the sensitivity to and required accuracy of the parameters used for the derivation*
> - *determining toxicologically and ecologically relevant groups of organisms to obtain a balanced consideration of effects in an ecosystem (based on physiology, taxonomy, ecological function, structure, exposure path, etc.) and in connection with this the further development and application of statistical techniques as a refinement of Health Council-mod2:*
>   - *developing and applying a method which can be used to determine if there are insensitive groups which should not be included in the calculations to derive the maximum acceptable risk level*
>   - *determining the method to assess the lowest NOEC value for a taxonomic group in relation to the number of NOEC values available (e.g. 14 values for fish and 2 for algae)*

4.6 Description of environmental quality

Although there are many data available on the quality of the environment, they can generally not be compared very well (see annex F). When determining limits it is absolutely necessary to have a systematic understanding of the present concentrations in the environment and their spread.

> *RECOMMENDATION 11:*
> *Making a systematic analysis of the available data on the presence of substances in water, sediment, soil and groundwater (and if necessary obtain data through measurements), to obtain a clear understanding of the extent to which the quality requirements to be set will be exceeded.*

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NATIONAL INSTITUTE OF PUBLIC HEALTH AND ENVIRONMENTAL PROTECTION
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Annex to report number 670101 002

DESIRE FOR LEVELS

Background study for the policy document "Setting Environmental Quality Standards for Water and Soil"

D.van de Meent, T. Aldenberg, J.H. Canton,
C.A.M. van Gestel, W. Slooff

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This study was commissioned by the Directorate General for the Environment, Drinking Water, Water and Soil Department, Water Section and the Substances and Risk Management Department. Previously this project was registered under project number 718922. Originally, this work has been published in Dutch, as RIVM-report no. 670101.001: "STREVEN NAAR WAARDEN".

TABLE OF CONTENTS

GLOSSARY

ANNEX A

aantal soorten	number of species
aantal genera	number of genera
algen, blauw	blue green algae
algen, groen	green algae
amfibieën	amphibians
arseen	arsenic
atrazin	atrazin
bacteriën	bacteria
cadmium	cadmium
chroom	chromium
diatomeeën	diatoms
holtedieren	coelenterates
inclusief sponzen	including sponges
insecten	insects
koper	copper
kreeftachtigen	crustaceans
kwik	mercury
laagste NOEC	lowest NOEC
lindaan	lindane
lood	lead
macrofyten	macrophytes
niet meegenomen in berekening	not included in the calculation
nikkel	nickel
PCP	pentachlorophenol
protozoën	protozoa
schimmels	fungi
TBTO	tributyltinoxide
vissen	fish
weekdieren	molluscs
wormen	worms
zink	zinc

ANNEX B

afwijkend gedrag en/of uiterlijk	abnormal behaviour and/or appearance
beweeglijkheid	mobility
blootstellingsduur	exposure time
chemische vorm	chemical form
criterium	criterion
eieren niet blootgesteld aan metaalion	eggs exposed to metal ion
eieren niet blootgesteld aan metaalion	eggs not exposed to metal ion
geen enkel effect	no effect
geen enkel effect zichtbaar (niet duidelijk naar waar gekeken is)	no effects observed (not clear what was studied)
groei	growth
histopathologische afwijkingen	histo-pathological abnormalities
leeftijd	age
Organismen	Organisms

referentie	reference
reproductie	reproduction
resultaten	results
sterfte	mortality
type toets	type of test
waarde voor ..-ion	value for .. ion
zie chemische vorm	see chemical form

ANNEX F

(niet) gecontamineerd	(un)contaminated
95 percentiel	95th percentile
achtergrond	background
boomgaard	orchard
bosbodems	forest soil
bouwland	agricultural land
dalgrond	reclaimed peat land
dennebos	pine forest
drinkwaterwinning	potable water production
duinen	dunes
enkeerdgrond	humic rich sand
fluvatiele afzettingen	fluvial deposits
gasfabrieksterrein	gas works site
geen gegevens beschikbaar	no data available
geschat	estimated
grondwater	ground water
havenslib	dredged harbour sediment
havenslibgronden	areas covered with dredged harbour sediment
Hoogovens	Hoogovens steel works
hoogveen	peat
humusarm	with low humus content
idem	ditto
industriegrond	industrial site
infiltratie	infiltration
kalkvrije	chalk free
kasgewas	greenhouse crop
kasgrond	greenhouse soil
klei	clay
laagveen	peat
land en tuinbouw	agriculture and horticulture
landbouw	agriculture
landbouwgrond	agricultural land
leem	loam
leemarme	with low loam content
loss	loess
Maasdal	Maas valley
mais	maize
nabij	near
natte grond	wet soil
natuurgebied	nature reserve
Ontwerp Bodemmeetnet	Proposed Soil Monitoring Network
per 5 jaar overstroomd	flooded every 5 years
podzol	podzol
polder	polder

rivier klei	river clay
stort	tip
tertiar zand	tertiary sand
tuinbouw	horticulture
tuintjes op voormalige stort	gardens on former tip
uiterwaard	foreland
veen	peat
veengrond	peat
veldgewas	field crop
venig	peaty
vlakvaaggrond	loam
waterwinning	water abstraction
weiland	pasture
woonbebouwing	urban area
zand	sand
zavel	sandy clay
zee klei	sea clay

Annex A Lowest aquatic NOEC values per group of species in $\mu g.l^{-1}$, including the number of species and the number of genera on which these values were based. All decimal commas should be replaced by decimal points.

Stofnaam	**laagste NOEC (µg/l)** **(aantal soorten;aantal genera)**							
	protozoën	holtedieren	**wormen**	**weekdieren**	**kreeftachtigen**	**insecten**	**vissen**	**amfibieën**
Cadmium	35 (3;3)		17,2 (1;1)	2,5 (1;1)	0,30 (2;1)		0,9 (14;12)	9 (1;1)
Zink	0,75 (1;1)			3,5 * (2;2)	56 (2;2)		26 (6;6)	
Nikkel	21 (3;3)				37 (1;1)		62 (2;2)	
Lood	10 (3;3)			15 (2;2)	15 (1;1)	565 (2;2)	17,3 (10;8)	
Kwik	0,5 (4;4)				0,02 (4;4)		0,17 (3;3)	
Chroom	35 (4;4)	1120 (1;1)		112 (1;1)	9 (2;2)	1120 (1;1)	63 (14;13)	350 (1;1)
Koper				8 (2;2)	5 (5;5)	8 (3;3)	11,8 (16;13)	
Arseen	2400 (1;1)			1000 (2;2)	88 (5;5)	1000 (1;1)	76 (4;4)	
TBTO				0,32 (1;1)	0,16 (1;1)		0,32 (2;2)	
Atrazin					60 (3;2)		65 (3;3)	
Lindaan				500 (1;1)	4,3 (2;2)	2,2 (1;1)	8,8 (3;3)	250 (1;1)
PCP		32 (1;1)		3,2 (1;1)	136 (1;1)	3200 (1;1)	9,3 (4;4)	32 (1;1)

* = inclusief sponzen

** = niet meegenomen in de berekening

Annex A continued

Stofnaam	laagste NOEC (µg/l) (aantal soorten;aantal genera)					
	bacteriën	**schimmels**	**algen groen**	**algen blauw**	**diatomeeën**	**macrofyten**
Cadmium	120		600	100		
	(4;4)		(4;3)	(1;1)		
Zink	500	65400 **	5	400	560	
	(2;2)	(5;5)	(5;4)	(1;1)	(1;1)	
Nikkel	403		650	25		
	(5;4)		(2;2)	(3;3)		
Lood	900		10	225	500	206
	(1;1)		(2;2)	(2:2)	(1;1)	(1;1)
Kwik	5		18,7	2,5		
	(1;1)		(2;1)	(1;1)		
Chroom			112	35	0,35	100
			(6;3)	(3;3)	(1;1)	(5;2)
Koper			80	5		
			(2;2)	(2;2)		
Arseen	4860		10	100	86	500
	(1;1)		(4;3)	(1;1)	(1;1)	(1;1)
TBTO			18			
			(2;2)			
Atrazin			19,4	1,5		
			(4;3)	(1;1)		
Lindaan			950	150		
			(1;1)	(1;1)		
PCP	1000		100	1000		1000
	(1;1)		(1;1)	(1;1)		(1;1)

* = inclusief sponzen

** = niet meegenomen in de berekening

Annex B Toxicity data for aquatic organisms

Organismen	type toets	leeftijd-stadium	blootstellingsduur	criterium	resultaat µg/l	chemische vorm	referentie
bacteriën							
Escherichia coli				NOEC^a	700		Bringmann & Kuhn, 1959
Zoogloea ramigera			32 u	NOEC^a	<1000	$ZnCl_2$	Norberg & Molin, 1983
schimmels							
Rhizoctonia solani			4 d	NOEC^a	65400	$ZnSO_4$	Babich & Stotzky, 1978
Fusarium solani			4 d	NOEC^a	65400	$ZnSO_4$	Babich & Stotzky, 1978
Cunninghamella echinulata			3 d	NOEC^a	65400	$ZnSO_4$	Babich & Stotzky, 1978
Aspergillus niger			4 d	NOEC^a	65400	$ZnSO_4$	Babich & Stotzky, 1978
Trichoderma viride			3 d	NOEC^a	65400	$ZnSO_4$	Babich & Stotzky, 1978
groene algen							
Chlorella vulgaris			16 d	NOEC^a	1000	$ZnSO_4$	Ahluwalia & Kaur, 1988
Chlorella pyrenoidosa			5 d	NOEC^a	1000	$ZnSO_4$	Brauwers, 1982
Chlorella vulgaris			5-6 d	NOEC^a	<50000	$ZnSO_4$	Skowronski & Rzecrycka, 1980
Chlorella pyrenoidosa			8 d	NOEC^a	830	$ZnCl_2$	Wong, 1980
Scenedesmus quadricauda			8 d	NOEC^a	700		Bringmann & Kuhn, 1959
Selenastrum capricornutum			14 d	NOEC^a	5		Kuwabara, 1985
Hormidium rivulare			7 d	NOEC^a	<1000	$ZnCl_2/SO_4$	Hargreaves & Whitton, 1976
blauw-groene algen							
Chroococcus paris			10 d	NOEC^a	400	$ZnSO_4$	Les & Walker, 1984
protozoën							
Euglena gracilis			14 d	NOEC^a	0,75	Zn^{2+}	Mills, 1976
diatomeeën							
Navicula incerta			4 d	NOEC^a	560	$ZnCl_2$	Rachlin et al., 1983
weekdieren							
Corbicula sp.	veld	adult	30 d	NOEC^a	250	$ZnSO_4$	Belanger et al., 1986
sponzen							
Ephydatia fluviatilis			10 d	NOEC^g	<7 1988	$ZnCl_2$	Francis & Harrison,

Organismen	type toets	leeftijd-stadium	blootstellingsduur	criterium	resultaat $\mu g/l$	chemische vorm	referentie
kreeftachtigen							
Daphnia magna		<24 u	50 d	NOEC[b]	25	$ZnSO_4$	Paulauskis & Winner 1988
Daphnia magna		<24 u	50 d	NOEC[b]	75	$ZnSO_4$	Paulauskis & Winner 1988
Daphnia magna		<24 u	50 d	NOEC[b]	150	$ZnSO_4$	Paulauskis & Winner 1988
Daphnia magna			21 d	NOEC[c]	<70		Skidmore & Firth, 1983
Orconectes virilis		adult	14 d	NOEC[c]	<5200	$ZnSO_4$	Mirenda, 1986
vissen							
Brachydanio rerio	pLC	eieren	16 d	NOEC[c]	500	$ZnSO_4$	Dave et al., 1987
Salmo gairdnerii	LC		730 d	NOEC[c]	140	$ZnSO_4$	Mance, 1987
Salmo gairdnerii		adult	85 d	NOEC[g]	520	$ZnSO_4$	Mance, 1987
Salvelinus fontinalis	pLC	eieren	84 d	NOEC[c]	709	$ZnSO_4$	Mance, 1987
Jordanella floridae	pLC	ei - larve	100 d	NOEC[abc]	75	$ZnSO_4$	Mance, 1987
Jordanella floridae	pLC	ei - larve	100 d	NOEC[abc]	26	$ZnSO_4$	Mance, 1987
Phoxinus phoxinus		juv.	109 d	NOEC[g]	60	nitraat	Mance, 1987
Phoxinus phoxinus		adult	100 d	NOEC[g]	130	nitraat	Mance, 1987
Pimephales promelas		adult/ei	56 d	NOEC[g]	78		Mance, 1987
Pimephales promelas		3 m	30 d	NOEC[ac]	1300	$ZnSO_4$	Mance, 1987
Pimephales promelas	pLC	eieren	20 d	NOEC[c]	180	$ZnSO_4$	Mance, 1987
Pimephales promelas		eieren	20 d	NOEC[c]	660	$ZnSO_4$	Mance, 1987
Pimephales promelas	LC		10 m	NOEC[g]	30		Skidmore & Firth, 1983

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[*] zie chemische vorm
[+] waarde voor Zn-ion
[a] groei
[b] reproductie
[c] sterfte
[g] geen enkel effect

Organismen	type toets	leeftijd-stadium	blootstellingsduur	criterium	resultaat µg/l	chemische vorm	referentie
bacteriën							
Methanobacterium thermoautotrophicum			6 u	NOEC[a]	100000	$NiCl_2$	Ahring & Westermann, 1985
TAM			6 u	NOEC[a]	6000	$NiCl_2$	Ahring & Westermann, 1985
Escherichia coli			5 u	NOEC[a]	5000		Babich & Stotzky, 1983
Pseudomonas tabaci			25 u	NOEC[a]	130000	$NiCl_2$	Sigee & Al-Rabaee, 1986
Pseudomonas putida			24 u	NOEC[a]	1,25	$NiCl_2$	Bringmann & Kuhn, 1977
groene algen							
Chlamydomonas sp.			12 d	NOEC[a]	10000		Folsom et al., 1986
Scenedesmus quadricauda			8 d	NOEC[a]	650	$NiCl_2$	Bringmann, 1978
blauwe algen							
Anabaena inequalis			12 d	NOEC[a]	25		Babich & Stotzky, 1983
Microcystis aeruginosa			8 d	NOEC[a]	2,5	$NiCl_2$	Bringmann & Kuhn, 1978
Nostoc muscorum			15 d	NOEC[a]	<500	$NiCl_2$	Rai & Raizada, 1987
protozoën							
Chilomonas paramaecium			48 u	NOEC[a]	410	$NiCl_2$	Bringmann et al., 1980
Uronema parduczi			20 u	NOEC[a]	21	$NiCl_2$	Bringmann et al., 1980
Entosiphon sulcatum			72 u	NOEC[a]	70	$NiCl_2$	Bringmann & Kuhn, 1978
kreeftachtigen							
Daphnia magna			21 d	NOEC[bc]	<30		Skidmore & Firth, 1983
Daphnia magna			21 d	NOEC[bc]	90	$Ni(CH_3COO)_2$	Kuhn et al., 1989
vissen							
Pimephales promelas			365 d	NOEC[abc]	380		Mance, 1987
Pimephales promelas		larven	25 d	NOEC[ac]	380		Mance, 1987
Salmo gairdnerii	pLC	eieren	85 d	NOEC[ac]	62	$NiCl_2$	Nebeker et al., 1985
Salmo gairdnerii	pLC	eieren	52 d	NOEC[ac]	134	$NiCl_2$	Nebeker et al., 1985
Salmo gairdnerii	pLC	larven	38 d	NOEC[ac]	134	* $NiCl_2$	Nebeker et al., 1985

TAM = thermophilic acetate-decarboxylating methanogenic bacterium.

[*] zie chemische vorm

[+] waarde voor Ni-ion

[a] groei

[b] reproductie

[c] sterfte

Organismen	type toets	leeftijd-stadium	blootstellingsduur	criterium	resultaat $\mu g/l^{-1}$	chemische vorm	referentie
bacterien							
Pseudomonas putida		24 u	16 u	NOEC^{a}	5	$HgCl_2$	Bringmann & Kuhn, 1977
groene algen							
Scenedesmus acutus			10 d	NOEC^{a}	<20	Hg^{2+}	Huisman et al., 1980
Scenedesmus quadricauda		10 d	8 d	NOEC^{a}	35	$HgCl_2$	Bringmann & Kuhn, 1978
blauwe algen							
Microcystis aeruginosa		10 d	8 d	NOEC^{a}	2.5	$HgCl_2$	Bringmann & Kuhn, 1978
protozoen							
Chilomonas paramaecium		72-96 u	48 u	NOEC^{a}	8	$HgCl_2$	Bringmann et al., 1980
Entosiphon sulcatum		72-96 u	72	NOEC^{a}	9	$HgCl_2$	Bringmann et al., 1980
Poterioochromonas malhamensis			72 u	NOEC^{a}	0.5	$HgCl_2$	Roderer, 1983
Uronema parduczi		48 u	20 u	NOEC^{a}	39	$HgCl_2$	Bringmann et al., 1980
kreeftachtigen							
Cyclops		nauplii	14 d	NOEC^{c}	32	$HgCl_2$	Mance, 1987
Daphnia magna				NOEC	1.1	Hg^{2+}	EPA, 1986
Daphnia magna			21 d	NOEC^{b}	<1.7	$HgCl_2$	Skidmore & Firth, 1983
Faxonella clypeata		m	30 d	NOEC^{c}	0.002	$HgCl_2$	Heit & Fingerman, 1977
		v	30 d	NOEC^{c}	0.2	$HgCl_2$	
Procambarus clarki		m&v	30 d	NOEC^{c}	0.02	$HgCl_2$	Heit & Fingerman, 1977
vissen							
Jordanella floridae			30 d	NOEC	0.17	Hg^{2+}	Skidmore & Firth, 1983
Pimephales promelas			60 d	NOEC	0.13	Hg^{2+}	Skidmore & Firth, 1983
Pimephales promelas		juveniel	60 d	NOEC^{ac}	0.31	$HgCL_2$	Snarski & Olson, 1982
Pimephales promelas	LC		41 w	NOEC^{ab}	<0.26	$HgCl_2$	Snarski & Olson, 1982
Salvelinus fontinalis			90 d	NOEC	0.29	Hg^{2+}	Skidmore & Firth, 1983

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[*] zie chemische vorm
[+] waarde voor Hg-ion
[a] groei
[b] reproduktie
[c] sterfte

Organismen	type toets	leeftijd-stadium	blootstellingsduur	criterium	resultaat µg/l	chemische vorm	referentie
bacteriën							
Pseudomonas putida		24 u cult.	16 u	NOEC[a]	900	$(CH_3COO)_2Pb$	Bringmann & Kuhn, 1977
groene algen							
Selenastrum capricornutum			13 d	NOEC[a]	10	Pb^{2+}	Christensen et al., 1979
Scenedesmus quadricauda			8 d	NOEC[a]	1850	$(CH_3COO)_2Pb$	Bringmann & Kuhn, 1978
blauwe algen							
Microcystis aeruginosa			8 d	NOEC[a]	225	$(CH_3COO)_2Pb$	Bringmann & Kuhn, 1978
Nostoc muscorum			15 d	NOEC[a]	<10000	$PbCl_2$	Rai & Raizada, 1988
diatomeeën							
Navicula incerta			96 u	NOEC[a]	500	$PbCl_2$	Rachlin et al., 1983
protozoën							
Uronema parduczi			20 u	NOEC[a]	35	$(CH_3COO)_2Pb$	Bringmann et al., 1980
Entosiphon sulcatum			72 u	NOEC[a]	10	$(CH_3COO)_2Pb$	Bringmann & Kuhn, 1978
Chilomonas paramaecium			48 u	NOEC[a]	110	$(CH_3COO)_2Pb$	Bringmann et al., 1980
weekdieren							
Lymnaea palustris		eieren	30 d	NOEC[b]	31	$Pb(NO_3)_2$	Mance, 1987
Lymnaea palustris		adult	120 d	NOEC[c]	12	$Pb(NO_3)_2$	Mance, 1987
Lymnaea palustris			4 m	NOEC[c]	19		Skidmore & Firth, 1983
Physa integra		adult	28 d	NOEC[c]	565	$Pb(NO_3)_2$	Mance, 1987
kreeftachtigen							
Daphnia magna	LC		21 d	NOEC[bc]	<30	$PbCl_2$	Skidmore & Firth, 1983
insecten							
Pteronarcys dorcata		larven	28 d	NOEC[c]	565	$Pb(NO_3)_2$	Mance, 1987
Brachycentrus sp.		larven	28 d	NOEC[c]	565	$Pb(NO_3)_2$	Mance, 1987

Organismen	type toets	leeftijd-stadium	blootstellingsduur	criterium	resultaat µg/l	chemische vorm	referentie
vissen							
Salvelinus fontinalis	pLC	1 jaar tot volw.	266 d	NOEC[abc]	474	$Pb(NO_3)_2$	Mance, 1987
Salvelinus fontinalis	pLC	1 jaar tot volw.	266 dagen	NOEC[f]	235	$Pb(NO_3)_2$	Mance, 1987
Salvelinus fontinalis	pLC	F1 - juv.	455 dagen	NOEC[f]	58	$Pb(NO_3)_2$	Mance, 1987
Salvelinus fontinalis	pLC	ei - larve	60 d	NOEC[g]	48	$Pb(NO_3)_2$	Mance, 1987
Salmo gairdnerii	LC	ei - adult[h]	570 d	NOEC[cf]	7,2	$Pb(NO_3)_2$	Mance, 1987
Salmo gairdnerii	pLC	ei - larve	60 d	NOEC[g]	7,1	$Pb(NO_3)_2$	Mance, 1987
Salmo gairdnerii	LC	ei - adult[i]	570 d	NOEC[cf]	4,0	$Pb(NO_3)_2$	Mance, 1987
Salmo salar		larven	90 d	NOEC[cf]	20	$Pb(NO_3)_2$	Mance, 1987
Brachydanio rerio		blastula		NOEC[f]	18	$Pb(NO_3)_2$	Mance, 1987
Catostomus commersoni	pLC	ei - larve	60 d	NOEC[g]	119		Mance, 1987
Esox lucius	pLC	ei - larve	20 d	NOEC[c]	253		Mance, 1987
Ictalurus punctatus	pLC	ei - larve	60 d	NOEC[g]	75		Mance, 1987
Lepomis macrochirus	pLC	ei - larve	60 d	NOEC[g]	70		Mance, 1987
Stiostedion vitreum			30 d	NOEC[c]	240		Skidmore & Furth, 1983
Salmo namaycush			60 d	NOEC[c]	48		Skidmore & Firth, 1983
planten							
Chara vulgaris			14 d	NOEC[a]	206	$Pb(C_2H_5)_3Cl$	Heumann, 1987
Chara vulgaris			14 d	NOEC[a]	2000	$Pb(NO_3)_2$	Heumann, 1987

[*] zie chemische vorm
[+] waarde voor Pb-ion
[a] groei
[b] reproductie
[c] sterfte
[f] afwijkend gedrag en/of uiterlijk
[g] geen enkel effect
[h] eieren niet blootgesteld aan metaalion
[i] eieren blootgesteld aan metaalion

Organismen	type toets	leeftijd-stadium	blootstellingsduur	criterium	resultaat $\mu g/l^{-1}$	referentie
groene algen						
Chlorella pyrenoidosa			4 d	NOEC^a	18	Mathijssen-Spiekman et al., 1989
Scenedesmus pannonicus			4 d	NOEC^a	32	id.
weekdieren						
Lymnaea stagnalis		~3 mnd	33 d	NOEC^b	0.32	Mathijssen-Spiekman et al., 1989
kreeftachtigen						
Daphnia magna		24 u	21 d	NOEC^b	0.16	Kuhn et al., 1989
Daphnia magna		< 1 d	20 d	NOEC^a	0.56	Mathijssen-Spiekman et al., 1989
vissen						
Oryzias latipes	pLC	< 6 u (eieren)	104 d	NOEC^f	1.0	Mathijssen-Spiekman et al. 1989
Poecilia reticulata	pLC	3 a 4 wk	91 d	NOEC^a	0.32	id.

[a] groei
[b] reproduktie
[f] afwijkend gedrag en uiterlijk

Annex B atrazin

Organismen	type toets	blootstellingsduur	criterium	resultaat $\mu g/l^{-1}$	referentie
groene algen					
Chlamydomonas sp.		91 u	NOEC[a]	<50	Foy, 1977
Chlorella vulgaris		5 d	NOEC[a]	<250	Veber et al., 1981
Scenedesmus quadricauda		8 d	NOEC[a]	15	Bringmann & Kuhn, 1978
Scenedesmus sp.		92 u	NOEC[a]	<50	Foy, 1977
blauwe algen					
Microcystis aeruginosa		8 d	NOEC[a]	1.5	Bringmann & Kuhn, 1978
kreeftachtigen					
Daphnia magna	3 gen.test	64 d	NOEC[b]	140	Macek et al., 1976
Daphnia pulex		28 d	NOEC[b]	<1000	Schober & Lambert, 1977
Gammarus fasciatus	2 gen.test	119 d	NOEC[a]	60	Macek et al., 1976
vissen					
Lepomis macrochirus	LC	18 m	MATC[ac]	>95 <500	Macek et al., 1976
Pimephales promelas	LC	43 w	MATC[ac]	>210 <870	Macek et al., 1976
Salvelinus fontinalis	LC	306 d	NOEC[ac]	65	Macek et al., 1976

[a] groei
[b] reproduktie
[c] sterfte

Annex B azinphos-methyl

Organismen	type toets	leeftijd stadium	blootstellingsduur	criterium	resultaat $\mu g/l^{-1}$	referentie
kreeftachtigen						
Asellus aquaticus			21 d	NOEC[g]	0.25	Dortland, 1980
Daphnia magna			21 d	NOEC[d]	0.1	Dortland, 1980
Gammarus pseudolimneaus			30 d	NOEC	0.1	EPA, 1972
insecten						
Acroneuria lycorias			30 d	NOEC	1.36	EPA, 1972
Chaoborus crystallinus			21 d	NOEC[c]	2.0	Dortland, 1980
Cloeon dipterum			21 d	NOEC[c]	2.0	Dortland, 1980
Ephemerella subvaria			30 d	NOEC	2.5	EPA, 1972
Hydropsyche bettoni			30 d	NOEC	2.94	EPA, 1972
Ophiogomphus rupinsulensis			30 d	NOEC	1.73	EPA, 1972
vissen						
Pimephales promelas	LC		250d	NOEC[b]	0.33	Adelman et al., 1976

[b] reproduktie
[c] sterfte
[d] beweeglijkheid
[g] geen enkel effect zichtbaar (onduidelijk waar naar gekeken is)

Annex B diazinon

Organismen	type toets	leeftijd-stadium	blootstellingsduur	criterium	resultaat µg/l^{-1}	referentie
groene algen						
Chlamydomonas reinhardtii			sev d	NOEC[a]	1000	Wong & Chang, 1988
kreeftachtigen						
Daphnia magna			21 d	NOEC	0.26	EPA, 1972
Daphnia magna			21 d	NOEC[bd]	0.2	Dortland et al., 1980
Gammarus pseudolimneaus			30 d	NOEC	0.2	EPA, 1972
insecten						
Acroneuria lycorias			30 d	NOEC	0.83	EPA, 1972
Ephemerella subvaria			30 d	NOEC	0.42	EPA, 1972
Hydropsyche bettoni			30 d	NOEC	1.79	EPA, 1972
Ophiogomphus rupinsulensis			30 d	NOEC	1.29	EPA, 1972
Pteronarcys dorsata			30 d	NOEC	3.29	EPA, 1972
vissen						
Pimephales promelas	pLC		32 d	NOEC[a]	50	Jarvinen & Tanner 1982
Pimephales promelas	pLC	5 d	168 d	NOEC[b]	<3.2	Allison, 1977

[a] groei
[b] reproduktie
[d] beweeglijkheid

Annex B dieldrin

Organismen	type toets	leeftijd-stadium	blootstellingsduur	criterium	resultaat $\mu g/l^{-1}$	referentie
weekdieren						
Lymnaea stagnalis		ei	19d	NOEC[b]	10	Adema & Vink, 1981
kreeftachtigen						
Daphnia magna		larve 1mm	3w	NOEC[bc]	32	Adema & Vink, 1981
vissen						
Lebistes reticulatus			450 d	NOEC	5	Warren, 1972
Salmo gairdnerii			130 d	NOEC	0.12	Chadwick & Shumway, 1970

[b] reproduktie
[c] sterfte

Annex B malathion

Organismen	type toets	leeftijd-stadium	blootstel-lingsduur	criterium	resultaat µg/l^{-1}	referentie
blauw-groene algen						
Anabaena			5 d	NOEC^a	10^4	Tandon et al., 1988
Aulosira fertilissima			5 d	NOEC^a	5x 10^4	Tandon et al., 1988
protozoen						
Euglena gracilis	pH 5		5 d	NOEC^a	1450	Moore, 1970
Paramecium aurelia			3 d	NOEC^a	1000	Tandon et al., 1987
kreeftachtigen						
Daphnia magna			21 d	NOEC^d	0.15	Dortland, 1980
Daphnia magna			21 d	NOEC	0.6	EPA, 1972
Gammarus pseudolimnaeus			30 d	NOEC	0.008	EPA, 1972
insecten						
Acroneuria lycorias			30 d	NOEC	0.17	EPA, 1972
Hydropsyche bettoni			30 d	NOEC	0.24	EPA, 1972
Ophiogomphus rupinsulensis			30 d	NOEC	0.28	EPA, 1972
Pteronarcys dorsata			30 d	NOEC	9.4	EPA, 1972
vissen						
Jordanella floridae	LC		110 d	NOEC^c	19.3	Hermanutz, 1978
Jordanella floridae	LC	2-3 d	140 d	NOEC^a	13.8	Hermanutz et al., 1985

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[a] groei
[c] sterfte
[d] beweeglijkheid

Annex B parathion-ethyl

Organismen	type toets	leeftijd-stadium	blootstellingsduur	criterium	resultaat µg/l^{-1}	referentie
bacterien						
Pseudomonas putida		24 u cul.	16 u	NOEC[a]	> 500	Bringmann & Kuhn, 1977
groene algen						
Scenedesmus quadricauda			8 d	NOEC[a]	195	Bringmann & Kuhn 1978
blauwe algen						
Microcystis aeruginosa			8 d	NOEC[a]	15	Bringmann & Kuhn, 1978
kreeftachtigen						
Asellus aquaticus			21 d	NOEC[c]	1.0	Dortland, 1980
Daphnia magna			21 d	NOEC[d]	0.2	Dortland, 1980
Daphnia magna		first instar	21 d	NOEC[b]	0.08	Spacie et al., 1981
Daphnia magna			21 d	NOEC[b]	0.002	Kuhn et al., 1989
Gammarus fasciatus		juveniel	~40 d	NOEC[c]	<0.04	Spacie et al., 1981
insecten						
Chaoborus crystallinus			21 d	NOEC[c]	<0.25	Dortland, 1980
Cloeon dipterum			21 d	NOEC[c]	0.1	Dortland, 1980
vissen						
Lepomis machrochirus	pLC		23 m	NOEC[e]	0.17	Spacie et al., 1981
			23 m	NOEC[abc]	3.2	
Pimephales promelas	pLC	5-14 d	8.5 m	NOEC[be]	4.0	Spacie et al., 1981
Salvelinus fontinalis	pLC		9 m	NOEC[abc]	>=7.0	Spacie et al., 1981
			9m	NOEC[b]	10	Spacie et al., 1981

[a] groei
[b] reproduktie
[c] sterfte
[d] beweeglijkheid
[e] histopathologische afwijkingen

LITERATURE TOXICITY AQUATIC ORGANISMS

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Annex C Lowest aquatic NOEC values for target species and sensitive species (in $\mu g.l^{-1}$)

	Azinphos methyl	Diazinon	Dieldrin	Malathion	Parathion
Moluscs					
L. stagnalis			10		
Crustaceans					
A. aquaticus	0.25				1.0
D. magna	0.1	0.23	32	0.3	0.03
G. pseudolimneus	0.1	0.2		0.008	
G. fasciatus					0.02
Insects					
A. lycorias	1.4	0.83		0.17	
C. crystallinus	2.0				0.12
C. dipterum	2.0				0.1
E. subvaria	2.5	0.42			
H. bettoni	2.9	1.8		0.24	
O. rupinsulensis	1.7	1.3		0.28	
P. dorsata		3.3		9.4	
Fish					
L. machrochirus					0.17
P. promelas	0.33	8.9			4
L. reticulatus			5		
S. fontinalis					7
S. gairdnerii			0.12		
J. floridae				16	

Annex D Toxicity data for soil organisms

Legends to the tables
a = growth
b = reproduction
c = mobility
d = mortality
e = histopathological abnormalities
f = food consumption/breakdown of litter
g = sexual development
h = population increase
i = regeneration
j = sprouting

x = total concentration, measured
y = total concentration, calculated by adding the added concentration to the original concentration
z = added concentration

S.B. = Standard soil: results converted to standard soil (organic matter 10%, clay 25%)

Toxicity of cadmium for soil organisms

organism	soil properties			time	crit.	result.	S.B.	chemical	references
	pH	% O.M.	% clay			(mg/kg)	(mg/kg)	species	
Microbial processes									
H2-oxidation	7	$2.5^{\#}$	$18.5^{\#}$	16h	EC50	133^{z}	183	$Cd(NO_3)_2$	Rogers & Pryfogle, 1986
						707^{z}	972	$CdCl_2$	
	(sandy loam; # estimated values)								
Glutaminic acid degrad.	7.7	1.6	2	1.5j	EC50	150^{y}	268	$CdCl_2$	Doelman & Haanstra, 1983
	7.4	2.6	19			1000^{y}	1361		
Fe(III)reduction	5.1	3.8	4	5d	NOEC	40^{z}	63	Cd^{2+}	Welp & Brummer, 1985
Cellulose degradation	brown earth			42d	EC50	149^{z}	235	$CdCl_2$	Khan & Frankland, 1984
Enzyme activity									
Urease	7.7	1.6	2	1.5j	EC50	120^{y}	214	$CdCl_2$	Doelman & Haanstra, 1983
	5.1	5.7	9			17^{y}	23		
	7.4	2.6	19			521^{y}	709		
	6.8	3.2	60			370^{y}	334		
	6.1	5.6	30	2h	EC50	562^{z}	617	$CdSO_4$	Tabatabai, 1977
	5.8	4.4	23			562^{z}	688		
	7.4	9.3	34			562^{z}	540		
Aryl sulphatase	7.7	1.6	2	1.5j	EC50	120^{y}	214	$CdCl_2$	Doelman & Haanstra, 1983
	5.1	5.7	9			1830^{y}	2512		
	7.4	2.6	19			141^{y}	191		
	6.8	3.2	60			1020^{y}	920		
Phosphatase	7.7	1.6	2	1.5j	EC50	310^{y}	554	$CdCl_2$	Doelman & Haanstra, 1983
	7.4	2.6	19			220^{y}	297		
	6.8	3.2	60			5390^{y}	4830		
Plants									
corn	5.6	1.6	7.8	5m	$NOEC^{a}$	13^{y}	21	CdAC	Haan et al., 1985
	5.4	2.4	26			7.1^{y}	9		
	5.2	3.2	37.7			51^{y}	56		
	5.0	3.4	2.6			6.4^{y}	10.5		
	5.4	6.8	3.3			50^{y}	71		
	4.6	19.4	2.6			7^{y}	6.8		
Avena sativa	brown earth			42d	EC50	44^{z}		$CdCl_2$	Khan & Frankland, 1984
Acari									
Platynothrus peltifer	food	*	*	12w	$NOEC^{b}$	2.9^{x}	0.97	$CdSO_4$	Straalen et al., 1989
					$NOEC^{f}$	27.3^{x}	9.1		
	(* food is considered to contain 95% O.M. and no clay)								
Collembola									
Orchesella cincta	food	*	*	9w	$NOEC^{bf}$	56^{x}	18.7	$CdSO_4$	Straalen et al., 1989
					$NOEC^{a}$	4.7^{x}	1.6		
	(* food is considered to contain 95% O.M. and no clay)								
Isopoda									
Porcellio scaber	food	*	*	67d	$NOEC^{bg}$	10^{z}	3.3	$Cd(NO_3)_2$	Capelleveen, 1987
					$NOEC^{af}$	2.25^{z}	0.75		
	(* food is considered to contain 95% O.M. and no clay)								

Toxicity of cadmium for soil organisms (continued)

Oligochaeta									
Dendrobaena rubida	6.5	9.7	0	3m	$NOEC^b$	101^x	134	$Cd(NO_3)_2$	Bengtsson et al., 1986
Lumbricus rubellus	7.3	3.4	17	12w	$NOEC^b$	10^x	13.6	$CdCl_2$	Ma, 1982a
Eisenia andrei	6	10*	20*	12w	$NOEC^a$	10^y	10.7	$Cd(NO_3)_2$	Dis et al., 1988
Enchytraeus albidus	6.5	10*	20*	4w	LC50	3680^y	3925	$CdCl_2$	Rombke, 1989
	(* assumption for O.M. and clay contents of artificial soil)								
Mollusca									
Helix aspersa	food	*	*	30d	$NOEC^b$	10^z	3.3	$CdCl_2$	Russel et al., 1984
	(* food is considered to contain 95% O.M. and no clay)								

Toxicity of zinc for soil organisms:

organism	soil properties			time	crit.	result.	S.B.	chemical	references
	pH	% O.M.	% clay			(mg/kg)	(mg/kg)	species	
Microbial processes									
Soil respiration	7.7	1.6	2	70w	NOEC	164^y	393	$ZnCl_2$	Doelman & Haanstra, 1983
	5.1	5.7	9	43w	NOEC	167^y	273		
	7.4	2.6	19	90w	NOEC	3100^y	3913		
	6.8	3.2	60	80w	NOEC	626^y	373		
Glutaminic acid degr.	7.7	1.6	2	1.5j	EC50	414^y	992	$ZnCl_2$	Doelman & Haanstra, 1983
	6.8	3.2	60			1726^y	1029		
Nitrification	5.5	2.37	28.1	7w	NOEC	136^y	138	$ZnSO_4$	Wilson, 1977
	6.2	1.6	7.6			124^y	231		
	5.1	1.14	2.4			17^y	40		
Enzyme activity									
Urease	7.7	1.6	2	1.5j	EC50	304^y	729	$ZnCl_2$	Doelman & Haanstra, 1983
	5.1	5.7	9			62^y	101		
	7.4	2.6	19			3350^y	4229		
	6.8	3.2	60			311^y	185		
	4.3	12.8	5			98^y	163		
Aryl sulphatase	7.4	2.6	19	1.5j	EC50	4490^y	5668	$ZnCl_2$	Doelman & Haanstra, 1983
	6.8	3.2	60			3086^y	1840		
Phosphatase	7.7	1.6	2	1.5j	EC50	164^y	393	$ZnCl_2$	Doelman & Haanstra, 1983
	5.1	5.7	9			2987^y	4888		
	6.8	3.2	60			2936^y	1750		
Isopoda									
Porcellio scaber	food	*	*	67d	$NOEC^a$	398^z	289	$Zn(NO_3)_2$	Capelleveen, 1987
					$NOEC^f$	1000^z	727		
					$NOEC^b$	2000^z	1455		
	(* food is considered to contain 95% O.M. and no clay)								
Oligochaeta									
Eisenia foetida	6	10*	20*	14d	LC50	662^z	741	$Zn(NO_3)_2$	Neuhauser et al.,1985
	(* assumption for O.M. and clay contents of artificial soil)								
Mollusca									
Arion ater	food (lettuce etc.)			27d	$NOEC^f$	10^z	7.3	$ZnCl_2$	Marigomez et al., 1986
	(* food is considered to contain 95% O.M.and no clay)								

Toxicity of nickel for soil organism:

organism	soil properties			time	crit.	result.	S.B.	chemical	references
	pH	% O.M.	% clay			(mg/kg)	(mg/kg)	species	
Microbial processes									
Soil respiration	7.7	1.6	2	70w	NOEC	$<158^y$	461	$NiCl_2$	Doelman & Haanstra, 1983
	5.1	5.7	9	43w	NOEC	$<152^y$	280		
	7.4	2.6	19	90w	NOEC	$>8025^y$	>9685		
	6.8	3.2	60	80w	NOEC	1039^y	520		
	4.3	12.8	5	82w	NOEC	$<154^y$	<359		
Glutaminic acid degr.	7.7	1.6	2	1.5j	EC50	308^y	898	$NiCl_2$	Doelman & Haanstra, 1983
	6.8	3.2	60			1239^y	620		
	4.3	12.8	5			604^y	1409		
Enzyme activity									
Urease	7.7	1.6	2	1.5j	EC50	414^y	1207	$NiCl_2$	Doelman & Haanstra, 1983
	7.4	2.6	19			1365^y	1647		
	6.8	3.2	60			409^y	205		
	4.3	12.8	5			2344^y	5469		
	7.8	3.74	30	2h	NOEC	29.4^z	26	$NiCl_2$	Tabatabai, 1977
Aryl sulphatase	7.7	2.6	2	1.5j	EC50	98^y	286	$NiCl_2$	Doelman & Haanstra, 1983
	5.1	5.7	9			1412^y	2601		
	7.4	2.6	19			110^y	136		
	6.8	3.2	60			2489^y	1245		
Phosphatase	7.7	1.6	2	1.5j	EC50	758^y	2210	$NiCl_2$	Doelman & Haanstra, 1983
	7.4	2.6	19			2165^y	2612		
Oligochaeta									
Lumbricus rubellus	7.3	3.4	17	12w	$NOEC^b$	50^z	65	$NiCl_2$	Ma, 1982a
	7.3	8	17	12w	$NOEC^a$	85^z	110	$NiCl_2$	Ma, 1982b
Eisenia foetida	6	10*	20*	14d	LC50	757^z	883	$Ni(NO_3)_2$	Neuhauser et al., 1985

(* assumption for O.M. and clay contents of artificial soil)

Toxicity of mercury for soil organisms:

organism	soil properties			time	crit.	result.	S.B.	chemical	references
	pH	% O.M.	% clay			(mg/kg)	(mg/kg)	species	
Microbial activity									
H2-oxidation	7			16h	EC50	36^z		$HgCl_2$	Rogers & Pryfogle, 1986
ATP-content	6.4	3.1	33.6	48d	NOEC	2^z	1.9	$HgCl_2$	Zelles et al., 1985
CO2-produktion	8.1	2.7	40	4w	NOEC	10^z	8.8	$HgCl_2$	Landa & Fang, 1978
	7.5	3.2	29	4w	NOEC	100^z	99		
	8.3	1.5	12	4w	NOEC	100^z	123		
Respiration	8.3	6.7		1d	NOEC	40^z		$HgCl_2$	Doelman & Haanstra, 1983
Ammonification	7.7	5.6		42d	NOEC	100^z		$HgCl_2$	Doelman & Haanstra, 1983
Oligochaeta									
Eisenia fetida				12w	$NOEC^i$	3.25^z		methyl-HgCl	Beyer et al., 1985
Mollusca									
Arion ater	food	*	*	27d	$NOEC^f$	10^z	8.3	$HgCl_2$	Marigomez et al., 1986

(* food is considered to contain 95% O.M. and no clay)

Toxicity of lead for soil organisms:

organism	soil properties pH	% O.M.	% clay	time	crit.	result. (mg/kg)	S.B. (mg/kg)	chemical species	references
Microbial processes									
Soil respiration	7.7	1.6	2	70w	NOEC	182^{y}	289	$PbCl_2$	Doelman & Haanstra, 1983
	5.1	5.7	9	43w	NOEC	163^{y}	214		
	7.4	2.6	19	90w	NOEC	1042^{y}	1237		
	6.8	3.2	60	80w	NOEC	3130^{y}	2350		
	4.3	12.8	5	82w	NOEC	176^{y}	221		
	6.7	2.0		14d	NOEC	5000^{z}		$Pb(NO_3)_2$	Mikkelsen, 1974
	6.8	1-2		6d	NOEC	1000^{z}			
Glucose-degradation	5.0		9	16d	NOEC	1000^{z}		$Pb(NO_3)_2$	Debosz et al., 1985
	5.7	2.8	12	60h	NOEC	$<750^{z}$	<984	$PbCl_2$	Doelman & Haanstra,1979b
Cellulose-degradation	-	-	-	30d	NOEC	100^{z}		$PbCl_2$	Khan & Frankland, 1984
Ammonification	6-7	2.2		14d	NOEC	1000^{z}		PbO	Bhuiya & Cornfield, 1974
Nitrification	6-7	2.2		14d	NOEC	1000^{z}			
Enzyme activity									
Urease	7.8	6.4	30	2h	NOEC	104^{z}	102	$Pb(NO_3)_2$	Tabatabai, 1977
	7.4	9.3	34	2h	NOEC	104^{z}	95		
	6.1	5.6	30	2h	NOEC	1036^{z}	1028	PbAC	
Dehydrogenase	4.1	2.8	12		NOEC	375^{z}	492	$PbCl_2$	Doelman & Haanstra,1979a
	7.0	3.2	99		NOEC	$>7500^{z}$	>4273		
	5.6	45.7	6		NOEC	$>7500^{z}$	>6268		
Plants									
Avena sativa	-	3*	18*	42d	$NOEC^{a}$	100^{z}	120	$PbCl_2$	Khan & Frankland, 1984
Triticum aestivum	-	3*	18*	42d	$NOEC^{a}$	$<500^{z}$	<600		
Raphanus sativa	5.4	3*	18*	42d	$NOEC^{a}$	100^{z}	120	$PbCl_2$	Khan & Frankland, 1983
	(root growth; NOEC shoot growth = 1000)								
	4.6	3*	18*	42d	$NOEC^{a}$	500^{z}	600		
	(* estimated values for sandy loam)								
Picea sitchensis	3.3	7.7		100d	$NOEC^{a}$	70 shoot^{x}			Burton & Morgan,1984
						40 root^{x}			
						<34 mycor. formation^{x}			
Nematods									
Mesorhabditis monhystera	agar/bacteria			22d	$NOEC^{h}$	<7.6 food^{x}		$Pb(NO_3)_2$	Doelman et al.,1984
Aphelenchus avenae	agar/fungi			21d	$NOEC^{h}$	$\leq$0.082 food^{x}			
Isopoda									
Porcellio scaber	litter	*	*		NOEC	40^{z}	23.4		Capelleveen, 1985
	(* litter is considered to contain 95% O.M. and no clay)								
Collembola									
Onychiurus armatus	food/fungi			17w	$NOEC^{ab}$	1096^{x}	643	$Pb(NO_3)_2$	Bengtsson et al., 1985
	(* food is considered to contain 95% O.M. and no clay)								
Oligochaeta									
Dendrobaena rubida	6.5	9.7	0	3m	$NOEC^{b}$	560^{x}	797	$Pb(NO_3)_2$	Bengtsson et al., 1986
	5.5					564^{x}	803		
	4.5					130^{x}	185		
Lumbricus rubellus	7.3	3.4	17	12w	$NOEC^{b}$	200^{z}	241	$PbCl_2$	Ma, 1982a
	7.3	8	17	12w	$NOEC^{a}$	1000^{z}	1133	$PbCl_2$	Ma, 1982b
Mollusca									
Arion ater	food (lettuce etc.)			27d	$NOEC^{f}$	1000^{z}	586	$Pb(NO_3)_2$	Marigomez et al., 1986
	(* food is considered to contain 95% O.M. and no clay)								

Toxicity of chromium for soil organisms:

organism	soil properties			time	crit.	result.	S.B.	chemical	references
	pH	% O.M.	% clay			(mg/kg)	(mg/kg)	species	
Microbial processes									
CO2-production	7			20h	EC50	200^{z}		$CrCl_3$	Skujins et al., 1986
Nitrification	7.2			21d	NOEC	100^{z}		$Cr_2(SO_4)_3$	Doelman & Haanstra, 1983
Glutaminic acid degr.	7	1.6	2	1.5j	EC50	600^{z}	1111	$CrCl_3$	
Enzyme activity									
Urease	7.7	1.6	2	1.5j	EC50	634^{y}	1174	$CrCl_3$	Doelman & Haanstra, 1983
	6.8	3.2	60	1.5j	EC50	486^{y}	286		
	5.1	2.6	17	2h	EC50	260^{z}	310	$CrCl_3$	Tabatabai, 1977
	7.8	6.4	30	2h	NOEC	26^{z}	24		
Aryl sulphatase	7.7	1.6	2	1.5j	EC50	184^{y}	341	$CrCl_3$	Doelman & Haanstra, 1983
	5.1	5.7	9	1.5j	EC50	13^{y}	19		
	7.4	2.6	19	1.5j	EC50	444^{y}	505		
	6.8	3.2	60	1.5j	EC50	646^{y}	380		
Phosphatase	5.1	5.7	9	1.5j	EC50	2780^{y}	4088		
	7.4	2.6	19	1.5j	EC50	4234^{y}	4811		
	6.3	13	29	3h	NOEC	520^{z}	481	Na_2CrO_4	Tyler, 1981
Plants									
Corn	5.6	1.6	7.8	5m	$NOEC^{a}$	440^{y}	671	Cr_3AC	Haan et al., 1985
	5.4	2.4	26	5m	$NOEC^{a}$	273^{y}	268		
	5.2	3.2	37.7	5m	$NOEC^{a}$	288^{y}	230		
	5.0	3.4	2.6	5m	$NOEC^{a}$	419^{y}	759		
	5.4	6.8	3.3	5m	$NOEC^{a}$	220^{y}	389		
	4.6	19.4	2.6	5m	$NOEC^{a}$	$>814^{y}$	>1475		
Oligochaeta									
Eisenia andrei	6	7.7	10.4	3w	$NOEC^{ab}$	287^{x}	405	$Cr(NO_3)_3$	Gestel et al., 1989
				6w	$NOEC^{b}$	287^{x}	405		

Toxicity of arsenic for soil organisms:

organism	soil properties			time	crit.	result.	S.B.	chemical	references
	pH	% O.M.	% clay			(mg/kg)	(mg/kg)	species	
Microbial processes									
N-mineralisation	5.8	4.4	23	20d	NOEC	375^{z}	419	$NaAsO_2$	Liang & Tabatabai, 1977
	6.6	5.0	45			375^{z}	311		
	7.8	6.4	30			375^{z}	368		
	7.4	9.3	34			375^{z}	336		
Enzyme activity									
Phosphatase	6.3	13	29	3h	NOEC	749^{z}	683	$NaAsO_2$	Tyler, 1981
Plants									
Gossypium hirsutum		2.5*	18*	6wk	$NOEC^{a}$	28^{z}	35	As_2O_3	Deuel & Swoboda, 1972
		3.2*	35*			149^{z}	143		
Glycine max		3.2*	35*			75^{z}	72		

(* estimated values)

Toxicity of copper for soil organisms:

organism	soil properties			time	crit.	result.	S.B.	chemical	references
	pH	% O.M.	% clay			(mg/kg)	(mg/kg)	species	
Microbial processes									
N-mineralisation	6.6	5.0	45	20d	NOEC	318^z	254	$CuSO_4$	Liang & Tabatabai, 1977
Ammonification	5.8	2.6	23	20d	NOEC	300^z	356	$CuCl_2$	Doelman & Haanstra, 1983
	5.1	2			NOEC	100^z			
	5.9	2			NOEC	100^z	140		
	7.4	2	16	21d	EC50	100^z			
Glutaminic acid degr.	7.7	1.6	2	1.5j	EC50	204^y	428	$CuCl_2$	Doelman & Haanstra, 1983
	7.4	2.6	19			822^y			
	6.8	3.2	60			1252^y			
	4.3	12.8	5			806^y			
Enzyme activity									
Urease	7.7	1.6	2	1.5j	EC50	624^y	1309	$CuCl_2$	Doelman & Haanstra, 1983
	7.4	2.6	19			2022^y	2603		
	6.8	3.2	60			1132^y	770		
	6.8	7.4	42	2h	EC50	318^z	256	$CuCl_2$	Tabatabai, 1977
	7.4	9.3	34			318^z	279	$CuSO_4$	
Aryl sulphatase	7.7	1.6	2	1.5j	EC50	284^y	596	$CuCl_2$	Doelman & Haanstra, 1983
	5.1	5.7	9			557^y	842		
	7.4	2.6	19			782^y	1007		
	6.8	3.2	60			4962^y	3340		
Phosphatase	7.7	1.6	2	1.5j	EC50	154^y	323	$CuCl_2$	Doelman & Haanstra, 1983
	5.1	5.7	9			1887^y	2852		
	7.4	2.6	19			752^y	968		
	6.8	3.2	60			2832^y	1927		
	4.3	12.8	5			2316^y	3247		
Plants									
corn	5.6	1.6	7.8	5m	$NOEC^a$	206^y	359	CuAC	Haan et al., 1985
	5.4	2.4	26			207^y	233		
	5.0	3.4	2.6			204^y	395		
	5.4	6.8	3.3			219^y	374		
	4.6	19.4	2.6			$>421^y$	>537		
Collembola									
Onychiurus armatus	food	*	*	17w	$NOEC^a$	2608^x	1304	$Cu(NO_3)_2$	Bengtsson et al., 1983
	(* food is considered to contain 95% O.M. and no clay)								
Oligochaeta									
Dendrobaena rubida	6.5	9.7	0	3m	$NOEC^b$	122^x	211	$Cu(NO_3)_2$	Bengtsson et al., 1986
Eisenia andrei	6	10*	20*	7d	$NOEC^b$	66^y	72	$CuCl_2$	Gestel et al., 1989
Eisenia andrei	6	10*	20*	12w	$NOEC^a$	62^y	68	$CuCl_2$	Dis et al., 1988
	(* assumption for O.M. and clay contents of artificial soil)								
Lumbricus rubellus	7.3	3.4	17	12w	$NOEC^b$	30^x	40	$CuCl_2$	Ma, 1982a
					$NOEC^f$	63^x	83		
					$NOEC^a$	373^x	493		
Allolobophora caliginosa	sand+grass (=1% om)			14d	$NOEC^b$	50^z		$CuSO_4$	Martin, 1986
					$NOEC^a$	100^z			
Mollusca									
Arion ater	food	*	*	27d	$NOEC^f$	25^z	12.5	$CuSO_4$	Marigomez, 1986
	(* food is considered to contain 95% O.M. and no clay)								

Toxicity of atrazin for soil organisms:

organism	soil properties pH	% O.M.	% clay	time	crit.	result. (mg/kg)	S.B. (mg/kg)	references
Microorganisms								
Biomass	6.9	2.9	8	15d	NOEC	5	17.2	Zelles et al., 1984
	6.4	3.2	33.6	15d	NOEC	10	31.2	
Microbial activity								
Denitrification	7.5	3.3	30	8d	NOEC	50	152	Yeomans & Bremner, 1985
	7.7	6.6	41	8d	NOEC	50	76	
	8.1	0.5	28	8d	NOEC	50	250	
	7.7	3	31	7d	NOEC	100	333	Yeomans & Bremner, 1987
	7.9	4.2	40	7d	NOEC	100	238	
	8.1	1.2	19	7d	NOEC	100	500	
Respiration	7.4	2.9		67h	NOEC	10	34	Tu, 1988
ATP-content	6.4	3.2	33.6	48d	NOEC	200	625	Zelles et al., 1985
CO2-production	6.4	3.2	33.6	48d	NOEC	200	625	
FDA-hydrolysis	6.4	3.2	33.6	48d	NOEC	200	625	
Enzyme activity								
Invertase	7.4	2.9		67h	NOEC	10	34	Tu, 1988
Amylase	7.4	2.9		67h	NOEC	10	34	
Acarina								
Acarina	8	0.8	26	30d	EC50num	0.3	6.5	Fratello et al., 1985
Collembola								
Onychiurus armatus				60d	NOEC^{b}	10		Mola et al., 1987
Onychiurus apuanicus				60d	NOEC^{b}	10		
collembola	8	0.8	26	30d	EC50num	1.3	6.5	Fratello et al., 1985
Oligochaeta								
Aporrectodea caliginosa	5.6	4.8		7d	LC50	52.2	109	Pizl, 1988
Lumbricus rubellus	5.6	4.8		7d	LC50	28.3	59	
Octolasion lacteum	5.6	4.8		7d	LC50	84.6	176	
Eisenia fetida	5.6	4.8		7d	LC50	74.9	156	
	7	10	5	14d	LC50	131	131	Haque & Ebing, 1983
Lumbricus terrestris	6.1	11.5	2.9	14d	LC50	444	386	
Eudrilus eugeniae				32d	NOLC	32		Caseley & Eno, 1966

Toxicity of lindane for soil organisms:

organism	soil properties pH	% O.M.	% clay	time	crit.	result. (mg/kg)	S.B. (mg/kg)	references
Collembola								
Folsomia candida		0.7	1.7	24h	NOLC	0.01	0.05	Thompson & Gore, 1972
					LC50*	0.15	0.75	
					LC50**	0.19	0.95	
	(* = 13 °C; ** = 24 °C)							
Oligochaeta								
Lumbricus rubellus		3.4	17	6w	NOEC^{b}	10	29	Ma, 1982a
Lumbricus terrestris	6.1	11.5	2.9	14d	LC50	113	98	Haque & Ebing, 1983
Eisenia fetida	7	10	5	28d	LC50	59	59	Heimbach, 1984

Toxicity of diazinon for soil organisms:

organism	soil properties			time	crit.	result.	S.B.	references
	pH	% O.M.	% clay			(mg/kg)	(mg/kg)	
Enzyme activity								
Amylase	7.4	2.9		3d	NOEC	10	35	Tu, 1988
Invertase				2d	NOEC	10	35	
Microbial processes								
Soil respiration	7.4	2.9		67h	NOEC	10	35	Tu, 1988
Insects								
Gryllus pennsylvanicus		1.4	2.3	24h	LC50	0.4	2.0	Harris, 1967
		15.9	23.2			3.32	2.1	
		64.6	16.5			17.0	5.7	
		0.5				0.3	1.5	Harris, 1964a
		0.5	1.7			0.23	1.2	Harris, 1966
		2.0	10.8			0.84	4.2	
		6.6	14.9			1.89	2.9	
		9.1	47.4			1.55	1.7	
		18.7	26.1			5.15	2.8	
		39.8	22.8			10.4	2.6	
Euxesia notata		1.4	10.5	24h	LC50	0.36	1.8	Harris, 1964b
Collembola								
Folsomia candida		0.7	1.7	24h	LC50	0.14	0.7	Thompson & Gore, 1972
					NOLC	0.05	0.25	
Carabidae								
Trechus quadristriatus				24h	LC50	5		Mowat & Coacker, 1967
Agonum dorsale						7		
Feronia melanaria						10		
Thread worms								
Melanotus communis		7.4		21d	LC50	2.13	2.9	Campbell et al., 1971
		9		28d	LC50	2.81	3.1	

Toxicity of azinphos methyl for soil organisms:

organism	soil properties			time	crit.	result.	S.B.	references
	pH	% O.M.	% clay			(mg/kg)	(mg/kg)	
Collembola								
Folsomia candida		0.7	1.7	24h	LC50	1.0	5.0	Thompson & Gore, 1972
					NOLC	0.5	2.5	
Carabidae								
Agonum dorsale	sandy loam			24h	LC50	500		Mowat & Coacker, 1967
Trechus quadristria						800		
Feronia melonaria						1800		

Toxicity of dieldrin for soil organisms:

organism	soil properties pH	 % O.M.	 % clay	time	crit.	result. (mg/kg)	S.B. (mg/kg)	references
Microorganisms								
Bacteria	6.5	0.7		5w	NOEC*	20	100	Tu, 1978
	7.6	8.1		5w	NOEC*	20	24.7	
	7.9	2.9		5w	NOEC*	20	69	
Fungi	6.5	0.7		5w	NOEC*	20	100	Tu, 1978
	(* = numbers)							
Microbial activity								
respiration	7.4	2.9		2d	NOEC	10	34	Tu, 1988
Enzyme activity								
Amylase	7.4	2.9		2d	NOEC	10	34	Tu, 1988
Invertase	7.4	2.9		2d	NOEC	10	34	Tu, 1988
Collembola								
Folsomia candida		0.7	1.7	24h	NOLC	0.1	0.5	Thompson & Gore, 1972
		0.7	1.7	24h	LC50	0.22	1.1	
Insects								
Gryllus pennsylvanicus		1.4	2.3	24h	LC50	0.27	1.35	Harris, 1967
		1.4	10.3	24h	LC50	0.27	1.35	
Carabidae								
Bembidion lampros				500h	LC50	3.0		Mowat & Coacker, 1967
Trechus quadristriatus				500h	LC50	0.8		
Nebria brevicollis				500h	LC50	1.0		
Harpalus aeneus				500h	LC50	1.3		
Harpalus rufipus				500h	LC50	1.0		
Feromia melanaria				500h	LC50	1.5		
Myriapoda								
Alloporus sp.				21d	NOLC	58		Basson, 1970

Toxicity of malathion for soil organisms:

organism	soil properties			time	crit.	result.	S.B.	references
	pH	% O.M.	% clay			(mg/kg)	(mg/kg)	
Microorganisms/Algae								
Anabaena cylindrica	6.1	0		1h	EC50	100	500	DaSilva et al., 1975
Aulosira sp.				1h	EC50	100	500	
Chloroglorea fritchii				1-8d	NOEC	100	500	
Cylindrospermum muscicola				17d	EC50	100	500	
Nostoc muscorum				1-8d	EC50	100	500	
Microbial processes								
Denitrification	7.7	6.6	41	8d	NOEC	10	15.2	Yeomans & Bremner, 1985
	8.1	0.5	28			10	50	
Urea hydrolysis	7.7	1.0	17	3wk	NOEC	10	50	Sahrawat, 1979
Nitrification	7.7	1.0	17	6wk	NOEC	10	50	Sahrawat, 1979
Enzyme activity								
Invertase	7.37	2.9		1-2d	NOEC	10	34	Tu, 1988
Glucanase	5.4	3.7	20	110d	EC50	14.75	40	Lethbridge et al., 1981
Plants								
Sorghum				7d	NOEC[j]		2.7	Ram & Gupta, 1974

Toxicity of parathion-ethyl for soil organisms:

organism	soil properties pH	 % O.M.	 % clay	time	crit.	result. (mg/kg)	S.B. (mg/kg)	references
Microorganisms/algae								
Algae	8.1			21d	NOEC^a	5		Muralikrishna & Venkateswarku, 1984
Microbial activity								
Urea hydrolysis	7.7	1	17	4w	NOEC	50	250	Sahrawat, 1979
Respiration	7.4	2.9		67h	NOEC	10	34	Tu, 1988
Enzyme activity								
Amylase	7.4	2.9		67h	NOEC	10	34	Tu, 1988
Invertase	7.4	2.9		67h	NOEC	10	34	Tu, 1988
Collembola								
Folsomia candida		0.7	1.7	24h	NOLC	0.01	0.05	Thompson & Gore, 1972
					LC50*	0.14	0.7	
					LC50**	0.03	0.15	
	(* = 13 °C; ** = 24 °C)							
Insects								
Gryllus pennsylvanicus		1.4	2.3	24h	LC50	0.46	2.3	Harris, 1967
		15.9	23.2	24h	LC50	4.32	2.7	
		64.6	16.5	24h	LC50	21.11	7.0	
		0.52		18h	LC50	0.25	1.25	Harris, 1964a
		2	10.6	18h	LC50	0.67	3.4	Harris, 1966
		6.4	14.8	18h	LC50	1.8	2.8	
		9.1	47	18h	LC50	1.5	1.6	
		18.7	25.1	18h	LC50	6.0	3.2	
		39.8	19.2	18h	LC50	13.6	4.5	
Euxesia notata		1.4	10.3	48h	EC50*	0.72	3.6	Harris, 1964b
	(* = effect on populations)							
Oligochaeta								
Allolobophora chlorotica				7d	LC50	80		Fayolle, 1979
Eisenia andrei	6	8.1	8.1	2w	NOEC^b	5	6.2	Emans & Janssen, 1989
					NOEC^a	16	19.8	
					LC50	218.3	270	

Toxicity of PAH for soil organisms:

organism	soil properties pH	 % O.M.	 % clay	time	crit.	result. (mg/kg)	S.B. (mg/kg)	references
Fluorene								
Oligochaeta								
Allolobophora caliginosa	6	10*	20*	14d	LC50	206	206	Neuhauser et al., 1986
Eisenia fetida	6	10*	20*	14d	LC50	173	173	
Eudrilus eugeniae	6	10*	20*	14d	LC50	197	197	
Perionyx excavatus	6	10*	20*	14d	LC50	170	170	
	(* assumption for artificial soil with 10% peat and 20% clay).							

Toxicity of chlorophenols for soil organisms:

organism	soil properties			time	crit.	result.	S.B.	references
	pH	% O.M.	% clay			(mg/kg)	(mg/kg)	
3-chlorophenol								
Oligochaeta								
Eisenia andrei	5.6	6.1	2.4	2wk	LC50	134	220	Gestel & Ma, 1989
	5.2	3.7	1.4			79	214	
	6	8.1	8.1			130	160	
	3.8	15.6	9			423	271	
Lumbricus rubellus	5.6	6.1	2.4	2wk	LC50	342	561	Gestel & Ma, 1989
	5.2	3.7	1.4			140	378	
	6	8.1	8.1			247	305	
	3.8	15.6	9			633	406	
2,4-dichlorophenol								
Oligochaeta								
Eisenia andrei	5.6	6.1	2.4	2wk	LC50	240	393	Gestel & Ma, 1989
	5.2	3.7	1.4			134	362	
	6	8.1	8.1			177	219	
	3.8	15.6	9			423	271	
Lumbricus rubellus	5.6	6.1	2.4	2wk	LC50	486	797	Gestel & Ma, 1989
	5.2	3.7	1.4			352	951	
	6	8.1	8.1			322	398	
	3.8	15.6	9			680	436	
2,4,5-trichlorophenol								
Oligochaeta								
Eisenia andrei	5.6	6.1	2.4	2wk	LC50	76	125	Gestel & Ma, 1989
	5.2	3.7	1.4			46	124	
	6	8.1	8.1			63	78	
	3.8	15.6	9			165	106	
Lumbricus rubellus	5.6	6.1	2.4	2wk	LC50	316	518	Gestel & Ma, 1989
	5.2	3.7	1.4			235	635	
	6	8.1	8.1			362	447	
	3.8	15.6	9			875	561	
2,4,6-trichlorophenol								
Oligochaeta								
Allolobophora caliginosa	6.0	10#	20#	14d	LC50	108	108	Neuhauser et al., 1986
Eisenia fetida						58	58	
Eudrilus eugeniae						85	85	
Perionys excavatus						78	78	
2,3,4,5-tetrachlorophenol								
Oligochaeta								
Eisenia andrei	5.6	6.1	2.4	2wk	LC50	166	272	Gestel & Ma, 1989
	5.2	3.7	1.4			117	316	
Lumbricus rubellus	5.6	6.1	2.4	2wk	LC50	875	1434	Gestel & Ma, 1989
	5.2	3.7	1.4			515	1392	

Toxicity of chlorophenols for soil organisms: (continued)

organism	soil properties			time	crit.	result.	S.B.	references
	pH	% O.M.	% clay			(mg/kg)	(mg/kg)	
pentachlorophenol								
Microbial processes								
ATP-content	6.4	3.1	33.6	48d	NOEC	2	6.5	Zelles et al., 1985
Soil respiration	5.2	6	<8	5h	NOEC	>1000	>1667	Vonk et al., 1986
	5.2	6	<8	5h	NOEC	100	167	
Nitrification	5.2	6	<8	28d	NOEC	10	17	Vonk et al., 1986
Plants								
Avena sativa		5.7	<8	3d	NOEC^{j}	32	56	Vonk et al., 1986
				2wk	NOEC^{a}	10	17.5	
Lactuca sativa				3d	NOEC^{j}	3.2	5.6	
				2wk	NOEC^{a}	1.0	1.7	
Oligochaeta								
Eisenia andrei	5.6	6.1	2.4	2wk	LC50	142	233	Gestel & Ma, 1989
	5.2	3.7	1.4			84	277	
	6	8.1	8.1			86	106	
	3.8	15.6	9			503	322	
	7	7.7	10.4	2wk	LC50	28.5	37	Gestel & Dis, 1988
	7	1.7	4.3			16	80	
	4.1	1.7	4.3			52	260	
Eisenia fetida	6	10	5	4wk	LC50	87	87	Heimbach, 1984
	6	10#	20#	4wk	LC50	10	10	Vonk et al., 1986
					NOEC^{b}	5.6	5.6	
Lumbricus rubellus	5.6	6.1	2.4	2wk	LC50	1013	1661	Gestel & Ma, 1989
	5.2	3.7	1.4			1206	3259	
	6	8.1	8.1			362	447	
	3.8	15.6	9			4627	2966	
Enchytraeus albidus	6.5	10#	20#	4wk	LC50	136	136	Rombke, 1989

assumption for artificial soil with 10 % peat and 20 % kaolin clay

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Annex E Data used for deriving maximum acceptable risk levels for soil

A. Data used when applying the Health Council procedure

The toxicity data used for this apply to standard soil. If more than one relevant parameter (reproduction, growth or survival) was determined for an organism then the most sensitive parameter was used.

Substance	organism	NOE(L)n (mg/kg)
cadmium	corn	19.4
	Platynothrus peltifer	0.97
	Orchesella cincta	1.6
	Porcellio scaber	0.75
	Dendrobaena rubida	134
	Lumbricus rubellus	13.6
	Eisenia andrei	10.7
	Helix aspersa	3.3

To apply modification 2, one single group value was calculated for earthworms by taking the geometric average of the three values (134, 13.6 adn 10.7), i.e. 26.9.

Substance	organism	NOE(L)C (mg/kg)
lead	Avena sativa	120
	Triticum aestivum	300*
	Rhaphanus sativa	120
	Porcellio scaber	23.4
	Onychiurus armatus	643
	Dendrobaena rubida	800
	Lumbricus rubellus	241
	Arion ater	586

* as the NOEC was specified as <600 half this value was used.
Modification 2; plants 163 (geometric mean 120, 300 and 120); earthworms 438 (geometric mean 797 and 241).

Substance	organism	NOE(L)C (mg/kg)
copper	corn	367
	Onychiurus armatus	1304
	Dendrobaena rubida	211
	Eisenia andrei	68
	Lumbricus rubellus	40
	Arion ater	12.5

Modification 2; earthworms 83 (geometric mean 211, 68 and 40).

B. Data used when applying the EPA method

When determining the lowest values according to Annex D only those values were included which could be converted to standard soil. In some cases the same parameter was studied in several soil types, in which case the geometric average was used.

Substance	Lowest NOE(L)C	organism/parameter	Lowest E(L)C50	organism/parameter
cadmium	0.75	Porcellio scaber	185 (geom. mean)	urease
zinc	7.3	Arion ater	393 (geom. mean)	urease
nickel	26	urease	596 (geom. mean)	aryl sulphatase
mercury	2	ATP-content	-	-
lead	23.4	Porcellio scaber	-	-
chromium	24	urease	188 (geom. mean)	aryl sulphatase
arsenic	71	Gossypium hirsutum	-	-
copper	12.5	Arion ater	140	ammonification
atrazin	24 (geom. mean)	biomass micro-org.	6.5	number collembola
azinphos methyl	5	Folsomia candida	2.5	Folsomia candida
diazinon	0.25	Folsomia candida	0.7	Folsomia candida
dieldrin	0.5	Folsomia candida	1.1	Folsomia candida
malathion	27.6	denitrification	40	glucanase
parathion-ethyl	0.05	Folsomia candida	0.7	Folsomia candida
lindane	0.05	Folsomia candida	0.95	Folsomia candida
3-CP	-	-	213 (geom. mean)	Eisenia andrei
2,4-diCP	-	-	303 (geom. mean)	Eisenia andrei
2,4,5-triCP	-	-	106 (geom. mean)	Eisenia andrei
2,4,6-triCP	-	-	58	Eisenia andrei
2,3,4,5-tetraCP	-	-	293 (geom. mean)	Eisenia andrei
pentaCP	1.7	Lactuca sativa	29.5 (geom. mean)	Eisenia andrei
Fluorene	-	-	170	Perionyx excavatus

Annex F Data on the present concentrations in water, sediment, soil and ground water

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
CADMIUM								Ros en Slooff (1987)
WATER (µg.l-1)								
Rijkswater	108				0.025	0.132	1.902	Van der Kooij (1989)
Niet-Rijkswater	110				0	0.2	1	ditto
SEDIMENT (mg.kg-1)								
Rijkswater	2925				0.525	1.537	15.192	ditto
Niet-Rijkswater	317				0.143	0.634	3.566	ditto
SOIL (mg.kg-1)								
land en tuinbouw	708	0.04	0.5	14		0.4		Wiersma et al. (1986)
idem (95 percentiel)	673	0.04	0.4	1				ditto
kasgrond	155	0.08	0.8	11		0.6		ditto
idem (95 percentiel)	147	0.08	0.6	1.3				ditto
	78	0.2	1	14		0.5		ditto
	46	0.1	0.4	2.9		0.3		ditto
	46	0.1	0.4	2.2		0.4		ditto
alle monsters	925		0.4				0.19	Van Driel et al. (1983)
kleigronden	520		0.41				0.19	gegegevens ook per regio
zandgronden	298		0.32				0.18	beschikbaar
veengronden	40		0.87				0.32	ditto
dalgronden	43		0.3				0.19	ditto
lossgronden	24		0.78				0.16	ditto
landbouw, klei	248		0.5					Van Driel en Smilde (1982)
zonder susp soils	63		0.34					ditto
landbouw, zand	40		0.3					ditto
landbouw, veen	22		0.9					ditto
landbouw, dalgrond	8		0.3					ditto
landbouw, loss			0.9					ditto
polder (1759)			0.3					Salomons en De Groot (1977)
polder (1927)			1.9					ditto
polder (1957)			13.4					ditto
uiterwaarden Rijn			16					ditto
uiterwaarden Maas			31					ditto
uiterwaarden Schelde			3					ditto
uiterwaarden	13		8.8					Ros en Slooff (1987)
Biesboschpolders	210		6.7					ditto
havenslib	149		7.1					ditto
natuur, zand		< 0.05		0.74				Edelman (1983) (gemiddelden)
natuur, zavel/leem		0.1		0.58				ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
natuur, klei		0.27		0.55				ditto
natuur, venige klei/kleiig veen		0.29		1.2				ditto
natuur, veen		1		1.8				ditto
dennebos, natuur	15		0.8					VTCB (1986)
dennebos, nabij verkeer	5		0.5					ditto
dennebos nabij Hoogovens	5		1.5					ditto
dennebos nabij Budelco	5		7.8					ditto
dennebos nabij Billiton	5		1.1					ditto
weiland	2	0.05		0.15				Hart et al. (1988)
weiland	2	< 0.005		< 0.005				ditto
weiland	3	0.1	0.133	0.15				ditto
ONTWERP-BODEMMEETNET								
leemarme veldpodzol	80	0.05	0.22	0.4				RIKILT (1989)
enkeerdgrond	72	0.05	0.211	0.42				RIKILT (1989)
veengrond	32	0.55	1.175	1.45				RIKILT (1989)
kalkvrije zware zavel/klei	56	0.16	0.281	0.45				RIKILT (1989)
leemarme vlakvaaggrond	16	0.05	0.052	0.06				RIKILT (1989)
GROUNDWATER (µg.l-1)								
Nederland	225			0.1				Van Duijvenbooden (1989)
idem	10	0.1		0.2				ditto
idem	9	0.2		0.4				ditto
idem	10	0.4		0.8				ditto
idem	11	0.8		1.6				ditto
idem	5	1.6		3.2				ditto
idem	4	3.2		6.4				ditto
idem	1	6.4		12.8				ditto
Z-Holland, niet gecontamineerd	171			0.05				ditto
idem	62	0.05		0.2				ditto
idem	21	0.2		0.5				ditto
idem	31	0.5		1.5				ditto
idem	7	1.5						ditto
MERCURY								
WATER (µg.l-1)								
Rijkswater	112		0.018	0.057	0.235			Van der Kooij (1989)
Niet-Rijkswater	73		0.004	0.06	0.5			ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
SEDIMENT (mg.kg-1)								
Rijkswater	2260		0.215	0.771	2.799			ditto
Niet-Rijkswater	275		0.055	0.215	1.679			ditto
SOIL (mg.kg-1)								
land en tuinbouw	707	0	0.16	31		0.07		Wiersma et al. (1986)
idem (95 percentiel)	671	0	0.08	0.32				ditto
kasgrond	155	0.02	0.36	7.2		0.16		ditto
idem (95 percentiel)	147	0.02	0.24	1.1				ditto
	78	0.01	0.24	3.2		0.1		ditto
	46	0.01	0.06	0.49		0.04		ditto
	46	0.01	0.07	0.28		0.06		ditto
landbouw, klei	248		0.2					Van Driel en Smilde (1982)
landbouw, zand	63		0.2					ditto (CCRX, 1986)
landbouw, veen	40		0.2					ditto
landbouw, dalgrond	22		0.1					ditto
landbouw, loss	8		0.1					ditto
natuurgebied	112	0,01	0.12	0.78				ditto
polder (1759)			0.3					Salomons en De Groot (1977)
polder (1927)			0.7					ditto
polder (1957)			10					ditto
uiterwaarden Rijn			12					ditto
uiterwaarden Maas			4					ditto
uiterwaarden Schelde			2					ditto
idem, zand		0.02		0.1				Edelman (1983)
idem, zavel/leem		0.06		0.36				ditto
natuurgebied, klei		0.08		0.15				ditto
idem, kleiige veen/venige klei		0.14		0.51				ditto
idem, veen		0.06		0.23				ditto
	3	2	6	12				CCRX (1986)
idem	3	0.1	4.627	10.43				ditto
	3	0.01	1.02	2.6				ditto
idem	3	2.3	3.967	4.6				ditto
polders met havenslib	248		5.375					ditto
bollenstreek	2		0.145					ditto
	2		0.075					ditto
idem		< 0.005						ditto
tuinbouw, glas	155	0.02	0.36	7.2				ditto
land- en tuinbouw	507	0.01	0.15	6.35				ditto
zand, kasgewas	116		0.1					ditto
zavel, kasgewas	152		0.16					ditto
klei, kasgewas	151		0.2					ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
zand, veldgewas	23	0.01	0.13	1.8				ditto
zavel, veldgewas	52	0.01	0.35	4.6				ditto
klei, veldgewas	40	0.01	0.38	6.35				ditto
ONTWERP-BODEMMEETNET								
leemarme veldpodzol	80	0.01	0.035	0.09				RIKILT (1989)
enkeerdgrond	72	0.015	0.041	0.07				ditto
veengrond	32	0.035	0.429	2				ditto
kalkvrije zware zavel/klei	48	0.025	0.09	0.18				ditto
leemarme vlakvaaggrond	16	0.01	0.021	0.035				ditto
GROUNDWATER (µg.l-1)								
		0.002	0.02	0.05				CCRX (1986)
		0.003	0.018	0.03				ditto
Z-Holland, niet gecontamineerd	207			0.05				Van Duijvenbooden (1989)
Z-Holland, niet gecontamineerd	10	0.05		0.2				ditto
Z-Holland, niet gecontamineerd	2	0.2		0.5				ditto
Z-Holland, niet gecontamineerd	1	1.5						
COPPER								Slooff et al. (1987)
WATER (µg.l-1)								
Rijkswater	113				2.263	5.139	13.448	Van der Kooij (1989)
Niet-Rijkswater	156				0	5	13.63	ditto
SEDIMENT (mg.kg-1)								
Rijkswater	2971				11.333	34.807	144.723	ditto
Niet-Rijkswater	316				8.556	26.428	96.997	ditto
SOIL (mg.kg-1)								
landbouw, klei	248			23				Van Driel en Smilde (1982)
landbouw, zand	63			11				ditto
landbouw, veen	40			101				ditto
landbouw, dalgrond	22			25				ditto
landbouw, loss	8			86				ditto
polder (1759)				29				Salomons en De Groot (1977)
polder (1927)				53				ditto
polder (1957)				247				ditto
uiterwaarden Rijn				295				ditto
uiterwaarden Maas				191				ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
uiterwaarden Schelde				81				ditto
natuur, zand		0.83	9.4					Edelman (1983)
natuur, zavel/leem		4.4	41					gemiddelden
natuur, klei		18	31					ditto
natuur, venige klei/kleiig veen		11	50					ditto
natuur, veen		5.2	29					ditto
dennebos, natuur	15			22				VTCB (1986)
dennebos, nabij verkeer	5			117				ditto
dennebos, nabij Hoogovens	5			43				ditto
dennebos, nabij Budelco	5			50				ditto
dennebos, nabij Billiton	5			37				ditto
weiland	2	35	40			tot 0.2		Hart et al. (1988)
weiland	2	25	30			tot 0.5		ditto
weiland	3	45	51	48				ditto
ACHTERGRONDGEBIEDEN								Slooff et al. (1987)
Zand A0			27					
Zand A1			3.2					
Zand B2			1.4					
Zand B3			1.4					
Zand C			1.8					
Zand G			2.8					
Zand			van 0.8	tot 9.4				
Zand, podzol			6					
Zand, podzol			2					
Zavel/leem			van 4.4	tot 41				
Bosbodems			van 13	tot 19				
Klei			van 18	tot 31				
Venige klei			van 11	tot 50				
Veen			van 5.2	tot 29				
Fluviatiele afzettingen (>300 jaar)			van 10	tot 22				
Fluviatiele afzettingen (>100 jaar)			van 17	tot 67				
LANDBOUWGRONDEN								
Zand	63		11					
	428		6.8					
	238		5.6					
			van 11	tot 15				
			van 6	tot 14				
			van 2	tot 10				
Zand			van 2	tot 3				
Tertiair zand	7		14.9					

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
Zandig loss	14		11.2					
Loss	8		13					
Loss	6		7.6					
Loss	5		8.9					
Loss	124		van 12	tot 15.7				
Loss colluvium	22		12.3					
Dalgrond	22		21					
OVERSTROMINGSGEBIEDEN								Slooff et al. (1987)
Uiterwaarden, Rijn en IJssel			van 160	tot 170				
Winterbed Maas	128		van 53	tot 59				
Maasdal, > 1x per 5 jaar overstroomd	124					50		
Maasdal, < 1x per 5 jaar overstroomd	95					22		
Geuldal	18					15		
Geuldal	14					13		
Wormdal	9					17		
Oevers van de Roer	18		60					
Verdronken land van Saeftinge	11					53		
HAVENSLIBGRONDEN (bij 50% < 16 um)								
Broekpolder (opgespoten 1969-1975)	153		van 93	tot 186				
Buiten Nieuwlandse Polder (1965-1969)	75		van 125	tot 152				
ONTWERP-BODEMMEETNET								
leemarme veldpodzol	80	1	8.325	27				RIKILT (1989)
enkeerdgrond	72	2.5	10.907	34				RIKILT (1989)
veengrond	32	12.5	58.032	200				RIKILT (1989)
kalkvrije zware zavel/klei	56	10.5	25.72	55				RIKILT (1989)
leemarme vlakvaaggrond	16	1	1.094	1.5				RIKILT (1989)
GROUNDWATER (μg.l-1)								
			1.3					Van Duijvenbooden (1989)
			1.5					ditto
			1.1					ditto
			0.9					ditto
			0.4					ditto
			2					ditto
			0.4					ditto
			1.9					ditto
			0.9					ditto
			1.9					ditto
			1					ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
			0.8					ditto
			2.2					ditto
			6.5					ditto
			0.3					ditto
			0.4					ditto
			0.9					ditto
			2.6					ditto
	4			0.01				ditto
	1			0.01				ditto
	3			0.01				ditto
	36	0.01		0.1				ditto
	26	0.01		0.1				ditto
	2	0.01		0.1				ditto
	21	0.1		0.25				ditto
	16	0.1		0.25				ditto
	3	0.25		0.5				ditto
	2	0.25		0.5				ditto
	2	0.5		2				ditto
	3	0.5		2				ditto
	14			0.01				ditto
	1			0.01				ditto
	1			0.01				ditto
	36	0.01		0.1				ditto
CHROMIUM								Slooff et al. (1989b)
WATER (µg.l-1)								
Rijkswater	112				1.402	7.191	26.864	Van der Kooij (1989)
Niet-Rijkswater	124				0.225	2.2	11.15	ditto
SEDIMENT (mg.kg-1)								
Rijkswater	2949				19.608	90.455	185.068	ditto
Niet-Rijkswater	320				11.136	28.348	68.37	ditto
SOIL (mg.kg-1)								
landbouw, klei	248	20	78	130				Van Driel en Smilde (1982)
landbouw, zand	63	0	26	80				ditto
landbouw, veen	40	20	63	100				ditto
landbouw, dalgrond	22	0	20	30				ditto
landbouw, loss	8		68					ditto
polder (1759)			94					Salomons en De Groot (1977)

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
polder (1927)			112					ditto
polder (1957)			406					ditto
uiterwaarden Rijn			530					ditto
uiterwaarden Maas			162					ditto
uiterwaarden Schelde			139					ditto
zand, natuurgebied				56				VTCB (1986)
veen, natuurgebied				164				ditto
veen (50% org.), natuurgebied				56				ditto
veen (100% org.), natuurgebied				50				ditto
zavel		11		43				Edelman (1983); gemiddelden
zavel/leem		33		75				ditto
klei		75		117				ditto
venige klei/kleiig veen		66		95				ditto
veen		16		42				ditto
polder uit 1759			94					Salomons en de Groot (1977)
polder uit 1927			112					ditto
polder uit 1957			406					ditto
weiland	2	14		19				Hart et al. (1988)
weiland	2	9		11.5				ditto
weiland	3	20	28.333	42.5				ditto
GROUNDWATER (µg.l-1)								
			0.6					Van Duijvenbooden (1989)
			0.4					ditto
			0.8					ditto
natuur			0.2					ditto
natuur			0.3					ditto
grasland			0.4					ditto
grasland			0.4					ditto
bouwland			0.3					ditto
bouwland			0.7					ditto
woonbebouwing			0.4					ditto
woonbebouwing			0.6					ditto
			0.68	2.4				Van Duijvenbooden et al.(1985)
			0.87	3.6				ditto
Veluwe, infiltratie		1		5				Van Duijvenbooden (1981)
duinen, infiltratie		0.6		1				ditto
Broekpolder (stort rivierslib)			3.5					Kerdijk (1981)
Z-Holland, niet gecontamineerd	177			0.5				Van Duijvenbooden (1989)
Z-Holland, niet gecontamineerd	36	0.5		1				ditto
Z-Holland, niet gecontamineerd	34	1		5				ditto
Z-Holland, niet gecontamineerd	31	5		10				ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
Z-Holland, niet gecontamineerd	6	10		20				ditto
ARSENIC								Slooff et al. (1989c)
WATER (µg.l-1)								
Rijkswater	113				0.924	1.64	4.127	Van der Kooij (1989)
Niet-Rijkswater	115				0	2.4	6.6	ditto
SEDIMENT (mg.kg-1)								
Rijkswater	2140				6.578	19.069	37.258	ditto
Niet-Rijkswater	307				2.776	11.173	26.248	ditto
SOIL (mg.kg-1)								
land en tuinbouw	704	0.1	12	110		11		Wiersma et al. (1986)
idem (95 percentiel)	668	0.1	10	27				ditto
kasgrond	155	1	12	35		12		ditto
idem (95 percentiel)	147	1	11	24				ditto
	78	1	12	38		11		ditto
	46	1	10	110		4		ditto
	46	1	14	36		15		ditto
landbouw, klei	248		14					Van Driel en Smilde (1982)
landbouw, zand	63		5					ditto
landbouw, veen	40		12					ditto
landbouw, dalgrond	22		2					ditto
landbouw, loss	8		8					ditto
polder (1759)			15.4					Salomons en De Groot (1977)
polder (1927)			21.4					ditto
polder (1957)			144					ditto
uiterwaarden Rijn			205					ditto
uiterwaarden Maas			61					ditto
uiterwaarden Schelde			51					ditto
natuur, zand		1.4		8.6				Edelman (1983); gemiddelden
natuur, zavel/leem		5.1		18				ditto
natuur, klei		12		21				ditto
natuur, venige klei/kleiig veen		11		33				ditto
natuur, veen		4.7		24				ditto
ONTWERP-BODEMMEETNET								
leemarme veldpodzol	80	0.55	1.005	1.8				RIKILT (1989)
enkeerdgrond	72	0.85	2.541	5.8				RIKILT (1989)

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
veengrond	32	2	12.725	27				RIKILT (1989)
kalkvrije zware zavel/klei	56	6.3	12.669	18				RIKILT (1989)
leemarme vlakvaaggrond	16	0.95	2.053	2.8				RIKILT (1989)
GROUNDWATER (µg.l-1)								
		0.29	3.5	149				Van Duijvenbooden (1989)
humusarm zand			3.3					ditto
humusrijk zand			3					ditto
hoogveen			2.4					ditto
laagveen			2.9					ditto
rivierklei			8.2					ditto
zeeklei			2.3					ditto
leem			2.6					ditto
Z-Holland, niet gecontamineerd	39			1				ditto
Z-Holland, niet gecontamineerd	111	1		5				ditto
Z-Holland, niet gecontamineerd	46	5		10				ditto
Z-Holland, niet gecontamineerd	26	10		20				ditto
Z-Holland, niet gecontamineerd	13	20						ditto
LOOD								
WATER (µg.l-1)								
Rijkswater	110				1.068	4.403	16.497	Van der Kooij (1989)
Niet-Rijkswater	113				0	3.9	12.8	ditto
SEDIMENT (mg.kg-1)								
Rijkswater	2911				13.927	66.781	254.818	ditto
Niet-Rijkswater	317				11.815	43.18	206.909	ditto
SOIL (mg.kg-1)								
land en tuinbouw	708	0	31	460		23		Wiersma et al. (1986)
idem (95 percentiel)	673	0	25	72				ditto
kasgrond	155	4	71	420		45		ditto
idem (95 percentiel)	147	4	58	230				ditto
	78	11	62	460		36		ditto
	46	6	20	110		16		ditto
	46	3	26	124		20		ditto
landbouw, klei	248		43					Van Driel en Smilde (1982)
landbouw, zand	63		31					ditto
landbouw, veen	40		71					ditto
landbouw, dalgrond	22		32					ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
landbouw, loss	8		30					ditto
polder (1759)			31					Salomons en De Groot (1977)
polder (1927)			130					ditto
polder (1957)			540					ditto
uiterwaarden Rijn			660					ditto
uiterwaarden Maas			610					ditto
uiterwaarden Schelde			147					ditto
natuur, zand		3.1		43				Edelman (1983); gemiddelden
natuur, zavel/leem		17		168				ditto
natuur, klei		47		58				ditto
natuur, venige klei/kleiig veen		57		200				ditto
natuur, veen		67		105				ditto
dennebos, natuur	15		90					VTCB (1986)
dennebos, nabij verkeer	5		522					ditto
dennebos, nabij Hoogovens	5		278					ditto
dennebos, nabij Budelco	5		364					ditto
dennebos, nabij Billiton	5		541					ditto
weiland	2	65		70				Hart et al. (1988)
weiland	2	75		80				ditto
weiland	3	75	75	75				ditto
zand A0			161					CCRX (1989a)
zand A1			23					ditto
zand B2			4.8					ditto
zand B3			2.7					ditto
zand C. achtergrond			3.1					ditto
Arnhem, gecontamineerd			131					ditto
Budel, gecontamineerd		15	51	108				ditto
Stein, overslag		1100		25000				ditto
schietbanen		2	215	300000				ditto
havenslibgrond		27		567				ditto
uiterwaarden Maas		18		680				ditto
uiterwaarden Geul/Roer		24		1128				ditto
uiterwaarden Rijn		40		270				ditto
uiterwaarden Schelde			36					ditto
uiterwaarden Schelde			135					ditto
uiterwaarden Schelde			165					ditto
ONTWERP-BODEMMEETNET								
leemarme veldpodzol	80	2	11.163	27				RIKILT (1989)
enkeerdgrond	72	4.5	16.66	42				RIKILT (1989)
veengrond	32	16	131.907	480				RIKILT (1989)
kalkvrije zware zavel/klei	56	13	25.839	36				RIKILT (1989)

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
leemarme vlakvaaggrond	16	2	9.125	29				RIKILT (1989)
GROUNDWATER (µg.l-1)								
			2					Van Duijvenbooden (1989)
			2.2					ditto
			1.8					ditto
natuur			0.9					ditto
natuur			1.9					ditto
grasland			2.2					ditto
grasland			1.4					ditto
bouwland			1.1					ditto
bouwland			3.2					ditto
woonbebouwing			5.2					ditto
woonbebouwing			1.2					ditto
Z-Holland, niet gecontamineerd	162			1				ditto
Z-Holland, niet gecontamineerd	77	1		5				ditto
Z-Holland, niet gecontamineerd	39	5		15				ditto
Z-Holland, niet gecontamineerd	20	15		50				ditto
Z-Holland, niet gecontamineerd	7	50						ditto
ZINC								
WATER (µg.l-1)								
Rijkswater	112				5.728	28.618	116.92	Van der Kooij (1989)
Niet-Rijkswater	173				0	24	83	ditto
SEDIMENT (mg.kg-1)								
Rijkswater	2970				71.479	234.993	1330.602	ditto
Niet-Rijkswater	317				62.083	139.182	755.224	ditto
SOIL (mg.kg-1)								
landbouw, klei	248		117					Van Driel en Smilde (1982)
landbouw, zand	63		44					ditto
landbouw, veen	40		101					ditto
landbouw, dalgrond	22		25					ditto
landbouw, loss	8		86					ditto
polder (1759)			93					Salomons en De Groot (1977)
polder (1927)			460					ditto
polder (1957)			2070					ditto
uiterwaarden Rijn			2360					ditto
uiterwaarden Maas			2040					ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
uiterwaarden Schelde			570					idem
natuur, zand		6.4		62				Edelman (1983)
natuur, zavel/leem		28		189				gemiddelden
natuur, klei		81		153				ditto
natuur, venige klei/kleiig veen		62		150				ditto
natuur, veen		37		120				ditto
dennebos, natuur	15		57					VTCB (1986)
dennebos, nabij verkeer	5		83					ditto
dennebos nabij Hoogovens	5		317					ditto
dennebos nabij Budelco	5		1339					ditto
dennebos nabij Billiton	5		171					ditto
weiland	2	30.5		32				Hart et al. (1988)
weiland	2	33		34.5				ditto
weiland	3	30	33.667	33				ditto
ONTWERP-BODEMMEETNET								
leemarme veldpodzol	80	2.5	18.757	76				RIKILT (1989)
enkeerdgrond	72	2.5	21.57	36				RIKILT (1989)
veengrond	32	25	99.875	250				RIKILT (1989)
kalkvrije zware zavel/klei	56	43	72.661	92				RIKILT (1989)
leemarme vlakvaaggrond	16	3.5	5.844	6				RIKILT (1989)
GROUNDWATER (µg.l-1)								
		5	65	16				Van Duijvenbooden (1989)
	45	4		8				idem
	330	8		16				ditto
	125	16		32				ditto
	40	32		64				ditto
	30	64		128				ditto
	10	128		256				ditto
	20	256		612				ditto
	5	612		1024				ditto
Z-Holland, niet gecontamineerd	94			1				ditto
Z-Holland, niet gecontamineerd	97	1		25				ditto
Z-Holland, niet gecontamineerd	48	25		50				ditto
Z-Holland, niet gecontamineerd	40	50		150				ditto
Z-Holland, niet gecontamineerd	24	150						ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
NICKEL								
WATER (µg.l-1)								
Rijkswater	114				1.896	3.513	7.444	Van der Kooij (1989)
Niet-Rijkswater	146				0	6	13.9	ditto
SEDIMENT (mg.kg-1)								
Rijkswater	2865				12.383	25.258	49.487	ditto
Niet-Rijkswater	320				11.317	23.822	54.998	ditto
SOIL (mg.kg-1)								
landbouw, klei	248		33					Van Driel en Smilde (1982)
landbouw, zand	63		5					ditto
landbouw, veen	40		26					ditto
landbouw, dalgrond	22		3					ditto
landbouw, loss	8		13					ditto
polder (1759)			41					Salomons en De Groot (1977)
polder (1927)			32					ditto
polder (1957)			58					ditto
uiterwaarden Rijn			68					ditto
uiterwaarden Maas			63					ditto
uiterwaarden Schelde			37					ditto
natuur, zand		< 0.5		6.8				Edelman (1983); gemiddelden
natuur, zavelleem		4.4		18				ditto
natuur, klei		27		47				ditto
natuur, venige klei/kleiig veen		19		37				ditto
natuur, veen		2.4		16				ditto
weiland	2	5		10				Hart et al. (1988)
weiland	2	5		10				ditto
weiland	3	15	20	30				ditto
GROUNDWATER (µg.l-1)								
		1	11.3	276				Van Duijvenbooden (1989)
			14.6					ditto
			7.9					ditto
natuur			11.4					ditto
grasland			9					ditto
bouwland			16.6					ditto
woonbebouwing			7.9					ditto
Z-Holland, niet gecontamineerd	84			1				ditto
Z-Holland, niet gecontamineerd	58	1		5				ditto
Z-Holland, niet gecontamineerd	41	5		15				ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
Z-Holland, niet gecontamineerd	13	15		50				ditto
Z-Holland, niet gecontamineerd	7	50						ditto
NAPHTHALENE								
WATER (µg.l-1)								
Rijkswater								
Niet-Rijkswater								
SEDIMENT (mg.kg-1)								
Rijkswater	33				0.124	0.432	1.199	Van der Kooij (1989)
Niet-Rijkswater	88				0.051	0.242	1.731	ditto
SOIL (µg.kg-1)								
achtergrond			0.01					Slooff et al. (1989d)
wei (natte grond)	1		< 1000					Hart et al. (1988)
wei (natte grond)	1		< 1000					ditto
GROUNDWATER (µg.l-1)								
van 8 tot 30 m	38	0	0	0				Van Duijvenbooden (1989)
van 8 tot 30 m	227	0.2		6.5				ditto
aachtergrond			0.001					Slooff et al. (1989d)
gasfabrieksterreinen		0.4	2000	8000				ditto
ANTHRACENE								
WATER (µg.l-1)								
Rijkswater								
Niet-Rijkswater								
SEDIMENT (mg.kg-1)								
Rijkswater	42				0.044	0.266	2.632	Van der Kooij (1989)
Niet-Rijkswater	112				0.02	0.133	1.516	ditto
SOIL (mg.kg-1)								
achtergrond			0.01					Slooff et al. (1989d)
gecontamineerd terrein		1.5		59.8				CCRX (1987)
wei (natte grond)	1			0.2				Hart et al. (1988)
wei (natte grond)	1			0.2				ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
GROUNDWATER (µg.l-1)								
achtergrond			0.001					Slooff et al. (1989d)
gasfabriekterrein		0.004	5.3	200				ditto
PHENANTHRENE								
Water (µg.l-1)								
Rijkswater	12						0.072	Van der Kooij (1989)
Niet-Rijkswater								
Sediment (mg.kg-1)								
Rijkswater	40				0.067	0.946	3.977	ditto
Niet-Rijkswater	115				0.063	0.49	4.066	ditto
SOIL (mg.kg-1)								
achtergrond			0.01					Slooff et al. (1989d)
gecontamineerd terrein		2		154.3				CCRX (1987)
wei (natte grond)	1			0.2				Hart et al. (1988)
wei (natte grond)	1			0.2				ditto
GROUNDWATER (µg.l-1)								
achtergrond			0.001					Slooff et al. (1989d)
gasfabriekterrein		0.08	31	200				ditto
FLUORANTHENE								
WATER (ng.l-1)								
Rijkswater	58					21.624	91.74	Van der Kooij (1989)
Niet-Rijkswater								
SEDIMENT (mg.kg-1)								
Rijkswater	1591				0.172	1.194	6.099	ditto
Niet-Rijkswater	154				0.15	1.033	7.467	ditto
SOIL (mg.kg-1)								
achtergrond			0.01					Slooff et al. (1989d)
zand			0.049					CCRX (1987)
klei			0.149					ditto
industrie grond			0.226					ditto
havenslibgrond			1.482					ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
gecontamineerd terrein		4.1		169.8				ditto
wei (natte grond)	1			0.5				Hart et al. (1988)
wei (natte grond)	1			0.5				ditto
GROUNDWATER (µg.l-1)								
achtergrond			0.001					Slooff et al. (1989d)
gasfabriekterrein		0.2	7	60				ditto
BENZO[a]ANTHRACENE								
WATER (µg.l-1)								
Rijkswater	11						0.021	Van der Kooij (1989)
Niet-Rijkswater								
SEDIMENT (mg.kg-1)								
Rijkswater	42				0.135	0.531	2.016	ditto
Niet-Rijkswater	103				0.062	0.486	5.752	ditto
SOIL (mg.kg-1)								
achtergrond			0.01					Slooff et al. (1989d)
zand			0.012					CCRX (1987)
klei			0.055					ditto
industrie grond			0.096					ditto
havenslibgrond			0.825					ditto
gecontamineerd terrein		2.7		59.7				ditto
wei (natte grond)	1			0.5				Hart et al. (1988)
wei (natte grond)	1			0.5				ditto
GROUNDWATER (µg.l-1)								
achtergrond			0.001					Slooff et al. (1989d)
gasfabriekterrein		0.04	3	12				ditto
CHRYSENE								
WATER (µg.l-1)								
Rijkswater	11						0.023	Van der Kooij (1989)
Niet-Rijkswater								

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
SEDIMENT (mg.kg-1)								
Rijkswater	41				0.13	0.6	2.08	ditto
Niet-Rijkswater	121				0.071	0.61	4.309	ditto
SOIL								
achtergrond			0.01					Slooff et al. (1989d)
zand			0.043					CCRX (1987)
klei			0.106					ditto
industrie grond			0.193					ditto
havenslibgrond			1.219					ditto
wei (natte grond)	1			0.5				Hart et al. (1988)
wei (natte grond)	1			0.5				ditto
GROUNDWATER (μg.l-1)								
achtergrond			0.001					Slooff et al. (1989d)
gasfabriekterrein		0.07	3	10				ditto
BEZO[k]FLUORANTHENE								
WATER (ng.l-1)								
Rijkswater	57						41.081	Van der Kooij (1989)
Niet-Rijkswater								
SEDIMENT (mg.kg-1)								
Rijkswater	1470				0.095	0.431	1.667	ditto
Niet-Rijkswater	152				0.05	0.25	2.453	ditto
SOIL (mg.kg-1)								
achtergrond			0.01					Slooff et al. (1989d)
zand			0.081					CCRX (1987)
klei			0.154					ditto
industrie grond			0.342					ditto
havenslibgrond			1.959					ditto
gecontamineerd terrein		2.2		39.4				ditto
wei (natte grond)	1			0.5				Hart et al. (1988)
wei (natte grond)	1			0.5				ditto
GROUNDWATER (μg.l-1)								
achtergrond			0.001					Slooff et al. (1989d)
gasfabriekterrein		0.04	0.8	7				ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
BENZO[a]PYRENE								
WATER (ng.l-1)								
Rijkswater								
Niet-Rijkswater								
SEDIMENT (mg.kg-1)								
Rijkswater	1534				0.071	0.613	2.446	Van der Kooij (1989)
Niet-Rijkswater	153				0.052	0.389	4.648	ditto
SOIL (mg.kg-1)								
achtergrond			0.01					Slooff et al. (1989d)
zand			0.006					CCRX (1987)
klei			0.023					ditto
industrie grond			0.06					ditto
havenslibgrond			0.48					ditto
gecontamineerd terrein		2.9		45.4				ditto
GROUNDWATER (µg.l-1)								
achtergrond			0.001					Slooff et al. (1989d)
gasfabriekterrein		0.08	1	8				ditto
BENZO[ghi]PERYLENE								
WATER (ng.l-1)								
Rijkswater	57						45.863	Van der Kooij (1989)
Niet-Rijkswater								
SEDIMENT (mg.kg-1)								
Rijkswater	1509				0.091	0.556	2.277	ditto
Niet-Rijkswater	153				0.083	0.57	3.336	ditto
SOIL (mg.kg-1)								
achtergrond			0.01					Slooff et al. (1989d)
zand			0.014					CCRX (1987)
klei			0.036					ditto
industrie grond			0.082					ditto
havenslibgrond			0.057					ditto
gecontamineerd terrein		0.04		25.5				ditto
wei (natte grond)	1			1				Hart et al. (1988)
wei (natte grond)	1			1				ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
GROUNDWATER (µg.l-1)								
achtergrond			0.001					Slooff et al. (1989d)
gasfabriekterrein		0.04	1.7	10				ditto
INDENO[1,2,3-cd]PYRENE								
WATER (ng.l-1)								
Rijkswater	55						59.28	Van der Kooij (1989)
Niet-Rijkswater								
SEDIMENT (mg.kg-1)								
Rijkswater	1530				0.092	0.625	2.563	ditto
Niet-Rijkswater	153				0.052	0.389	3.163	ditto
SOIL (mg.kg-1)								
achtergrond			0.01					Slooff et al. (1989d)
zand			0.021					CCRX (1987)
klei			0.041					ditto
industrie grond			0.089					ditto
havenslibgrond			0.628					ditto
gecontamineerd terrein		1.9		24				ditto
wei (natte grond)	1			1				Hart et al. (1988)
wei (natte grond)	1			1				ditto
GROUNDWATER (µg.l-1)								
achtergrond			0.001					Slooff et al. (1989d)
gasfabriekterrein		0.04	1	9				ditto
ATRAZIN								
SOIL (mg.kg-1)								
Tuintjes op voormalige								
stort, inclusief	6	< 0.2	0.597	3.4				Wegman et al. (1975)
propazin en simazin	6	< 0.2	1.537	8.2				
GROUNDWATER (µg.l-1)								
Vierlingsbeek		< 0.1		0.8				Van Beek (1987)
Bergeijk, zand, mais	40	< 0.02	< 0.177	0.58				Verdam et al. (1988)
Noord-Brabant, mais	8			< 0.2				Lagas et al. (1988)
Genderen		< 0.1		0.7				Tweede Kamer (1989)

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
Noordwijk, waterwinning	4		ca. 0.001					Van de Werken et al. (1989)
mais		< 0.02		0.8				Van Duijvenbooden (1989)
HCH								
WATER (ng.l-1)								
Rijkswater	45				6	12	37	Van der Kooij (1989)
Niet-Rijkswater	97				0.4	10	29.8	ditto
SEDIMENT (µg.kg-1)								
Rijkswater	963				0.708	3.774	37.607	ditto
Niet-Rijkswater	139				0.318	0.952	4.114	ditto
SOIL (µg.kg-1)								
polders (met havenslib)				1				Wegman et al. (1978)
natuurterrein	59			1				Edelman (1983)
natuurterrein	21	1		10				ditto
natuurterrein	9	10		20				ditto
natuurterrein	5	20		40				ditto
natuurterrein	0	40		60				ditto
natuurterrein	2	60		80				ditto
natuurterrein	96	< 1		76				ditto
landbouwgrond, geschat		80		250				ditto
g/kg, gecontamineerd terrein				55				ditto
grasland, leemarme veldpodzol	32	< 0.5	> 0.111	2				Greve (1989)
grasland, enkeerdgrond	32	< 0.5	> 0.431	2.5				ditto
grasland, veengrond	32	< 0.5	> 0.169	1				ditto
bouwland, kleigrond	32	< 0.5	> 0.016	0.5				ditto
bouwland, leemarme veldpodzol	32	< 0.5	> 1.091	3.6				ditto
bouwland, enkeerdgrond	32	< 0.5	> 0.522	4.1				ditto
boomgaard, kleigrond	32	< 0.5	> 0.247	1				ditto
boomgaard, enkeerdgrond	32	< 0.5	> 0.619	2				ditto
bos, leemarme veldpodzol	32	< 0.5	< 0.5	0.5				ditto
bos, leemarme vlakvaaggrond	32	< 0.5	< 0.5	0.5				ditto
GROUNDWATER (ng.l-1)								
landbouwgebied, geschat			15					Slooff en Matthijsen (1987)
gecontamineerd terrein			560					ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
AZINPHOS-METHYL								
No data available								
MALATHION								
No data available								
PARATHION-ETHYL								
No data available								
TRIBUTYLTINOXIDE								
No data available								
DIELDRIN								
Water (ng.l-1)								
Rijkswater								
Niet-Rijkswater	22				0	1	10	Van der Kooij (1989)
SEDIMENT (µg.kg-1)								
Rijkswater	998				0.312	9.091	81.959	ditto
Niet-Rijkswater	118				0.287	1.111	8.788	ditto
SOIL (mg.kg-1)								
polders met havenslib, 1976	15	0.03	5.943	26				Wegman et al. (1978)
polders, 1976	13	< d.g.	0.002	0.03				ditto
polders met havenslib, 1977	17	0.02	4.525	16				ditto
SOIL (µg.kg-1)								
grasland, leemarme veldpodzol	32	< 0.5	> 0.572	2.5				Greve (1989)
grasland, enkeerdgrond	32	< 0.5	> 0.613	1.7				ditto
grasland, veengrond	32	< 0.5	> 1.316	3.9				ditto
bouwland, kleigrond	32	< 0.5	> 1.881	5.1				ditto
bouwland, leemarme veldpodzol	32	< 0.5	> 3.572	23				ditto
bouwland, enkeerdgrond	32	< 0.5	> 0.428	2.7				ditto

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
boomgaard, kleigrond	32	< 0.5	> 2.853	30				ditto
boomgaard, enkeerdgrond	32	< 0.5	> 6.356	23				ditto
bos, leemarme veldpodzol	32	< 0.5	> 0.05	0.6				ditto
bos, leemarme vlakvaaggrond	32	< 0.5	> 0.019	0.6				ditto
natuurterrein	13			1				Edelman (1983)
natuurterrein	66	1		10				ditto
natuurterrein	14	10		20				ditto
natuurterrein	3	20		40				ditto
natuurterrein	96	< 1		30				ditto
DIAZINON								
No data available								
2-CHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8	< 0.01	0.045	0.12				Goewie et al. (1986)
3-CHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8			< 0.01				Goewie et al. (1986)
4-CHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8			< 0.01				Goewie et al. (1986)
2,3-DICHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8	< 0.01	0.016	0.05				Goewie et al. (1986)

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
2,4-DICHLOROPHENOL								
SOIL (µg.kg-1)								
natuurterrein	84			1				Edelman (1983)
natuurterrein	8	1		5				ditto
natuurterrein	2	5		10				ditto
natuurterrein	1	10		15				ditto
natuurterrein	1	15		20				ditto
natuurterrein	96	< 0.5		18				ditto
GROUNDWATER (µg.l-1)								
drinkwaterwinning inclusief 2,5-DCF	8	< 0.01	0.008	0.02				Goewie et al. (1986)
2,5-DICHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning inclusief 2,4-DCF	8	< 0.01	0.006	0.02				Goewie et al. (1986)
2,6-DICHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8	< 0.01	0.016	0.06				Goewie et al. (1986)
3,4-DICHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	6			< 0.01				Goewie et al. (1986)
3,5-DICHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8	< 0.01	0.008	0.03				Goewie et al. (1986)

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
2,3,4-TRICHLOROPHENOL								
WATER (ng.l-1)								
Rijkswater								
Niet-Rijkswater	5				0	0	80	Van der Kooij (1989)
SEDIMENT (mg.kg-1)								
Rijkswater								
Niet-Rijkswater								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8			< 0.01				Goewie et al. (1986)
2,3,5-TRICHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8	< 0.01	0.005	0.02				Goewie et al. (1986)
2,3,6-TRICHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8			< 0.01				Goewie et al. (1986)
2,4,5-TRICHLOROPHENOL								
WATER (ng.l-1)								
Rijkswater (stand.)	53					0.004	0.035	Van der Kooij (1989)
Niet-Rijkswater								
SEDIMENT (mg.kg-1)								
Rijkswater								
Niet-Rijkswater								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8	< 0.01	0.004	0.01				Goewie et al. (1986)

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
2,4,6-TRICHLOROPHENOL								
WATER (ng.l-1)								
Rijkswater (stand.)	53					0.004	0.035	Van der Kooij (1989)
Niet-Rijkswater								
SEDIMENT (mg.kg-1)								
Rijkswater								
Niet-Rijkswater								
SOIL (µg.kg-1)								
natuurterrein	88			1				Edelman (1983)
natuurterrein	8	1		5				ditto
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8			< 0.01				Goewie et al. (1986)
3,4,5-TRICHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8			< 0.01				Goewie et al. (1986)
2,3,4,5-TETRACHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8	< 0.01	0.001	0.01				Goewie et al. (1986)
2,3,4,6-TETRACHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8	< 0.01	0.01	0.01				Goewie et al. (1986)
2,3,5,6-TETRACHLOROPHENOL								
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8	< 0.01	0.003	0.01				Goewie et al. (1986)

	N	MIN	AVG	MAX	10-P	50-P	90-P	REFERENCE
PENTACHLOROPHENOL								Slooff et al. (1989a)
WATER (ng.l-1)								
Rijkswater	51					9	51	Van der Kooij (1989)
Niet-Rijkswater	5				0	0	80	ditto
SEDIMENT (mg.kg-1)								
Rijkswater								
Niet-Rijkswater								
SOIL (µg.kg-1)								
natuurterrein	91			1				Edelman (1983)
natuurterrein	5	1		5				ditto
natuurterrein	96	< 0.2		4.4				ditto
GROUNDWATER (µg.l-1)								
drinkwaterwinning	8	< 0.01	0.01	0.04				Goewie et al. (1986)

LITERATURE CONCENTRATIONS IN THE ENVIRONMENT

Beek CGEM van 1987
Landbouw en drinkwatervoorziening, oriënterend onderzoek naar de beïnvloeding van de grondwaterkwaliteit door bemesting en het gebruik van bestrijdingsmiddelen
KIWA Mededeling nr.99

CCRX 1986
Evaluatierapport kwik in het nederlandse milieu
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