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Human exposure to soil contamination: a qualitative and quantitative analysis towards proposals for human toxicological intervention values (partly revised edition)

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This report is a revision of the report published in 1991. A number of corrections to the 1991 version were made and moreover, the formulas (Annex 1) for the calculation of human toxicological intervention values and actual human risks have been adjusted to recent recommendations and information.

1991: This report was commissioned by the Directorate-General for the Environment, Directorate Drinking Water, Water and Soil in the framework of the Project Assessment of Risks to Man and the Environment in case of Soil Contamination, following letter of instruction, ref. 1668408 of 20 April 1988.
1995: This text has been translated from Dutch by the "Algemeen Vertaalbureau Muiderkring"*, in order of Sumitomo Heavy Industries, Ltd., Tokyo, Japan, in the beginning of 1995.

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A memorandum on the status of this report

In the period 1990-1994 the RIVM produced a series of reports on risks for humans, ecosystems and risks due to contaminant migration, under commission of the Dutch Ministry of Housing, Physical Planning and Environment (VROM). This report belongs to this series. The objective of the report is to show how the human-toxicological part of the intervention value is determined.

Since 1991 new scientific insight has made several changes in the formulae and input data used to calculate human exposure possible. Furthermore, the TCB, who has intensely revised the exposure model, has made some useful suggestions for improvement. Most of these have been processed in the revision of this report, which took place in 1994. Since December 1993, several Working Groups for the Implementation of the Remediation Procedure, initiated by the Ministry, have been operational in revising the present Soil Clean-up Act. One ministerial circular, released in May 1994, was followed by another in December 1994. After evaluation, both will realise future implementation in the Dutch Soil Clean-up Act. New scientific knowledge and revisions to the ministerial circulars warrant the following remarks on the report of 1991 and the revised version of 1994.

1. The terminology has undergone some major changes: First of all, the term C-standard value has been replaced by *intervention value*. When one of the contaminants exceeds the intervention value, the case is considered a "*serious contamination*", replacing the term "serious hazard to public health or the environment". In the case of "serious contamination" the remediation *priority* has to be determined. As a consequence, exceeding the intervention value no longer automatically implies the necessity of remediation, as stated on page 1 of the report!
2. The proposed procedure for derivation of the intervention values has been accepted. However, some minor and major changes were adopted in Tables 2, 9 and 10. The adapted values, as listed in Annex 1.11, were implemented in the ministerial circular of May 1994.
3. A procedure has been developed for assessing the actual (i.e. location-specific) human risks for priority-setting of cases with serious soil contamination, as published in the ministerial circular of 22 December 1994. A manual for calculating these actual risks has also been released. Characteristic for the procedure is the relatively poor accuracy of the actual human exposure calculation, mainly for air quality. For this reason, calculations should be combined with measurements in the contact media (indoor air, plant tissue).

Foreword

The Directorate-General for Environmental Protection commissioned the RIVM to provide the technical-scientific basis for certain elements of Part II (the technical part) of the Guideline Soil Protection.

The results will be used in the periodical revision of the Guideline. In this context, the criterion 'serious threat to public health or the environment' takes a prominent place. This criterion is elaborated by working out the already existing figures for the C-values in the standard table in the present Guideline. Based on these C-standard values it may be determined whether or not such a 'serious threat' exists in cases of soil contamination and whether soil clean-up operations or reseach will be called for.

The RIVM brief comprises the following three aspects: hazards to the public health and the environment respectively as a result of exposure to soil contamination and views on exposure in relation to dispersion through air and ground water.

In this report proposals are being made towards the formulation of human toxicologically based C-standard values, based on recommended human toxicological limit values, as indicated by Vermeire et al. (1991) and the exposure routes, initiated by Linders (1990) and further elaborated in this report.

I would like to mention the fruitful cooperation I have had with Mr. Veerkamp (Shell) and Mr. Te Berge (DSM), who helped quantify and develop models for the various exposure routese. Also, I would like to thank various RIVM colleagues for their contributions in the discusions we have had.

The revised edition published January 1994 has taken into account various comments on published reports. Recent information has been integrated into the formulas (see Annex 1). This refers in particular to the TCB advisory report (TCB, 1992) and the Bockting and Van den Berg report (1992) on plant uptake of trace metals. Moreover, Annex 1.11 includes the proposals for intervention values concerning soil clean-up, as presented to Parliament (VROM, 1993).

In 1994, two Parlimentary notes has been released, concerning adjustments in the Dutch Act on Soil Protection. According to the differences in relation to the contests of this report, a few notes has to be made:

- The term "C-value", has been changed in "Intervention value", referring to an eventual intervention by soil and/or groundwater clean-up;
- The CSOIl-model is not meant, nor suited to calculate the actual (i.e. location specific) risks with high accuracy. In many cases, especially in the case of volatile compounds, measurements in contact media (indoor air, plants) are, in combination with CSOIL calculations, necessary.

CONTENTS

SUMMARY

In view of a revision of the Dutch Soil Protection act, proposals are presented in this report for human toxicologically based intervention values for soil and groundwater, calculated from human toxicological guideline values and human exposure. To this purpose the exposure model CSOIL is presented and discussed. This model has been developed to quantify the exposure due to soil contamination. Moreover, the uncertainties of the model calculations are discussed. The CSOIL model is not only used for the derivation of intervention values, but is also used, in combination with measurements in contact media, for the calculation of the actual human exposure to determine the priority of remediation.

SAMENVATTING

In het kader van de herziening wet bodembescherming zijn voorstellen gedaan voor humane interventiewaarden voor bodem en grondwater, berekend met behulp van humaan toxicologische grenswaarden en humane blootstelling. Ten behoeve van dit doel wordt het humane blootstellingsmodel CSOIL gepresenteerd en bediscussieerd. Dit model is ontwikkeld met het doel om de humane blootstelling ten gevolge van bodemverontreiniging te kunnen kwantificeren. Bovendien worden de onzekerheden van de modelberekeningen besproken. Het CSOIL model wordt niet alleen gebruikt bij de afleiding van de interventiewaarden, maar wordt tevens toegepast, in combinatie met metingen in contact media, voor de berekening van het actuele humane risico, ten behoeve van de bepaling van de saneringsurgentie.

1. INTRODUCTION

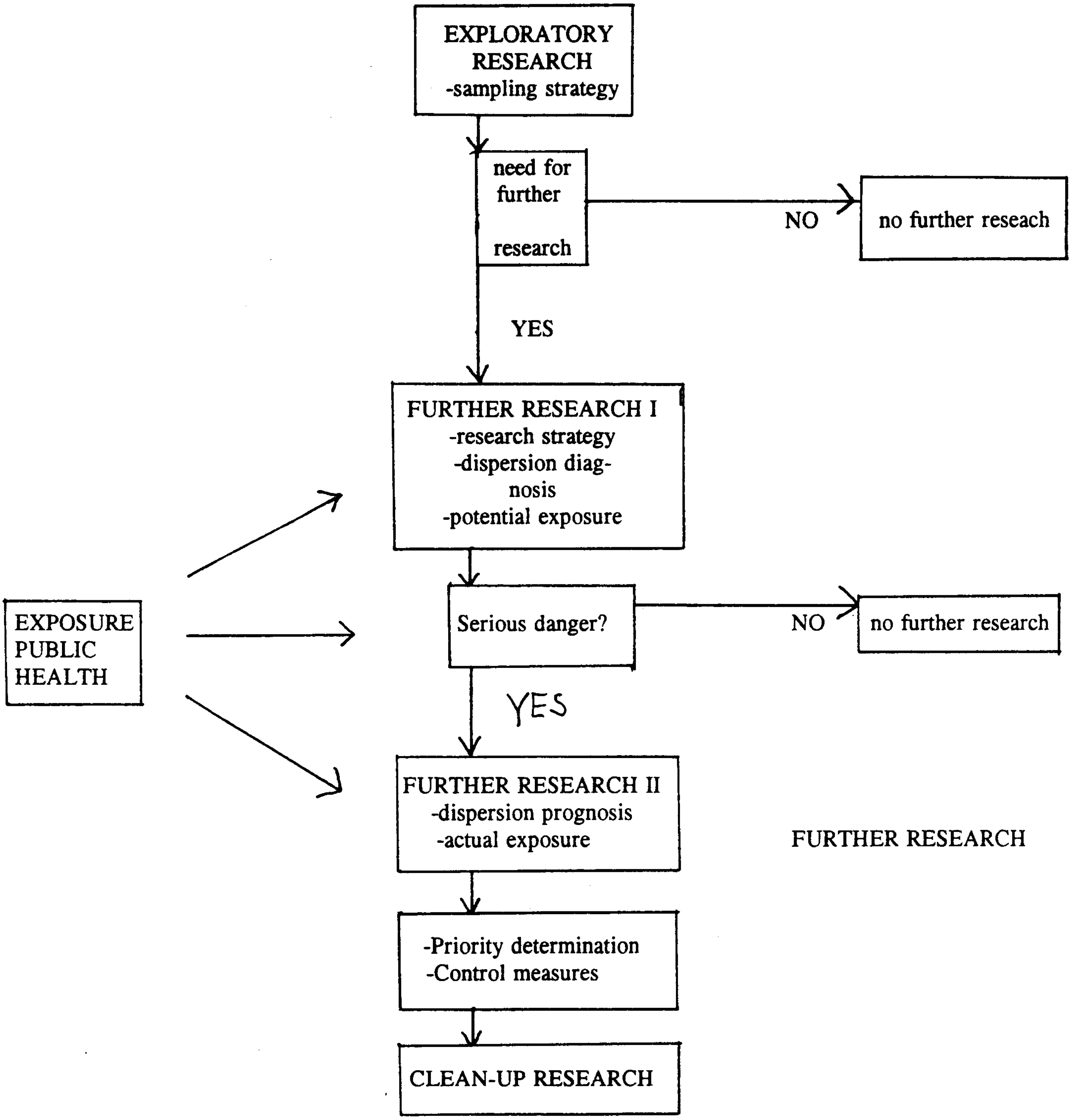
In the annex (Hazards Leaflet, VROM, 1988a) to the National Environmental Policy Plan (NMP) hazards are defined as the possibility of unwanted consequences of an activity. In the case of soil contamination this possibility refers to exposure. The unwanted consequences are interpreted in terms of toxicological effects affecting man. The activity concerns an instance of soil contamination.

Concerning the procedure assessing the extent of the contamination of a site and the need for clean-up, the Guidline Soil Protection (VROM, 1990a) introduces the concept "serious threat to the public health or the environment" as a key term.
It is determined by the nature and the concentrations of the pollutants, which give an indication of the extent of the contamination and the potential effects, as well as of the extent and the possibility of dispersion or contact. This norm indicates whether or not there is an intolerable hazard to man or the environment through potential exposure (routes). These aspects have been integrated in the revised standard criterion and new C-standard values have been derived from them.
The C-standard value is a general criterion for soil quality which can be used to assess the concept "serious hazard to the public health or the environment".
When a "serious threat" occurs in the sense that the C-standard value on the research scale developed in the Hazards Leaflet (see also Lamé and Bosman, 1990) is exceeded, this means that the site will have to be cleaned up (clean-up necessity). Soil use is one of the factors determining the extent to which "actual" risks to man or the environment as a result of exposure to soil contamination occurs. Based on a so-called actual exposure analysis, which takes into account soil condition, geohydrology and soil-use, the priority of the clean-up for a specific site must be determined. The C-standard value does not provide information on these actual risks.
The concept "serious threat to the environment" has been worked out by Denneman and van Gestel (1990) and translated into proposals for environment-toxicologically based C-standard values. Linders (1990) and Vermeire et al. (1991) contributed towards the derivation of human toxicological C-standard values.
Linders (1990) developed a model procedure for the assessment of the risks for man in the case of exposure to high concentrations in the environment. This model will henceforth be referred to as the RIVM model. The procedure may be used for two purposes:
1. Calculation of C-standard values, based on potential risk assessments (when these values are exceeded, clean-up becomes a necessity).
2. Calculation of the actual risks in the context of stage 2 of the Guideline Soil Protection (upon determining the necessity of clean-up, see also Kliest (1990) and Lagas et al. (1990).

Figure 1 shows the positioning of the determination of potential and actual exposure in the framework of the Guideline Soil Protection.

Linders based himself on the concentrations in the contact media, which, however, cannot be used for the calculation of C-standard values, as these concentrations are not known. Substance behaviour should be the starting-point instead.

Figure 1. Positioning of potential and actual exposure analysis in the framework of the Guideline Soil Protection and the relative positions in the chain of soil clean-up reseach.



Data on soil conditions, human behaviour, contents in contact media and the degree of contact with media must be derived on the basis of models or assumed.
The second element in the calculation of C-standard values concerns the toxicological assesssment framework (Vermeire et al., 1991). This framework provides maximum exposure limits for carcinogenic and non-carcinogenic substances, based on toxicological information. Given the more elaborate model for the exposure routes compared to Linders (1990), the combination of these two elements will give the C-standard values. A conclusive report (Van den Berg and Roels, 1991), finally, will propose new C-standard values, based on the integration of earlier standard values focused on environmental and public health aspects.

As already indicated by Linders (1990), models for individual exposure routes have been described in various reports. The present report contains a justification of the choices made to arrive at an integrated model from which the proposed human toxicological C-values have been derived. It explains the various exposure routes and the quantification of the exposure, including the possible preliminary actions, like calculation of indoor air concentrations or drinking water concentrations after permeation of pipes.

The final choice of the calculation model to be used has been based on an extensive and in-depth study of the HESP (ECETOC/Veerkamp, 1990) and SOILRISK (Ten Berge, 1990) models, in addition to the RIVM[1] model (Linders, 1990) and background literature. The aim has been not to repeat earlier studies, but to analyse the backgrounds, correspondences and differences for the various approaches in the three models mentioned above. The HESP and SOILRISK models are focused on the determination of actual exposure risks, which expresses itself in the choice of routes and the use of parameters and constants (focused on the local situation). Moreover, in these two models the norms are checked afterwards and the normative aspects (definition of "serious threat") do not apply, contrary to the present determination of C-values to which the normative aspect is central.
Chapter 2 discusses the final CSOIL model, including the premises and the quantification. Chapter 3 evaluates the individual exposure routes. A number of striking characteristics of the various models should be stated first. The SOILRISK model only analyses the exposure of children as the most sensitive group. Furthermore, no time fractions are used in this model. The RIVM model uses weekly fractions and the HESP model features a highly detailed calculation of the exposure, distinguishing between summer and winter, active and passive behaviour, etc, which makes it difficult to draw direct and immediate comparisons.

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[1] In order to be able to differentiate between the various models the final model has been named CSOIL

2. CSOIL MODEL FOR THE DERIVATION OF C-STANDARD VALUES

2.1 Substance properties

For the quantification of the exposure to contaminated substances, the following set of data served as starting-point:

molecular weight, water-solubility (preferably measured at a temperature of between 10 to 20°C), octanol water partition coefficient (expressed in its log value), Henry constant, air diffusion coefficient and the permeation coefficient.

Table 4 gives the data for the substances that are mentioned in the Guideline Soil Protection (1990). On the basis of the Henry constant and water-solubility, the vapour pressure has been computed for all substances.

2.2 Soil condition

Concerning soil condition the derivation of the C-standard values should be chosen so as to enable evaluation of the potential risks. This means that

a) all routes may apply;
b) circumstances relatively favourable to dispersion of substances (low adsorption, high porosity) were maintained.

The combination of these circumstances occurs in the case of contamination under unsaturated conditions and a sandy substratum.
Table 5 gives an overview of the magnitude of the parameters used in the model.

2.3 Exposure routes

Linders (1990) examined the direct and indirect routes through which man may be exposed to (the results of) soil contamination. Figure 2 shows the exposure model in a schematic way:

- the contaminated substance is distributed over the soil phases;
- tranfer processes take place;
- this leads to both direct and indirect exposure.

The direct exposure routes concern:

- oral intake of soil, water and air;
- dermal contact with soil, water and air;
- inhalation of soil, water and air.

Indirect exposure occurs through consumption of food contaminated through soil contamination: crops, milk, meat, fish and drinking water.

Linders (1990) explained why a number of direct (particularly surface water as contact medium) and indirect routes (through fish, meat and other animal-derived products) were not considered in the determination of the C-standard values. These routes may be relevant to the actual exposure analysis, however, and quantifications were therfore given in the HESP, SOILRISK AND RIVM models.

2.4 The exposed: man

In the quantification of the various forms of exposure, a distinction was made between children and adults (Linders, 1990). Table 6 gives a number of data on these two groups which have been used in the different formulas. For the risk assessment for the public health a model situation was chosen for the estimation of potential exposure which comprises all relevant exposure routes and takes children as the most vulnerable group.

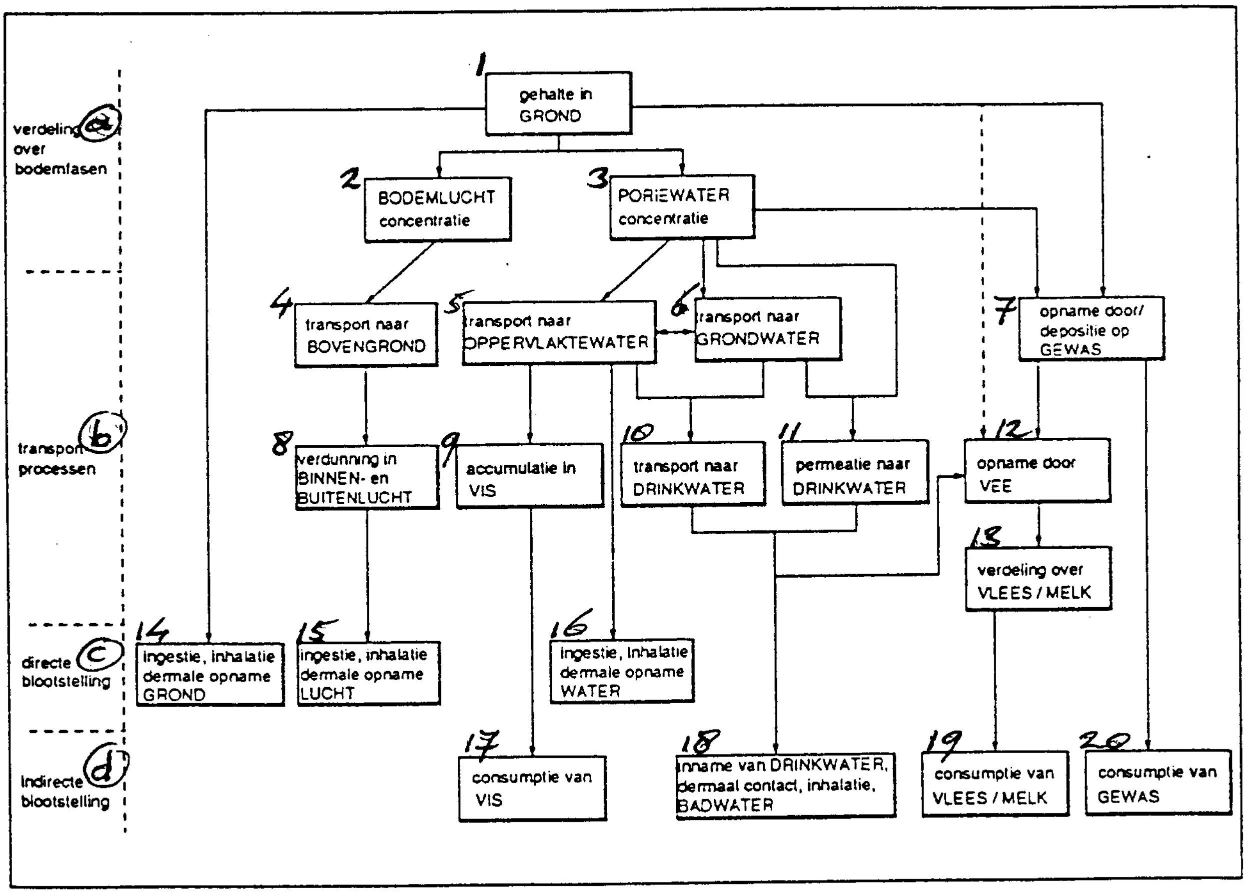

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Figure 2 Schematic presentation of the human exposure routes in cases of soil contamination

TRANSLATIONS OF THE DUTCH WORDS IN THE TABLES AND FIGURES

PAGE 5

1. content in SOIL
2. SOIL AIR concentration
3. PORE WATER concentration
4. transport to UPPER GROUND
5. transport to SURFACE WATER
6. transport to GROUND WATER
7. uptake by/deposition on CROP
8. dilution in INDOOR AIR and OURDOOR AIR
9. accumulation in FISH
10. transport to DRINKING WATER
11. permeation to DRINKING WATER
12. uptake by CATTLE
13. division over MEAT/MILK
14. ingestion, inhalation dermal intake SOIL
15. ingestion, inhalation dermal intake AIR
16. ingestion, inhalation dermal intake WATER
17. FISH consumption
18. intake of DRINKING WATER, dermal contact, inhalation BATHING WATER
19. MEAT/MILK consumption
20. CROP consumption

a. division over soil phases
b. transport processes
c. direct exposure
d. indirect exposure

3. QUANTIFICATION OF THE EXPOSURE

The qualitative description of the exposure discussed in this chapter must be supplemented by quantitative information, which has been incorporated in the present report as follows:

- Tables 4 up to 8 showing the parameter data for the model;
- annexes 1 up to 8, for the formulas, the model calculation for each exposure route (the elements of the model);
- annex 9 with the tables 9.1 up to 9.8 showing the results per calculation step on "C-value level".

This information allows the reader to follow and check the calculations step-by-step.

3.1 Distribution over the soil phases

From the content in the solid soil phase (Cs in mg/kg dry soil) the concentration in the gas phase (Csa in mg substance/dm^3 soil air) and in the soil moisture or pore water (Cpw in mg substance/dm^3 soil moisture) can be calculated, assuming that there is an equilibrium between the three soil phases.
Based on data on the soil-water distribution coefficient [Kd in(mg substance/kg dry soil)/(mg substance/dm^3 water) i.e. dm^3/kg)], air-water [Henry coefficient in (mg substance/dm^3 air)/(mg substance/dm^3 water] and the soil parameters (Table 5) the contents in the different phases can be calculated. The only condition for this calculation is that the concentration in the water should not be higher than the water solubility (S). If this is the case, water solubility must be used for the water concentration (Cpw=S) and the gas phase concentration should be adjusted as well.
In addition, the mass balance should be taken into account in this calculation. Mackay et al. (1985) described a set of formulas apart from the fugacity theory (see annex 1) in order to be able to make this calculation. In view of the important role attributed to organic carbon in the soil in the sorption/distribution of organic compounds in the soil, Kd is generally converted into a soil-organic substance-independent parameter Koc:

Koc = Kd / foc
Koc = distribution coefficient corrected for organic substances [dm^3/kg org.subst.]
Kd = fraction organic carbon [kg org.subst/kg dry soil]

Based on a partition model for the description of the distribution of organic substances, studies have been conducted into relations between Koc and the octanol-water distribution coefficient: Kow. Various relations have been described. This model uses the Karickhoff (1981) relation.

Koc = 0.411 * Kow

On the basis of experimentally determined or calculated Kow, Koc can be calculated and when the organic carbon fraction of the soil is known, the groundwater distribution coefficient can be calculated as well.
Tables 9.1 and 9.2 respectively give the mass fractions and concentrations in soil air, pore water and the solid phase.

3.2 Model calculations for concentrations in contact media

3.2.1 Indoor and outdoor air

The migration process by which contaminants may leave the soil and infiltrate the indoor or outdoor air, can be described on the basis of models as the resultant of a number of separate processes. First, the contaminant must enter the moving soil phases, soil water and/or soil air (see 3.1) from the immobile solid soil phase. Subsequently, a vertical transport through the soil should take place via the creeping-space, resulting in evaporation from the soil system. During evaporation into the outdoor air, a certain degree of dilution will occur.

Burdening of the inside air occurs through the creeping space situated below houses. As a rule, creeping-spaces in the Dutch situation are not screened off. Here dilution takes place by means of ventilation with the outdoor air through ventilation holes. Finally, transport to the inside air will occur via the creeping spaces.

Upward vertical transport of contaminants through the soil system may take place via the water and air compartments (Kliest, 1990 and Fast et al., 1987). Both air-diffusion and convection transport with water (evaporation) may contribute to a large extent to transport through the soil (Fast et al., 1987).

After calculation of the transport fluxes from the soil system, the degree of dilution in the outdoor air or the creeping-space can be calculated, which will yield the concentration in the outdoor and indoor air.

For a number of parameters, use has been made of data from the study by Fast et al. (1987).

For the inorganic compounds it is assumed that they do not contribute significantly to exposure through inhalation. As a rule these substances are not volatile. However, sufficiently reliable data allowing control calculations are lacking (Kliest, 1990).

3.2.1.1 Flux calculation

For the calculation model use has been made of the universally applicable Jury theory (1984).

Figure 3 shows which fluxes are calculated first: J2, the flux through the boundary soil-air, which limits the fluxes from the soil; J3, the water evaporation flux from the soil to the soil boundary layer which does not hold water anymore and J4, the diffusion flux from the soil to the boundary section soil-air. The diffusion flux is determined by the concentration gradient in the soil, while assuming that there is a linear concentration gradient with a maximal content in the soil at a depth of 0.75 metre. If the soil-air boundary flux J2 is less than the diffusion flux J4 and the water evaporation flux J3 added together, the soil-air boundary flux limits the soil flux and should therefore be used and vice versa.

The water evaporation flux J3 has been calculated on the basis of data referring to the Dutch situation:
0.1 $dm^3.m^{-2}.d^{-1}$ [Fast et al., 1987].

Annex 2 gives the formulas used for these calculations; Table 9.3 in annex 9 shows the results of these calculations.

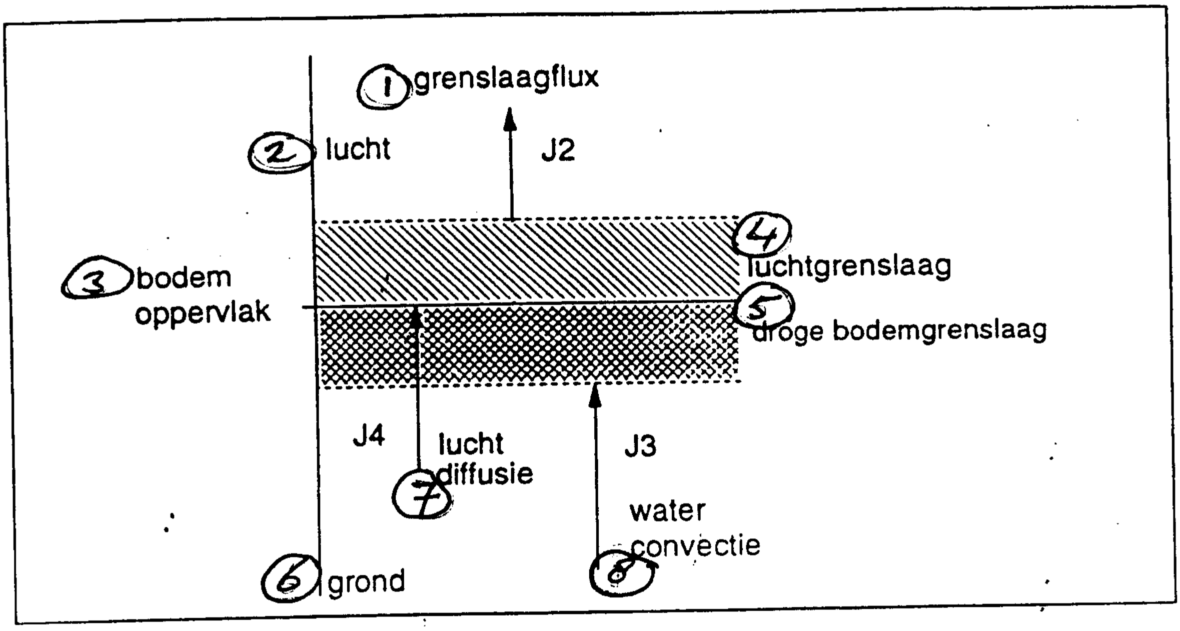

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Figure 3. Overview of transport fluxes from the soil to the gas phase for soil contaminants.

3.2.1.2 Outdoor air concentration

The flux which evaporates from the soil is diluted by the aeration flux which operates there, subject to weather conditions. Factors like mixture altitude, wind speed, surface roughness and dispersion coefficients play a role in this process. For the formulas used to calculate the dilution factor, we refer to annex 3, which is based on the reports on the HESP and SOILRISK models. This model uses the SOILRISK approach. The calculation of the dilution factor was performed based on the annual average for Dutch weather conditions.
The formulas for the calculation of the outdoor air concentrations are given in annex 4; the results of the calculation are shown in Table 9.3 of annex 9.

3.2.1.3 Indoor air concentration

The flux evaporating from the soil into the crawl space is diluted by the ventilation in the crawl space. The degree of dilution is determined by the ventilation velocity and the size of the crawl space. For this calculation, data were used from a Dutch research (Fast et al., 1987).
Concerning the indoor air concentration it is a precondition that it is higher than the outdoor concentration. If this is not the case, the indoor concentration is equated to the outdoor concentration. The formulas for the calculation of the indoor air concentration are given in annex 4; the results of the calculations are shown in Table 9.3 in annex 9.

PAGE 8

1. boundary layer flux
2. air
3. soil surface
4. air boundary layer
5. dry soil boundary layer
6. ground
7. air diffusion
8. water convection

PAGE 9

1. ground/plant

3.2.2 Uptake by crops

Crops may be contaminated via two routes:
1. uptake from the soil, particularly via soil moisture;
2. via deposition from the air, by soil particles in the air.

In order to determine the extent to which the contamination accumulates on crops, expressed as the bioconcentration factor BCF, a distinction must be made between metals/inorganic substances and organic compounds.

The formulas used for these calculations are given in annex 5; the results of the calculations are shown in Table 9.4 in annex 9.

3.2.2.1 Metals

Due to the limited knowledge of the accumulation mechanisms of these substances, the measured BCF values are proposed as starting-point. The viability of these values is discussed in section 4.3.2.1. Sauerbeck (1988) subdivided a number of substances into groups with a certain range for the bioaccumulation factor (ECETOC, 1990). Table 8 gives these data. For the derivation of the C-standard values, the geometric range average was used as value.

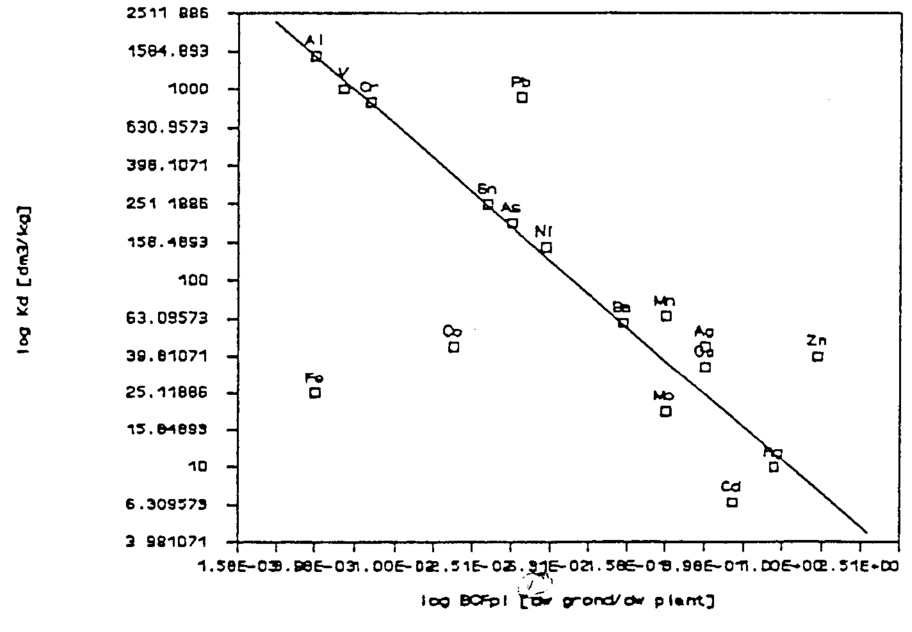

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Figure 4. Correlation between Kd (soil-water distribution coefficient) and BCFpl (accumulation factor plant), based on data by Baes et al. (1984).

If a measured BCF-value is not available, the BCF-value should be calculated with the formula drawn up by Baes et al. (1984), which gives a correlation between the BCF-value and the soil-water distribution coefficient Kd:

$\ln BCFpl = 2.67 - 1.12 * \ln Kd$, see Fig. 4.

Kd, of course, must be known. If this is not the case, the BCF-value must be estimated on the basis of 'expert judgement'.

3.2.2.2 Other inorganic substances

Assuming that the plant partly consists of water (for approximately 80%) and that the concentration of an inorganic compound in this situation is equal to the concentration in the soil moisture, a fixed BCF-value may be calculated on fresh weight basis and in relation to a soil moisture concentration of 0.8% (Briggs et al., 1982 and 1983, Ryan et al., 1988). On dry-weight basis, this means a BCF-value of 4.
As a worst-case scenario for the exposure to inorganic compounds it is assumed that they are completely water-soluble and to be found in the aqueous phase for 100%.

3.2.2.3 Organic substances

Based on the anaysis by De Nijs and Vermeire (1990), the relations according to Briggs (1982 and 1983) were chosen to calculate the BCF values for subsoil (root) and aboveground (leaf) parts of the crop, based on the octanol-water-partition-coefficient and the concentration of the substance in the soil moisture.

3.2.2.4 Deposition on crops

Due to various processes, soil particles also occur in the air and may subsequently be deposed on crops. Following this, the contaminant may be absorbed by the crop. If the crop were washed before use, this problem would be partly solved, but this possibility has not been taken into account here.
The deposition is calculated on the basis of the Hetrick and McDowell-Boyer equation (1984), from the EPA report "Users Manual for Tox-Screen". Annex 5 gives the formulas, which have been based on Dutch deposition velocity data (Olie et al., 1983).

3.2.3 Permeation in drinking water

Pollution of the drinking water as a result of soil-contamination may take place via three routes (see Figure 2). As for polluted groundwater and surface water used for drinking water in the context of the derivation of the C-standard values, it may be stated that monitoring and purification should lead to a negligible exposure via intake of drinking water. It should be added here that the Dutch National Environmental Policy Plan (NMP, VROM, 1988b) indicates that the environmental quality at regional level should be such as to reduce purification measures for drinking water from soil water reserves to a minimum. Consumption of drinking waater through private water catchment without purification hardly takes place (of all Dutch households, about 1% is not connected to the public drinking water supply system). Therefore, this leaves the possibility of consumption after permeation of the contaminant from the soil water or soil-air phase through the pipe into the drinking water.
Permeation does not occur in metals and inorganic substances. So far, only one study exists on the permeation of organic compounds, namely by KIWA (Vonk, 1985a and 1985b). This study indicates that particularly low-

density polyethylene (LDPE) pipes show permeation, much more so than other pipe types (HDPE, PVC, concrete, cast iron). For PVC the permeation mechanism is different from that operating in LDPE. It relies on an expansion process with 'moving front', instead of diffusion. Such an expansion process only occurs at concentration levels at which, in the case of LDPE, this would long have given problems. In order to calculate the permeation in this model, therefore, the LDPE formula derived in this study is used, except that a prolonged mean concentration (see 4.3.3) was used as the norm concentration, instead of the maximal concentration upon standstill. In addition, only the permeation from the soil water is considered here, excluding permeation via the soil air.
For this model use has been made of data generated by KIWA, additional data from the Municipal Waterworks Rotterdam (Van der Heijden and Hofman, 1987) and estimates based on structural similarities. The permeation-coefficients are shown in Table 4.
Annex 6 gives the formulas used in calculating the permeation and the resulting concentration in the drinking water. The calculated concentrations in the drinking water are given in Table 9.5 in annex 9.

3.2.4 Concentration in bathroom air

Due to the occurrence of contaminants in tap water, which only refers to organic substances (see 3.2.3) exposure may take place as a result of evaporation from the tap water during showering, provided that they are volatile compounds.
This route is not relevant to inorganic substances/metals, on the one hand because these substances do not permeate the drinking water and on the other hand because the evaporation coefficient is very low for these substances.
On the basis of the degree of evaporation, the concentration in the drinking water and water use, the concentration in the bathroom air can be calculated. the formulas are given in annex 7; the results of the calculation are shown in Table 9.5 in annex 9.

3.3 Exposure calculations

Linders (1990) described the major part of the exposure calculations in great detail. In a few instances where Linders did not give them, the calculations have been derived from HESP or SOILRISK and described briefly in this report. Annex 8 gives the formulas. The results of all calculations are given per route and per adult or child in Tables 9.7 and 9.8 respectively in annex 9.

3.3.1 Ingestion of soil and dust

Ingestion of soil and dust takes place through eating soil particles and licking contact surfaces like fingers and hands. For the calculation of prolonged exposure it is assumed that an average uptake of 150 mg/d soil and dust by children and 50 mg/d by adults takes place on a yearly basis.

3.3.2 Dermal contact with soil and dust

The intake of contaminants may take place through dermal contact with contaminated soil. For inorganic substances the adsorption factor is zero, which means that no exposure takes place via this route.

3.3.3 Inhalation of soil particles

Soil particles form part of the particles occurring in the air. By inhalation of these particles, adsorption may take place. This is especially true for particles $< 10\ \mu m$. Retention of these particles is assumed to take place by a fraction of 0.75. Particles $> 10\ \mu m$ are probably decomposed in the gastrointestinal tract. Given the assumption that all contaminants are absorbed, it makes no difference whether the intake occurs via the gastrointestinal tract or the lung.

3.3.4 Inhalation of air

Inhalation of air refers to the inhalation of contaminants present in the vapour phase arriving there from the soil by evaporation. A distinction should be made between breathing in indoor or outdoor air.
No distinction was made between active and passive breathing periods. For adults it is assumed that they spend 8 hours in the work place during a certain period (measured over 12 months per year, five days a week). Exposure does not occur during this period.

3.3.5 Consumption of crops

Exposure may occur by eating contaminated crops. The content in the crop is a function of the deposition on the plant and the accumulation from the soil into the crop. The exposure level depends on the content in the crop, the amount of crops consumed and the fraction in the total food package of crops from contaminated soil. It has been assumed that the amount of home-grown crop equals a fraction of 0.1 as compared to total vegetable and fruit consumption. (Linders, 1990).

3.3.6 Intake of drinking water

Following permeation of the drinking water pipes by organic contaminants from the soil into the drinking water, exposure takes place via drinking of this water.

3.3.7 Inhalation of vapours during showering

Due to the occurrence of organic contaminants in tap water, exposure may take place as a result of evaporation of tap water during showering.
On the basis of the concentration in the bathroom and the time spent there, the exposure can be quantified.

3.3.8 Dermal contact during bathing or showering

During showering or bathing, dermal contact takes place with the contaminants that entered the drinking water following permeation. As a worst-case scenario, the SOILRISK approach was chosen, which considers dermal contact during showering.

3.4 Calculation of the exposure

With the help of the formulas derived in the last section, the total contamination dose received by children or adults through soil contamination can be computed.

In order to be able to compare the mean daily life-time exposure with the TDI, it will first be necessary to integrate the exposure of children and adults into one daily average dose. Checking against the sensitive group made up by children who receive the highest dose relatively speaking, is not useful as this exposure is relatively brief and the TDI also takes account of an extrapolation factor for the sensitivity within the human population. For this reason it is proposed to calculate the daily average life-time dose as the total dose during life-time exposure divided by the duration of the exposure:

$$\mathrm{DOSE} \quad = \quad [\ \mathrm{sum}\ (\mathrm{TCH}\ j=1 \ldots x + \mathrm{sum}\ (\mathrm{TAD}\ j=x+1 \ldots L)\ ]\ /\ L$$

in which:
DOSE : daily average life-time dose [mg.kg^{-1}.d^{-1}]
L : duration of exposure = 70 [j]
x : age change in behaviour = 6 [j]
TCH : daily exposure child [mg.kg^{-1}.d^{-1}]
TAD : daily exposure adult [mg.kg^{-1}.d^{-1}]
so:

$$\mathrm{DOSE} \quad = \quad (6 * \mathrm{TCH} + 64 * \mathrm{TAD})/70$$

It has been assumed that children from age 7 will change their behaviour and that the ingestion of soil decreases as a result (Ruck, 1990 and Hawley, 1985).
The total calculated dose or exposure reflects the uptake of the amount of dust as the absorption factor has been allowed for in all steps (in nearly all cases it has been fixed at 1). As the TDI reflects the toxicologically tolerable daily intake, it cannot be automatically compared to the total dose mentioned earlier. This can be done by converting the total intake into the total oral intake and dividing it by the oral resorption factor (Linders, 1990). In practice this means that the oral resorption factor is fixed at 1 as well.

In principle it can be stated that the total dose increases linearly to the soil content. However, if the maximum water-solubility is exceeded, the exposure will become constant, whether there is a direct relation with the water and air concentration or not, so that the dose will only increase by exposure to soil particles and crop deposition. Figures 5A up to 5C illustrate this.

Figure 5A. Relation between benzene rate in the soil and the total dose of this substance. Apart from the dose for children, adults and the daily average life-time dose derived from it, the TDI (toxicologically tolerable daily intake) has been shown.

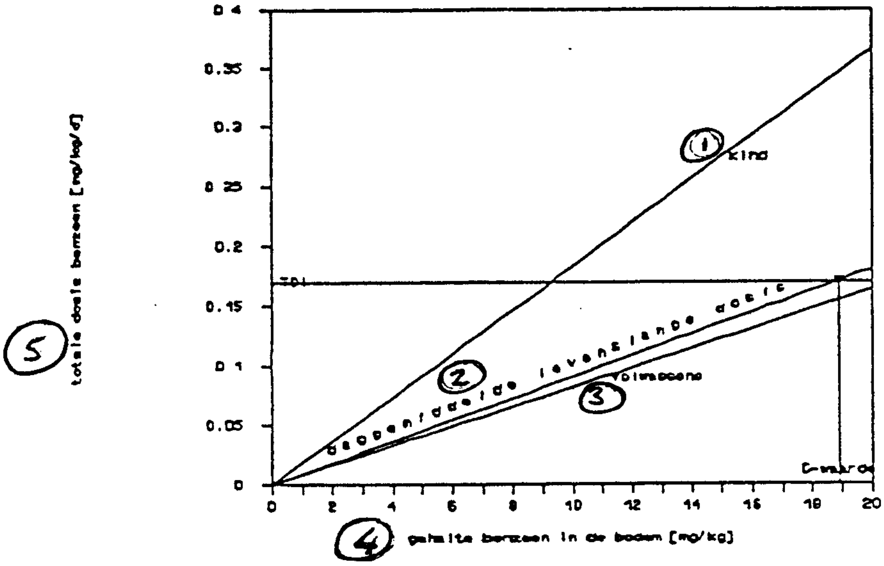

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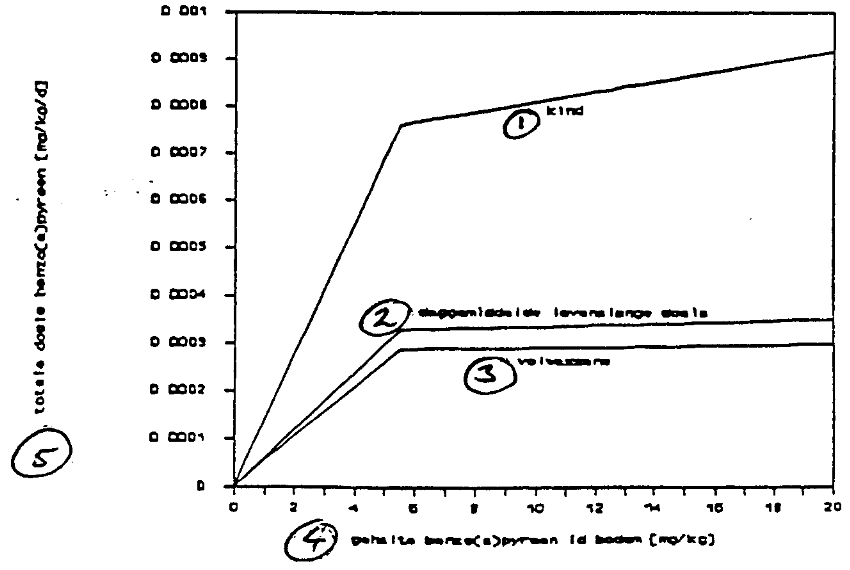
Figure 5B. Relation between the rate of benzo(a)pyrene in the soil and the total dose of the substance. Apart from the dose for children and adults and the daily average life-time dose derived from it,, the TDI (toxicologically tolerable daily intake) has been shown as well. At a rate of appr. 5.8 mg.kg^{-1}, water-solubility is exceeded.



Please, see next page for the translation

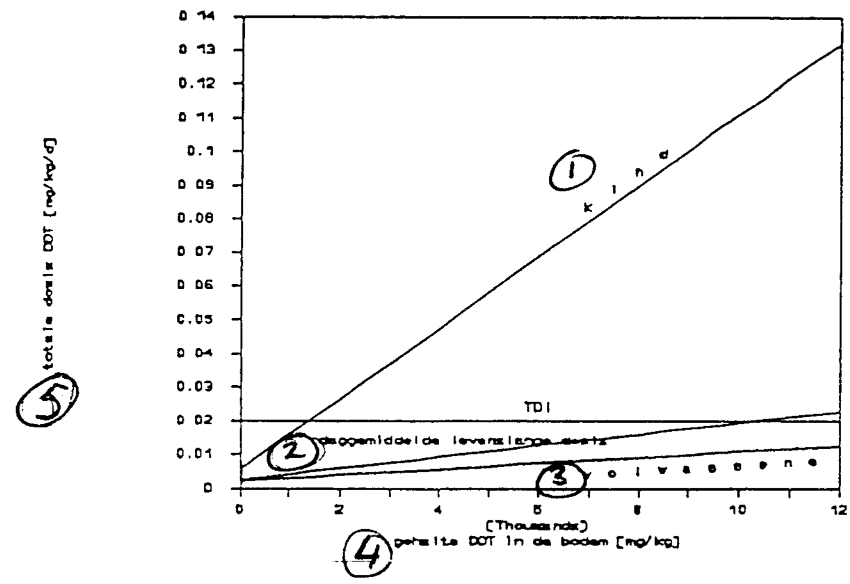
PAGE 14
5A
1. child
2. daily average life-time dose
3. adult
4. content of benzene in soil
5. total dose of benzene

PAGE 14
5B
1. child
2. daily average life-time dose
3. adult
4. content of benzo(a)pyrene in soil
5. total dose of benzo(a)pyrene

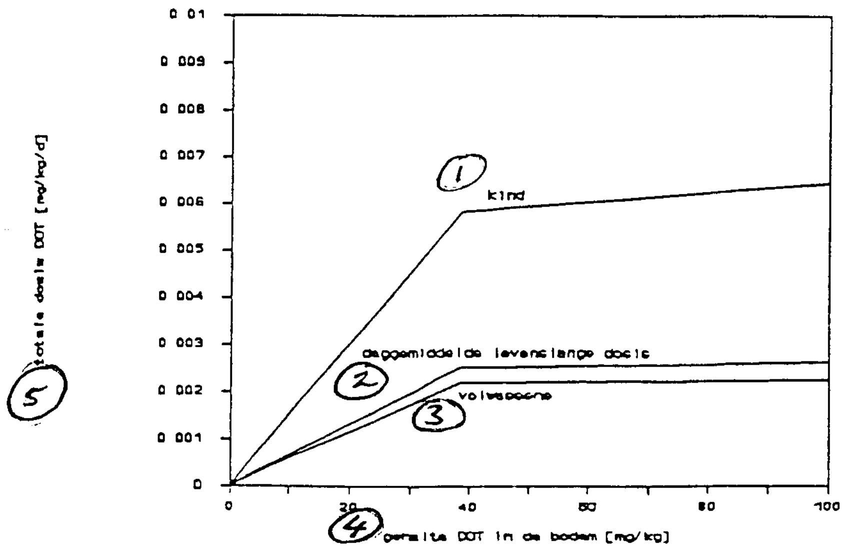
PAGE 15
5C
1. child
2. daily average life-time dose
3. adult
4. content of DDT in soil
5. total dose of DDT

1. child
2. daily average life-time dose
3. adult
4. content of DDT in soil
5. total dose of DDT

Figure 5C. Relation between the rate of DDT in the soil and the total dose of the substance. Apart from the dose for children and adults and the daily average life-time dose derived from it, the TDI (toxicologically tolerable daily intake) has been shown. At a rate of appr. 39 mg.kg^{-1} water solubility is exceeded. In order to show the relation between the C-value and this point, the inset gives an enlargement of the first part of the curve.



Please, see page 14a for the translation



Please, see page 14a for the translation

It should be observed that the exposure calculations and the resultant proposals for human toxicological C-standard values, do not take into account the following aspects:

- transformation of the substance; as this is affected by many factors and cannot be sufficiently modelled;
- substance wash out, which leads to a gradual decrease in the concentration ('finite source').

3.5 Derivation of human toxicological C-standard values

In the leaflet "Environmental Programme 1991-1994, Part III: Conceptual Framework for Environmental Policy" (VROM, 1990b) the C-standard value is related to the concept 'intervention value'. This is an environmental quality target which sets higher standards than the concentrations derived from the "maximum tolerable risk" (MTR). When the C-standard value is exceeded, intervention will consist of determining the need for clean-up and following up with the further research including an actual exposure analysis.
In establishing the human-toxicological recommended values (Vermeire et al., 1991), a distinction was made between non-genotoxic carcinogens and non-carcinogens on the one hand, and genotoxic carcinogens on the other hand. In correspondence with the Risk Leaflet (VROM, 1988a), these recommended values were based on the toxicologically Tolerable Daily Intake (TDI) and a maximum tolerable risk level of 10^{-4} per lifetime respectively.
Given the intervention value character of the C-standard value and the positioning regarding the "maximum tolerable risk", the proposed human toxicological C-standard value is defined in terms of the contaminant rate in the soil, while the lifetime average daily intake calculated with the help of the CSOIL model corresponds with a substance-dependent specified exceeding of the product of the maximum tolerable risk and an uncertainty factor N. This uncertainty factor concerns the uncertainties in the derivation of the toxicologically tolerable daily intake dose (Vermeire et al., 1991) and is a function of the safety factor. The reduction factor has a value of 1,2,3 or 4 for non-carcinogens and a value of 1 for carcinogens.
Table 1 gives the human-toxicological recommended values and the uncertainty reduction values.

The proposed human toxicological C-standard values are determined as follows:

1. calculating the dose for children and adults as a function of the contamination rate in the soil (Cs) according to the given formulas;
2. calculating the daily average lifetime dose for children and adults taken together;
3. determining the soil-rate where the daily average lifetime dose corresponds with the product of the human toxicological recommended values (TDI or R in the Vermeire et al., 1991 concept) and the uncertainty reduction factor; this rate will then be the proposed human toxicological C-standard value.

The proposed C-standard value, then, is not based on the toxicologically tolerable concentration in air (TCL). An example of this procedure is given in Figure 5A for benzene, where a C-value of 18.9 $mg.kg^{-1}$ has been derived.
In Table 2 the human toxicological C-standard values thus derived are given for both soil and groundwater. It should be observed here that the derived C-standard value has not been derived on the basis of an exposure analysis. It is the pore water concentration, which can be calculated on the basis of the C-standard value for soil, assuming that there is an equilibrium between the solid and aqueous phases (see formulas in annex 1).

Table 1. Data concerning 'toxicologically tolerable daily dose' (TDI in mg.kg^{-1}.d^{-1}), uncertainty reduction factor (N) and 'toxicologically tolerable concentration in air' (TCL in ug.m^{-3}) and corresponding uncertainty factor (N) for the substances considered. Adjusted on the basis of Vermeire (1993; reference: Annex 1)

name	TDI [mg.kg^{-1}.d^{-1}]	N	TCL [ug.m^{-3}]	N
arsenic	0.0021	1		
barium	0.02	1		
cadmium	0.001	1		
chromium (III)	0.005	3		
chromium (VI)	0.0000007	1		
cobalt	0.0014	2		
copper	0.14	2		
mercury	0.00061	1		
lead	0.0036	1		
molybdenum	0.01	2		
nickel	0.05	2		
tin	2	2		
zinc	1	1		
ammonium compounds	1.7	1		
bromides	1	1		
cyanides free	0.05	2	200	1
cyanides complex	0.013	3		
fluorides	0.07	1		
phosphates	70	2		
sulfides	0.0015			
thiocyanates	0.011	1		
benzene	0.0043		6.5	
ethylbenzene	0.136	3	77	3
phenol	0.06	3	100	1
cresol(p)	0.05	3	170	3
toluene	0.43	1	3000	1
xylene(m)	0.01	3	54	3
catechol	0.04	3		
resorcinol	0.02	3		
hydroquinol	0.025	3		
anthracene	0.05			
benzo(a)anthracene	0.02	1		
benzo(k)fluoranthene	0.02	1		
benzo(a)pyrene	0.002	1		
chrysene	0.002	1		
phenanthrene	0.02	1		
fluoranthene	0.02	1		
indene(1#2#3cd)pyrene	0.02	1		
benzo(ghi)perylene	0.02	1		
pyrene	0.02	1		
naphthalene	0.05			
1#2-dichloroethane	0.014	1	48	1

(Table 1. ctnd.)

name	TDI [mg.kg.$^{-1}$.d^{-1}]	N	TCL [ug.m^{-3}]	N
dichloromethane	0.06	2	1700	2
tetrachloromethane	0.004	2	60	2
tetrachloroethene	0.016	3	2500	1
trichloromethane	0.03	3	100	3
trichloroethene	0.54	2	1900	2
vinyl chloride	0.0035	1	100	1
monochlorobenzene	0.0005	2	600	2
p-dichlorobenzene	0.0005	2	600	2
trichlorobenzene(1#2#4)	0.0005	2	600	2
tetrachlorobenzene(1#2#3#4)	0.0005	2	600	2
pentachlorobenzene	0.0005	2	600	2
hexachlorobenzene	0.0005	2	600	2
monochlorophenol (2)	0.003	2		
dichlorophenol (2#4)	0.003	2		
trichlorophenol (2#3#4)	0.003	2		
tetrachlorophenol (2#3#4#5)	0.003	2		
pentachlorophenol	0.03	2		
chloronaphthalene	0.0005		600	
trichlorobiphenyl (2#5#2#)	0.00009	3		
hexachlorobipenyl	0.00009	3		
DDT	0.02	1		
DDE	0.02	1		
aldrin	0.0001	2		
dieldrin	0.0001	2		
endrin	0.0001	2		
HCH	0.001	2	0.25	2
carbaryl	0.01	2		
carbofuran	0.01	2		
propoxur	0.02	2		
maneb	0.05	2		
atrazine	0.002	3		
heptane	3.1	2	71	3
octane	3.1	2	71	3
cyclohexanone	4.6	2	136	3
butylbenzylphtalic acid	0.025	2		
di(2-ethylhexyl)phtalic acid	0.025	2		
pyridine	0.001	3	120	1
styrene	0.077	2	800	2
tetrahydrofuran	0.01	3	35	3
tetrahydrothiophene	0.18		650	

In the integration report (Van den Berg and Roels, 1991) an alternative approach will be considered (e.g. whether or not to conduct an exposure analysis).

In the derivation of the C-standard values, background exposure for the substances considered here, as described by Vermeire et al. (1991), is not taken into consideration. Background exposure of course contributes to the total burdening of man, but in view of the amount of background exposure in relation to the human toxicologically recommended values and the concept followed (MTR-level), it is assumed that this added burdening will not lead to adverse effects.
There is one exception to the procedure that has been followed. In the case of lead there is a child-specific TDI, which means that the human toxicological C-standard value must be focused on the exposure of children. This leads to a lower value, as appears from the correction column in Table 2.

3.6 Verification by other norms or criteria

On the basis of the established C-standard values it can be verified if these values also meet other criteria, like crop norms, toxicologically tolerable concentration in air (TCL)-values, odour threshold values (OT-values) and drinking water norms.
Table 3 lists the substances which were found to exceed crop norms, OT-values or TCL-values. Where relevant the calculated value was given in addition to the criterion.
For indoor and outdoor air concentrations it is stated that they must be under the TCL- and OT-norm values. When either of these norm values is exceeded, the C-standard value must be adjusted in such a way that excession no longer occurs. In this case the indoor air concentration measured given the C-standard value must correspond with the lowest TCL- or OT-value, where for the TCL value an uncertainty reduction factor is taken into account if necessary (see Table 1). In cases where concentrations were exceeded, the C-standard value has been adjusted, as shown in the correction column in Table 2.
In cases where the drinking water norms in the Waterleidingbesluit (Staatsblad, 1984) are exceeded, given a soil contamination rate equalling the C-standard value as a result of permeation of the drinking water pipe, this could also lead to an adjustment of the C-standard value. Table 10 indicates the relation between the calculated drinking water concentrations and the drinking water norms. The proposed human toxicological C-standard values have not been adjusted yet, as the basis for the drinking water norms and the C-standard values differs. The integration report (Van den Berg and Roels, 1991) may provide further comments on this matter. It may be observed here that the calculated drinking water concentrations are higher than the drinking water norms and that adjustment of the proposed C-standard values would lead to significantly lower norm values.
Direct testing of groundwater- or soil moisture concentrations on the basis of drinking water norms has not taken place, as it has not been assumed (as indicated in section 3.2.3) that purification of groundwater would fail to be carried out. On the other hand, it must be stated that the use of groundwater in which concentrations exceed the C-standard values proposed in this report, could be restricted. Product norms occupy a special position, as derived, for instance, for crops governed by the Warenwet (heavy metals and inorganic compounds - Staatsblad, 1985) and the Residubeschikking (pesticides - Staatscourant, 1984).

Table 2. Proposed human toxicological C-standard values for soil and groundwater (foc=0.02).

The indication ** behind the substance name means that water solubility is exceeded at this soil-content.

			after correction	
name	C-soil	C-soil water	C-soil	C-soil water
	[mg.kg^{-1}]	[g.m^{-3}]	[mg.kg^{-1}]	[g.m^{-3}]
arsenic	300	5.07		
barium	698	13.9		
cadmium	1.84	0.13		
chromium (III)	2140	21.4		
chromium (VI)	0.0999	0.000998		
cobalt	400	3.99		
copper	5020	8.64		
mercury	87.1	0.87		
lead	514	5.35	162	1.69
molybdenum	36.8	0.734		
nickel	1790	81		
tin	571000	11400		
zinc	1840	19.1		
ammonium compounds		2350		
bromides		1380		
cyanides free	18.5	138		
cyanides complex	7.2	54		
fluorides		96.9		
phosphates		194000		
sulfides				
thiocyanates	2.03	15.2		
benzene	18.9	14.9		
ethylbenzene	263	22.3	51.9	4.40
phenol	62.9	170	21.0	56.7
cresol(p)	84.4	88.3	1.81	1.89
toluene	132	31.6		
xylene(m)	25.8	1.96		
catechol	28.3	145		
resorcinol	13.7	75.2		
hydroquinol	16.4	101		
anthracene				
benzo(a)anthracene **	10100	0.01		
benzo(k)fluoranthene **	10900	0.0006		
benzo(a)pyrene **	996	0.0003		
chrysene	39.2	0.00109		
phenanthrene	121	0.423		
fluorantene	196	0.112		
indene(1#2#3cd)pyrene **	11400	0.0001		
benzo(ghi)perylene **	11800	0.00026		
pyrene **	1040	0.032		
naphtalene				

Table 2. Proposed human toxicological C-standard values for soil and groundwater (foc=0.02). (ctnd.)

The indication ** behind the substance name means that water solubility is exceeded at this soil-content.

			after correction	
name	C-soil	C-soil water	C-soil	C-soil water
	[mg.kg^{-1}]	[g.m^{-3}]	[mg.kg^{-1}]	[g.m^{-3}]
1#2-dichloroethane	1.82	4.92		
dichloromethane	16.5	21.9		
tetrachloromethane	0.812	0.211		
tetrachloroethene	5.13	1.46		
trichloromethane	11.6	12.6	11.0	12.0
trichloroethene	247	56.2	238	54.2
vinyl chloride	0.04	0.00728		
monochlorobenzene	0.588	0.108		
p-dichlorobenzene	1.64	0.079		
trichlorobenzene(1#2#4)	3.81	0.0403		
tetrachlorobenzene(1#2#3#4.	6.64	0.0161		
pentachlorobenzene	8.83	0.00726		
hexachlorobenzene	9.85	0.00548		
monochlorophenol (2)	5.78	2.69		
dichlorophenol (2#4)	12.2	1.04		
trichlorophenol (2#3#4)	22.4	0.359		
tetrachlorophenol (2#3#4#5)	14.3	0.769		
pentachlorophenol	521	0.47		
chloronaphthalene				
trichlorobiphenyl (2#5#2#)	3.07	0.000938		
hexachlorobiphenyl	5.11	0.000167		
DDT **	10400	0.0031		
DDE **	3450			
aldrin	5.77	0.000028		
dieldrin	2	0.00106		
endrin	1.58	0.00216		
HCH	6.63	0.153		
carbaryl	186	0.0967		
carbofuran	158	0.215		
propoxur	246	0.841		
maneb **	58800	0.0001		
atrazine	4.92	3.57		
heptane	472	6.63	3.74	0.052
octane **	1940000	0.66	2.64	0.011
cyclohexanone	3700	5380	329	479
butylbenzylphtalic acid	282	1.25		
di(2-ethylhexyl)phtalic acid **	8890	0.285		
pyridine	1.24	0.103		
styrene	153	14.9	35.4	3.45
tetrahydrofuran	0.58	0.0401	0.46	0.032
tetrahydrothiophene				

Table 3. Certain criteria are exceeded, the soil-rate equalling the C-standard value. An overview of the substances that are found to exceed the criteria and the extent of the excession.

TESTING AGAINST THE CROP NORM a)

	crop norm [mg.kg^{-1} fresh weight]	calculated content in crop [Cpt'] [mg.kg^{-1} fresh weight]
cadmium	0.03 - 0.2	0.22
lead	0.2 - 2.5	0.62
mercury	0.01 - 0.03	0.11
cyanide	0.2 -75	22.2
pentachlorophenol	0.01	12.9
endrin	0.02	0.04
DDT	0.05 - 0.1	0.70
hexachlorobenzene	0.01 - 0.05	0.22
HCH	0.01 - 1	0.43

TESTING AGAINST THE TCL-VALUE

	TCL-value [g.m^{-3}]	reduction factor	calculated indoor air concentration [g.m^{-3}]
trichloromethane	$1.0\ 10^{-4}$	3	$3.15\ 10^{-4}$
1,2-dichloroethane	$4.8\ 10^{-5}$	1	$4.15\ 10^{-5}$
trichloroethene	$1.9\ 10^{-3}$	2	$3.94\ 10^{-3}$
ethylbenzene	$7.7\ 10^{-5}$	3	$1.17\ 10^{-3}$
phenol	$1.0\ 10^{-4}$	1	$1.17\ 10^{-4}$
heptane	$7.1\ 10^{-5}$	3	$2.69\ 10^{-2}$
octane	$7.1\ 10^{-5}$	3	$1.28\ 10^{-2}$
cyclohexanone	$1.4\ 10^{-4}$	3	$4.72\ 10^{-3}$
tetrahydrofuran	$3.5\ 10^{-5}$	3	$1.32\ 10^{-4}$

TESTING AGAINST THE ODOUR THRESHOLD VALUE b)

	OT-value [g.m^{-3}]	calculated indoor air concentration [g.m^{-3}]
phenol	$3.9\ 10^{-5}$	$1.17\ 10^{-4}$
cresol	$1.3\ 10^{-6}$	$6.07\ 10^{-5}$
trichloroethene	$3.9\ 10^{-3}$	$3.94\ 10^{-3}$
styrene	$6.8\ 10^{-5}$	$2.91\ 10^{-4}$

a) Tables 2.1 and 2.2 taken from VROM (1990) - Provisional Inspection Directive
b) Table 5.2 taken from VROM (1990) - Provisional Inspection Directive

These product norms are not (yet) available for meat, milk and fish. In this context it must be stressed that the objective of (the derivation of) C-standard values (intervention values soil quality based on potential exposure to soil contamination via all relevant exposure routes) differs from the objective of product norms (focused on crops and their marketing potential). Crop contents, which can be calculated with the model based on soil-content of the contaminant at the level of C-standard values, are within the range of crop norms, or near the maximum rate, with the exception of DDT and pentachlorophenol. Moreover, a large variation in contamination rates has been found between various crops (Sauerbeck, 1988). This test, then, does not give rise to adjustment of the model calculations or the standard values derived from them. It is possible, however, that the standard values proposed in this report will entail restrictions for the cultivation of crops sensitive to certain substances. Exposure to contamination via crops (consumption) may be avoided by means of changes in use or use measures (e.g. different crop choice, agricultural measures).

When (forthcoming) product norms for meat become available, it is recommended that the C-standard values be tested against them. The present exposure model will have to be extended in order to do so. Proposals for extending the formulas were already put forward by Linders (1990) and ECETOC (1990).

3.7 Actual exposure

The actual exposure can be calculated in the same way as for potential exposure. However, for the calculation of the actual exposure, the actual site-specific data should be considered where possible. Based on the given formulas the various routes may be examined step-by-step, taking into consideration that the concentrations in the contact media for the major routes, or routes characterized by the largest uncertainty factor, are being measured instead of calculated. Ideally, only the formulas in annex 8 would be needed, while the formulas in annexes 1-7 would merely support the research.

In cases of actual exposure it may be that product norms are being exceeded (given the approach chosen for the time being), in spite of the fact that the C-standard value is not being exceeded, as a result of which product use would have to be restricted.

Another aspect that must be taken into consideration in the actual exposure analysis is the background exposure, which did not play a role in determining the proposed C-standard values.

4. DISCUSSION

This chapter discusses the differences and correspondences between the three models evaluated, RIVM, HESP and SOILRISK, following the same sequence used in the preceding chapters to discuss the various steps in the calculation. Moreover, the uncertainties in parameters, processes, etc. are considered.
Again it should be emphasized that HESP and SOILRISK merely cover the objective of estimating the actual risks as a result of exposure to soil contamination, whereas the RIVM model and the CSOIL model are primarily aimed at deriving C-standard values. In addition, SOILRISK only analyses the exposure for children, which means a limitation. Finally, time fractions are increasingly accounted for, going from the SOILRISK via RIVM to the HESP model.

4.1.1 Substance properties

In principle the various models use the same set of parameters.
The HESP model employs one fixed value for the air diffusion coefficient, namely that of benzene. In SOILRISK the air diffusion coefficients have been calculated, based on the molecular weight and the Millington-Quirk soil-retardation factors (see also Jury et al., 1983). In a few cases (see Table 4) measurement data were available. (Fast et al., 1987).
From a comparison between the calculated values and the given values for the air diffusion coefficient it becomes clear that no major incorrections are being introduced by using the calculated values in all cases. As the calculation is easily made, this approach was chosen in the CSOIL model.
The ratio between the given and calculated value ranged from 0.73 to 1.07.
Using one fixed value, as in HESP, led to more significant deviations (range computed in relation to fixed value of 0.54 to 1.35).
For the permeation coefficient one fixed value was chosen in both the HESP and SOILRISK models, namely the highest value found in the KIWA study (Vonk, 1985a and b), that for monochlorobenzene.
The use of this value leads to overestimation of a potential exposure via the drinking water route following permeation. Data are available for a number of substances mentioned in the test table of the Guideline Soil Protection, taken from Vonk (1985a) and studies by the Gemeentelijke Drinkwaterleiding Rotterdam (Van der Heijden and Hofman, 1987) and the Gemeentelijk Waterleidingbedrijf Amsterdam (Van Geel et al., 1988). The GDR,in particular, made estimations for a number of permeation coefficients. For CSOIL use was made of the data generated by KIWA, the additional GDR data and estimations based on structural similarities. The permeation coefficients are given in Table 4.

An uncertainty that cannot be properly described and quantified concerns speciation. Particularly for inorganic compounds, speciation, for instance whether or not they are found in water-soluble form, is essential.
Apart from the uncertainties introduced by the use of estimates where data are lacking, the measurement data, likewise are characterized by a degree of uncertainty. More in particular, these uncertainties refer to the possibilities of measuring certain properties. Low water-solubility and vapour pressures are hard to measure and may lead to large variations in the results (hexachlorobenzene - water solubility: 0.004-0.11 g.m^{-3}). The same is true for measuring high Kow-values, although this parameter is not as uncertain as the other parameters.

4.1.2 Soil condition

As both SOILRISK and HESP discuss actual risks, the choice of soil-condition data does not play a role. However, in a number of cases, a kind of "default-values" were given, which have been included in Table 5 for reasons of comparison.
In general it may be said that for organic substances where the water solubility is not exceeded at a soil-content equal to the C-standard value (see Table 2), an increase in the organic carbon content leads to increased

sorption and so lower concentrations in soil moisture and soil air, which in turn leads to lower exposure values and vice versa.

Table 9 shows the C-soil values for foc values of 0.01 and 0.20 for the given substances. In general the following equation is found for the relation between the C-value and the organic carbon rate:

$$C_x = C_{ref} * foc_x / foc_{ref},$$

in which C_x : C-standard value for foc = x
C_{ref} : C-standard value for foc = ref.

As becomes clear from Table 9, this relation is reasonably reliable for most of the compounds considered (i.e. the C-value for foc=0.20 is 20 times larger than the C-value for foc=0.01), but for some substances large deviations (up to a factor 10) occur.

The dependence on the organic carbon rate may be reason to differentiate the C-standard values for this situation. In the integration report (Van den Berg and Roels, 1991) this matter is discussed further, also in relation to the differentiation as proposed by Dennemand and Van Gestel (1990) with reference to the proposed C-standard values.

As for metals and other inorganic compounds, this model did not consider dependences on the organic carbon, lutum or acidity rates of the soil, as relevant viable data in this field are not available.

A lower volume fraction air or water in the soil also gives a lower exposure value and vice versa. However, an increasing air pore volume, given constant porosity and hence a decreasing water pore volume, generally leads to decreasing C-values. For the inorganic compounds and substances where water evaporation constitutes the major soil air flux, a linear decrease is found, while for substances where the diffusion flux is the major soil air flux, a logarithmic decrease in the C-values is found. The C-value is only slightly or not at all affected by the pore water-air relation for substances where evaporation does not play an important role: metals, PAHs, pesticides and chlorophenol.

4.1.3 Exposure routes

In principle the three modles mentioned before consider the same exposure routes. However, in the context of determining new C-standard values, a number of routes have been ruled out as they were not considered relevant.

Table 9. C-values soil [mg.kg^{-1}] for two different organic carbon contents: 1 and 20% respectively.

foc 0.01	foc 0.20	
300	300	arsenic
698	698	barium
1.84	1.84	cadmium
2140	2140	chromium (III)
0.0999	0.0999	chromium (VI)
400	400	cobalt
5020	5020	copper
87.1	87.1	mercury
514	514	lead
36.8	36.8	molybdenum
1790	1790	nickel
571000	571000	tin
1840	1840	zinc
314	314	ammonium compounds
185	185	bromides
18.5	18.5	cyanides free
7.2	7.2	cyanides complex
12.9	12.9	fluorides
25800	25800	phosphates
10	10	sulfides
2.03	2.03	thiocyanates
10.6	167	benzene
133	2570	ethylbenzene
42.8	424	phenol
48.1	732	cresol (p)
68.7	1270	toluene
13.1	252	xylene (m)
23.8	109	catechol
11.9	47.2	resorcinol
15	43	hydroquinol
10	10	anthracene
10100	10100	benzo(a)anthracene **
10900	10900	benzo(k)fluoranthene **
996	996	benzo(a)pyrene **
19.9	302	chrysene
60.6	1100	phenanthrene
98.9	1710	fluoranthene
11400	11400	indene(1#2#3cd)pyrene **
11800	11800	benzo(ghi)perylene **
1040	2320	pyrene **
10	10	naphthalene
1.25	12.1	1#2-dichloroethane
9.82	136	dichloromethane
0.434	7.6	tetrachloromethane
2.75	47.9	tetrachloroethene
6.74	98.4	trichloromethane
129	2370	trichloroethene

0.0246	0.316	vinyl chloride
0.302	5.69	monochlorobenzene
0.828	15.9	p-dichlorobenzene
1.91	36	trichlorobenzene (1#2#4)
3.34	60.3	tetrachlorobenzene (1#2#3#4)
4.45	77.8	pentachlorobenzene
4.97	85.7	hexachlorobenzene
3.07	53.8	monochlorophenol (2)
6.17	117	dichlorophenol (2#4)
11.3	212	trichlorophenol (2#3#4)
7.19	137	tetrachlorophenol (2#3#4#5)
262	4600	pentachlorophenol
10	10	chloronapthalene
1.55	26.2	trichlorobiphenyl (2#5#2#)
2.6	39.7	hexachlorobiphenyl
10400	10400	DDT **
3450	3450	DDE **
2.96	40.1	aldrin
1.01	17.3	dieldrin
0.795	14.1	endrin
3.34	63	HCH
93.9	1630	carbaryl
79.4	1410	carbofuran
123	2240	propoxur
58800	58800	maneb **
2.7	44.4	atrazine
245	4540	heptane
1950000	1950000	octane **
2210	30400	cyclohexanone
142	2600	butylbenzylphtalic acid
8890	8890	di(2-ethylhexyl)phtalic acid **
0.631	12.2	pyridine
77.5	1480	styrene
0.331	5.06	tetrahydrofuran
10	10	tetrahydrothiophene

** at a content in the soil equal to this C-value, water solubility is exceeded.

4.1.4 The exposed: man

In order to compare the assumptions relating to parameters regarding man used in this model, Table 6 shows the parameter values from HESP, SOILRISK, RIVM and Hawley (1985) as main reference.
Human (behavioural) parameters are likewise characterized by uncertainty, i.e. the normal variation in the population. They seem to be of minor importance, however, compared to the other uncertainties.

4.2 Distribution over soil phases

In calculating the distribution of the contamination over the soil phases solid phase, soil moisture and soil air, the mass balance was taken into consideration, as well as the equilibrium between the three phases. SOILRISK uses the same approach, but HESP only employs the equilibrium distribution and disregards mass balance. Particularly for non-volatile, easily water-soluble substances, like the inorganic substances, phenol or cyclohexanon, this leads to substantial deviations in the sense that the fractions calculated in soil air and soil moisture are too high.
The Karickhoff (1981) linear relation was used for the relation between the groundwater distribution coefficient corrected for organic carbon Koc and the octanol/water distribution coefficient Kow. The same Karickhoff (1981) article gives a relation which yields the relationship between these parameters after logtransformation. This relation leads to virtually identical Koc-values for all substances considered. In the lierature different relationships with slightly deviating parameter values were described for this relation. These parameter values did not, however, vary widely as regrads the results (the Koc-values). Ryan et al. (1988) found deviations for the extreme Kow-values up to a factor 4 between the various ways of expressing this relation.
The linear equation was chosen as it was also used in HESP and SOILRISK by Mackay et al. (1981) and in the BNS model (Evaluation New Substances) (De Nijs et al., 1988 and Van de Meent, 1989).

In forming the model and particularly the distribution over the phases, the equilibrium principle was used. This was primarily based on laboratory observations, where equilibrium was seen to establish itself very fast, for instance between soil and soil moisture (within 24-28 hours). Regarding the Kd or Koc calculations, Karickhoff (1981) concluded that for substances, as described in this report, the correspondence between measured and computed Koc-values was generally good, with deviations up to a factor 3, with a few exceptions. For the 49 substances considered in the article the difference between 'log-measured Koc and log-estimated Koc' was 0.20 ± 0.46.

4.3 Model calculations for concentrations in contact media

4.3.1 Indoor and outdoor air

Contrary to the HESP approach, both diffusion and evaporation are considered. Furthermore, an indoor air calculation is performed, based on a crawl space with an uncovered soil layer.
SOILRISK does not apply the element volatilization through water evaporation correctly, as it is not added up with the diffusion flux. For the rest the maximal diffusion flux, J1, is not important, but the boundary layer flux, J2, must be compared with the sum of the diffusion flux, J4 and the water evaporation flux, J3, in order to determine which one limits the soil-volatilization flux (Figure 3).
Application of this method has pointed out that the J4-diffusion flux is generally used for the volatile substances (aromatics, chlorinated aliphates) and the J3-flux for non-volatile substances (phenols, PAHs) (see Table 9.3, annex 9). The boundary layer flux, J2, turned out to be restrictive only in a limited number of cases (benzo(k)fluoranthene, pyrene and atrazine).
For the volatile substances (fraction in soil air > 0.001) the contribution of evaporation to the total flux is 0.07 ± 0.09. For non-volatile substances this value is 0.82 ± 0.29.

In the annexes to Fast et al. (1987) a water evaporation flux of $51.m^{-2}.d^{-1}$ was calculated. Further study of the data from this research shows this to be incorrect. The measurement data indicate a mean water increase in air of 2.5 ± 1.9 $g.m^{-3}$ and a model calculation gives a nominal value of 6 $g.m^{-3}$. Combined with data on ventilation velocity and creeping-space size, this gave a water evaporation flux of 40 ± 20 and 100 $g.m^{-2}.d^{-1}$ respectively. Further consultation of Kliest confirmed this. (Kliest, 1991).
Field research (Fast et al., 1987) showed that indoor air concentrations are not always related to the soil-rate. Two observations must be made in this context:

- substance-bound transport may play a role in cases of dispersion of a dry contaminated surface;
- for dieldrin and aldrin unexpected relatively high concentrations were found at the water-air boundary, suggesting that the compounds had not been adsorbed.

Adequate quantification or explanation of these phenomena is not possible, so that they have been left out in the CSOIL model. They should be considered, however, and should be performed in the actual risk assessment measurements when necessary (Kliest, 1990).

An important condition to the application of the Jury-theory is that there is no soil-depletion and the gradient should only be determined by the concentration in the soil. Both assumptions can be verified.
Only in the case of vinyl chloride is depletion found to occur relatively fast (after 100 hours). This means that both the flux and the exposure decrease fast. In fact this may give rise to a higher C-standard value.
With the depletion of vinylchloride, the gradient simultaneously decreases, but is still only determined by the rate in the soil.

The approach to the calculation of the volatilization flux from the soil is based on both mechanics theory (Jury et al., 1981 and 1984a and b) and empirical findings. Jury et al. (1984b) performed a test for the gas diffusion fluxes, which showed a relatively good correspondence between calculated and measured values. Quantitatively, deviations were seen to occur compared to measured values ranging from a factor 6 smaller to a factor 2 larger. Empirical findings largely concern the water evaporation flux, which has been calculated and measured (Fast et al., 1987). The uncertainties here refer especially to the choice of parameters.

4.3.1.1 Outdoor air concentration

Two models are available for the calculation of the outdoor air concentration, HESP and SOILRISK. The HESP model calculates the vertical dilution for an infinitely extended source from a chain of fluxes. The SOILRISK model (CPR, 1988) calculates the horizontal and vertical mixture, in other words the dilution, for a finite magnitude, taking the soil flux as starting-point. The SOILRISK calculation is the most appropriate and is therefore used. The ventilation velocity is calculated based on wind speed and mixture altitude, which is related to the dispersion, which again depends on the weather stability class (CPR, 1988). The Pasquill-weather stability D-class (neutral weather conditions) was chosen as standard value. SOILRISK started from a roughness length of 0.3 m, characteristic of cultivated land. This model chose a value of 1.0 m, representative for residential areas. This results in a lower dilution of outdoor air concentration for children (161 instead of 337 $m.h^{-1}$) and for adults (at a breathing altitude: 1.75 m) in a virtually identical dilution (387 compared to 337 $m.h^{-1}$). In this approach, the dilution is dependent on the size of the location. When the diameter of the contaminated section increases, dilution decreases.
In the HESP model the dilution varies from a factor 42 to 103$m.h^{-1}$, depending on the substance.

The uncertainties in the calculation of this concentration are related to the descriptions and paramenters used. Little can be said about the magnitude of these uncertainties, except that uncertainties of a factor 5 appear to be possible from the data on dilution velocities mentioned above.

4.3.1.2 Indoor air concentration

The SOILRISK model assumed a somewhat larger size of the creeping-space and a higher ventilation degree than found in the Dutch situation (Table 7). As a result, the concentrations given in the SOILRISK model are a factor 3.2 higher than the calculations used here. The dilution factor in these CSOIL data is 0.625 m.h^{-1}, compared to 2 m.h^{-1} in the SOILRISK model. Both SOILRISK and HESP give calculation methods for creeping-space concentrations in the case of concrete creeping-spaces, in other words with an extra protection from the soil. This leads to a much lower flux to the creeping-space and so to the indoor air. For calculations of a closed creeping-space, see relevant reports on SOILRISK and HESP.

As to indoor air concentrations, the varying ventilation velocities, ranging from min. 0 to max. 7.4 ; mean 1.25 h^{-1}) and varying fractions of the contribution of the creeping-space to indoor air, ranging form min. 0.03 to max. 0.68; mean 0.11) give rise to uncertainties.

4.3.2 Uptake by crops

For the quantification of the impact on crops, basically the same methods have been used in all three models.

4.3.2.1 Metals

Linders (1990) did not give a quantification due to a lack of viable data. In the case of metals, the HESP and SOILRISK models used the Baes (1982) relation. Given fixed Kd-values, this formula leads to a maximum difference of a factor 12 between calculated and measured BCF-values, and a factor 20 between calculated and measured Kd, given fixed BCF-values (see Figure 4). Baes et al. (1984) later elaborated the formula to its present form. Here too, large deviations are found, generally up to a factor 5 for the substances considered here, with the exception of iron, with a factor 70. For this reason and in view of the unreliability of the Kd-values, it would be better to start from measured BCF-values where possible. The HESP report gives a Table to this purpose, derived from Sauerbeck (1988).Table 8 shows these data. Sauerbeck (1988) also described the sensitivity of different crops to accumulation.

The results of this type of model calculation are not only influenced by the soil type, which could be corrected by means of the organic carbon rate, but also by other soil parameters, like pH and redox-potential.

4.3.2.2 Other inorganic substances

Assuming that plants partly consist of water (appr. 80%) and that the concentration of an inorganic compound in plants is equal to the concentration in soil moisture, a fixed BCF-value on dry-weight basis of 4 has been proposed. This does not appear unrealistic and has in fact been established by Briggs et al (1982 and 1983) as a fixed parameter of 0.82. Deviations in factor magnitude are dependent on the plant's water-rate, but will be relatively small. The assumption that the substance has been completely dissolved will lead to larger mistakes and is more open to debate. It is clear that compounds like sulphides are on the whole poorly water-soluble, so that the approach used will lead to overestimation of the exposure in this case. However, since more reliable data are lacking, the procedure described above has been used.
Moreover, the inorganic compounds in the plants could precipitate when evapotanspiration from the plant takes place, potentially resulting in a higher accumulation. More information on this matter is still lacking.

4.3.2.3 Organic substances

De Nijs and Vermeire (1990) performed an analysis in order to determine which soil-plant transfer factors or models could best be used for organic substances. This analysis included the models used in SOILRISK and HESP. In these tranfer models, the examination of relations between the octanol-water partitioning coefficient and the soil-moisture concentration was of essential importance. Both for the aerial and subterranean parts of the plant, the relations by Briggs et al. (1892 and 1983) were considered most viable. The Travis and Arms relation (1988) yields similar rates for the description of topsoil rates compared to Briggs' model, that is, within the range of the octanol-waterpartitioning coefficient for which data were used. Beyond this range, larger deviations are found.

4.3.2.4 Deposition on crops

Linders (1990) did not describe deposition, but SOILRISK, HESP and De Nijs and Vermeire (1990) used the same model, the one according to Hetrick and McDowell-Bayer (1984), from an EPA-report titled Users Manual for TOX-Screen. The way they worked out the equation differed, however.
The difference is in the factor that allows for efflorescence in combination with a time period for crop growth and has a magnitude of 0.83. As there is little difference numerically speaking between the model results, the original formula was chosen, as described in HESP.

4.3.2.5 Uncertainties

As for inorganic substances the description of crop uptake merely concerns empirical relations and for organic substances empirical relations that are based to at least some extent on underlying mechanisms (uptake by plants through soil water). Empirical relations generally lead to more uncertainties than mechanical relations, depending on the application area in relation to the calibration area. In the case of inorganic substances, the experimentally derived BCF-values may vary from a factor 10 to 100 (Sauerbeck, 1988; Table 8) depending on soil properties in relation to substance properties and the crops.
When Baes' relation (1982) is used, this uncertainty may increase even further (see Figure 4).
The RCF-ralation by Briggs et al. (1982) has been derived for the log-Kow area from -1 to 5 and covers almost the entire area of the substances considered here. Briggs et al (1982) found deviations between measured and calculated values of a factor 2.
The SCF-relation by Briggs et al. (1983) has been derived for the log-Kow area -0.57 to 3.7, while deviations up to a factor 3 between calculated and measured values were found. The Travis and Arms relation (1988) has been calculated based on data in a log-Kow area of 1.15 to 9.35. However, this function is not as viable, as it does not include a relation with the soil type or, more importantly, with the organic carbon fraction in the soil. Still, the same trend is observed here as well. At log-Kow values under 1 this relation cannot be used anymore at all.

4.3.3 Permeation in drinking water

All models use the same formula. Deviations depend on the permeation coefficients used (see 4.1.1), the dimensions of the drinking water pipe (see Table 7) and the use of the calculated maximum versus the long-term mean concentration.
The original formula was intended to help predict the maximum concentration after a certain time-period of water stagnation in the water pipe. In the present exposure analysis, however, we are more interested in the mean concentration over the whole day.
A KIWA research showed that given a wall thickness of 3.5 mm. for the compounds considered, an equilibrium

was only reached after a period of between 60 to 400 days. It may be assumed, therefore, that the moving force for permeation will be constant over 24 hours. In view of the high consumption rate in relation to the amount in which permeation can occur under normal circumstances, much lower concentrations will be found during 24 hrs-permeation. A possible approach in this case would be to calculate the amount of permeated substance for 24 hours and to distribute this amount over the mean daily consumption by a Dutch family.

The given formula can be used both for permeation from the water and the vapour-phase. In all models only water-phase permeation is discussed. The Vonk (1985a) research established that the permeation coefficients for the vapour phase were a factor of between 4 to 6 higher than for the water phase (this was studied for a limited number of substances only). As the concentration in the soil air (which is important in this case instead of the concentration in the soil moisture) was less than a factor 5 smaller than that in the soil moisture only for a very limited number of the substances discussed here, the vapour-phase concentration need not be considered for these substances. For the substances where this is the case, exposure even at this higher permeation coefficient and relatively high soil-air concentration does not contribute significantly to the total exposure.

Very little is known of permeation in the drinking water and the uncertainties here relate particularly to the size of the parameters and the selected, as opposed to the actual material use. For toluene, a variation in the mean permeation of 50% was found for a range of concentrations. Vonk (1985a) remarks that this is a 'worst-case' approach and that in actual reality other factors lead to a lower permeation than that calculated on the basis of the model situation in hand.

4.3.4 Concentration in the bathroom air

The approach is the same in the three models, but contrary to the RIVM model, HESP and SOILRISK use a factor that indicates the extent of volatilization. In Table 9.5 in annex 9 this coefficient is shown for the substances in the test table.
The kwa-values (which express the extent of volatilization as a fraction of the originally present substance) for the substances considered vary from negligible to maximally 28%.

4.4 Exposure calculations

A number of factors affect the uncertainties in the exposure calculations. In nearly all cases it is assumed that the adsorption factor fa equals 1. This is certainly not the case, but since more detailed data are not available, this uncertainty has to be accepted. If in the determination of human toxicological standard values an adsorption factor other than 1 has been used, this will have to be taken into account here.
A second aspect concerns contact time, contact surface and the extent of contact.These have been based on realistic assumptions, but in reality significant deviations are possible.

4.4.1 Ingestion of soil

The RIVM and SOILRISK models have chosen a direct approach to the uptake of an amount of soil of 200 and 250 mg/day respectively, while RIVM applies a time fraction and SOILRISK does not. The HESP model considers the issue from a perspective of contact surfaces and covering of surfaces, based on the Hawley article (1985), but does not find essentially different values for soil-ingestion outside of the home. The data used in the models to calculate the exposure through ingestion are given in Table 7.

Furthermore, HESP uses the same approach for the calculation of ingestion of contaminated soil via indoor dust. Taking into account the length of exposure and the possibility of exposure, this leads to an exposure of

the same dimensions via this route.
A number of remarks must be made when the dust-exposure route is calculated separately. First, it is not sure whether hands and fingers are licked off to the same extent as with soil. Moreover, following on the Hawley research (1985), a great deal of research into tracers has been done, which considered dust burdening implicitly. Ruck (1990) conducted an extensive literature analysis concerning soil ingestion and pica-behaviour. Without considering time fractions for contact, this study posits an uptake of 500 mg/d as a value that may be used to derive soil criteria. As this is intended to effect a high degree of certainty, it is suggested not to use these high values in this model, but, based on data by Hawley (1985) and tracer studies, to use the following annual average soil and dust uptake values for children and adults respectively: 150 mg/d and 50 mg/d. These figures take account of the time fractions. The HESP, SOILRISK, RIVM and Hawley studies calculated an annual uptake by children of 190, 250, 86 and 165 mg/d respectively.

As for uncertainties, the variations in the daily intake and the adjustment for dust intake play an important role. The long-term mean daily uptake of 150 $mg.d^{-1}$ seems to be a satisfying compromise, which does not conflict with other conclusions (Van Wijnen et al., 1990).

4.4.2 Dermal exposure to soil

The data used in the different models are given in Table 7.
For inorganic substances all three models use the Hawley approach (1985), although the ways in which these data are used differs. HESP does not take into account the matrix effect (fixed at 1 instead of 0.15 as determined) and SOILRISK does not consider absorption velocity. The RIVM model provides the most appropriate approach, but does not account for the effect of indoor dust.
Consequentially this model used the essential information by Hawley. The exposure calculated with the help of HESP or SOILRISK in this case also leads to an exposure value that is 10 and 3 times higher respectively. The extent of the exposure to soil per surface area unit of exposed skin constitutes an important factor. As regards the outdoor situation measurement data exist for children. For adults this has been calculated on the basis of the degree of skin-coverage by soil particles. The indoor situation is calculated by means of coverage figures.

4.4.3 Inhalation of soil particles

The RIVM report does not quantify this type of exposure. The HESP and SOILRISK approaches are identical and again based on Hawley. Contrary to Hawley, a constant value was chosen for the daily breathing volume during the day and no distinction was made between active and passive breathing. In addition to the indoor exposure, outdoor exposure has been considered as well.
The calculation further contains facors like the concentration of particles in air and the fraction of soil in particles.
Table 7 shows the basic data and the data for all models evaluated for contrastive puroposes.

4.4.4 Inhalation of air

Both RIVM, SOILRISK and HESP follow the same approach. No distinction was made between active and passive breathing spells. In the case of adults it has been assumed that they spend 8 hours in the working place during a certain period of time (12 months a year, 5 days a week). During this time, exposure to soil contamination does not take place.

4.4.5 Consumption of crops

As for the exposure calculation all models use the same approach. The only difference concerns the daily consumption of vegetables and fruit and the share of contaminated foodstuffs in the total vegetative food package (see Table 7).
At the same time this gives an indication of the uncertainty with reference to the contribution of this route to the overall dose. The contribution of home-grown contaminated crops to the total daily crop consumption has been set at 10% with a view to the derivation of C-standard values (calculation of actual exposure risks is a different case), but may vary from 0 to 100%.

4.4.6 Intake of drinking water

The three models use the same approach.

4.4.7 Inhalation of vapours during showering

The three models use the same approach.

4.4.8 Dermal contact during bathing or showering

This route has not been considered in the RIVM model. The HESP model uses the same aproach for dermal contact during bathing as it did for dermal contact with soil, in other words, Hawley's approach (1985). SOILRISK, on the other hand, calculated the extent of dermal contact during showering.
An important difference between the two approaches is the fact that HESP uses one value for absorption velocity, whereas SOILRISK employs a formula that calculates the adsorption velocity depending on molecular weight and the octanol-water distribution coefficient. Figure 6 shows this difference. Given increasing log-Kow, the sorption velocity increases strongly, while an increase in molecular weight leads to a decrease. Brown and Rossi (1989) carried out a study into maximizing the absorption velocity at higher Kow-values, for which a correction formula was developed (Ten Berge, 1991). The Brown and Rossi (1989) approach was not chosen, as the substances examined in their study differ from the substances considered here, contrary to the compounds examined by Fiserova-Bergerova and Pierce. The relation used by the latter appears to be adequate (Ten Berge, 1991). The Brown and Rossi correction (1989) was chosen, as such a relation is generally thought to be correct and has been corroborated in the literature (Ten Berge, 1991). For the volatile compounds the absorption velocities are generally comparable as to magnitude, although this is not true for the highly molecular, hydrophobic, non-volatile compounds (Figure 6; Table 9.5 in annex 9).
Quantitative comparison shows that this route could give small contributions to the total exposure for some of these compounds. For the time being, then, the SOILRISK approach is recommended. To illustrate this, the formulas for both approaches have been given in annex 8.

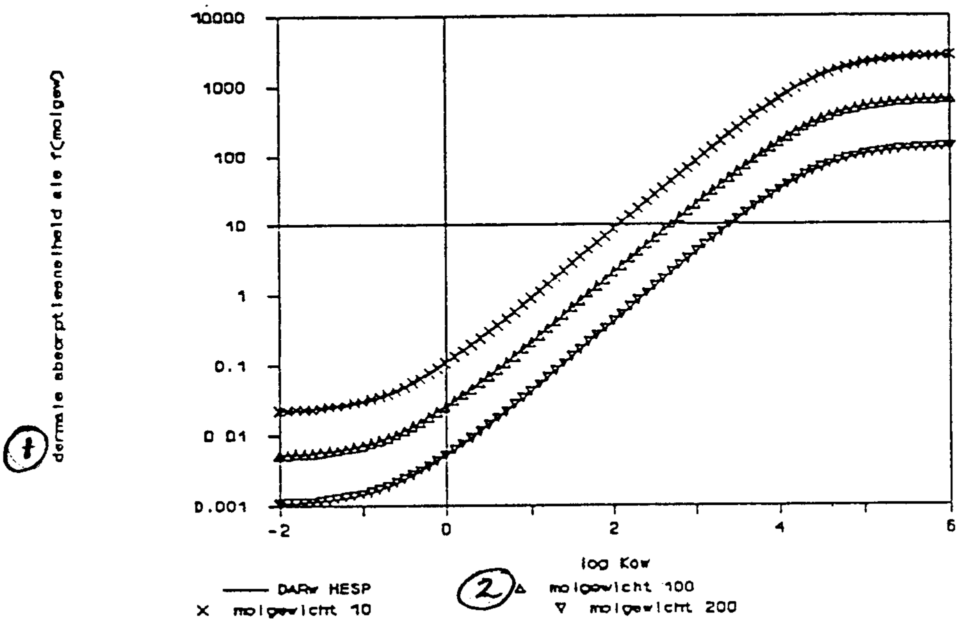


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Figure 6 The relation for the dermal absorption velocity of a contamination during showering according to Fiserova-Bergerova and Pierce (1989) as function of log-Kow and molecular weight. For the highest log-Kow values Brown and Rossi's correction (1989) was applied. Moreover, the absorption velocity as used in the HESP model (10[mg.m^{-2}]/[mg.dm^{-3}].h^{-1}) was given for comparison.

PAGE 35
1. dermal absorption velocity
2. molecular weight

PAGE 37
Figure 7.
1. all considered compounds
2. C. soil value
3. vapour pressure(pa) - volatility

Figure 8.
1. all considered compounds
2. C. soil value
3. water-solubility

PAGE 38
Figure 9A.
1. chlorobenzenes
2. proposed hum tox C-soil value
3. number of chlorine atoms

Figure 9B.
1. chlorobenzenes
2. proposed hum tox C-soil water value
3. number of chlorine atoms

PAGE 41
Figure 10.
1. metals
2. relative contribution to the dose
3. ground ingestion
4. BCF-value + crop consumption

Figure 11.
1. chlorobenzenes
2. relative contribution to the dose
3. inhalatory route
4. number of chlorine atoms + crop consumption

4.5 Analysis relative importance exposure through various routes and discussion proposed C-standard values

In order to gain an understanding of the relative contribution of the various exposure routes for the substances given in the test Table in the Guideline Soil Protection, an analysis was performed for the derived human toxicological C-standard values (Table 9.6 in annex 9).
This analysis showed that inhalation of soil particles, inhalation during showering, dermal contact with the soil, consumption of drinking water and dermal contact during showering contributed only marginally with a maximum of 9% for all mentioned routes together for the substances considered here, excepting cyclohexanone, where consumption of drinking water contributes for 16%. This is to say that ingestion of soil, consumption of crops and inhalation of (particularly indoor-)air taken together (with the exception of cyclohexanone) account for at least 90% of the dose. Probably this is also true for substances not considered here.
Although soil-ingestion is an important route for some substances (metals, PAHs, DDT), the most important contribution for most substances is through inhalation of contaminated air and consumption of contaminated crops.

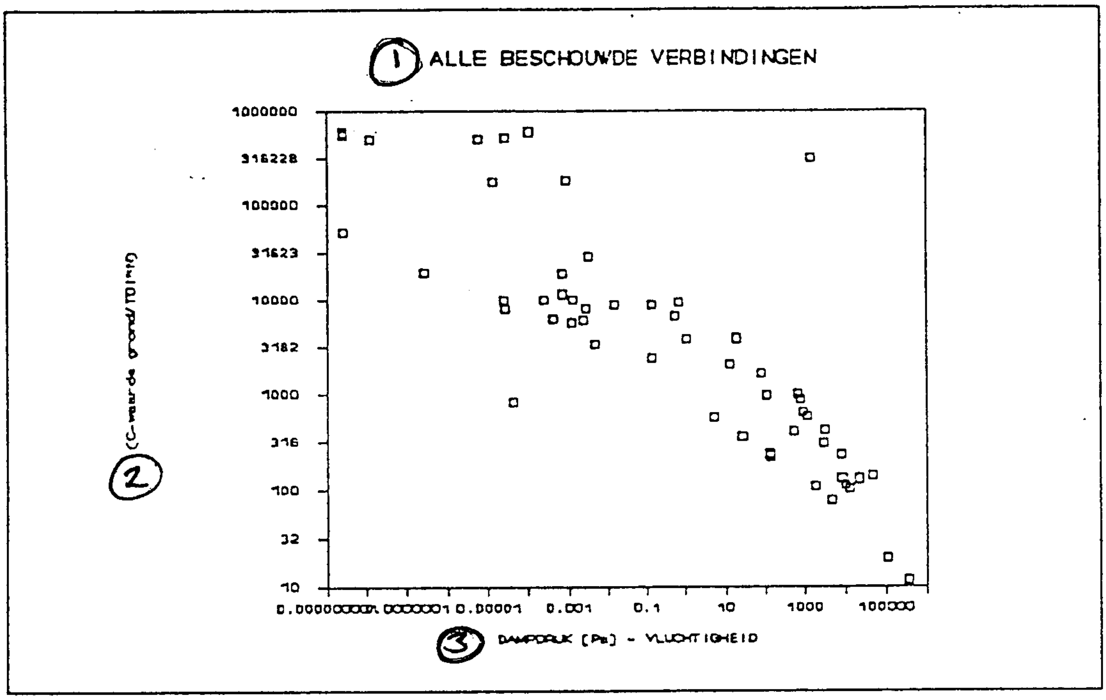
The C-standard value is determined by the human-toxicolgical recommended value (derived from tolerated exposure) and the way in which exposure is effected. More in particular, the exposure is determined by the ecochemical behaviour, in other words, the physicochemical parameters. High water-solubility and volatility lead to higher exposure, whereas, for instance, high Kow-values lead to higher sorption and thus, lower exposure, while for crop accumulation this can lead to various results, depending on the Kow-value. The influence of the behaviour aspect, expressed in substance-specific parameters, is illustrated in Figures 7 and 8, which show the the relation between the C-soil value and toxicological recommended values as a function of the physicochemical parameters water-solubility and vapour pressure. Although these Figures reflect the trend discussed before, they cannot be used for quantification.

Within groups of substances, logical series are generally found for the C-values. For Cholorobenzenes, for instance, the C-soil value is found to increase with the extent of chlorination and the reverse holds true for the C-soil water value (see Figure 9).
High human toxicological recommended values in combination with a low volatility and water-solubility (for instance DDT) leads to a high C-value. A low toxicological recommended value in combination with a high volatility (for instance vinyl chloride) leads to a low C-value. For metals a low toxicological recommended value in combination with a low BCF-value (for instance tin) leads to a high C-value.

4.5.1 Metals

In the case of metals the only relevant routes are soil ingestion and consumption of crops. The relative contribution of these routes is independent of the soil-rate, but is determined by the BCF-value or the extent of plant-uptake. (Figure 10). Metals with a higher BCF-value give rise to a relatively higher crop-rate, and so to higher exposure and a higher relative contribution.
Thus, given (measured) BCF-values of 0.03 (arsenic), 0.3 (copper), 1 (molybdenum) and 3 (cadmium), the contribution of crop consumption for children was 55, 92, 99 and 99% respectively.

Figure 7. Influence of the physicochemical parameter vapour pressure [Pa] on the relation between C-soil value and the human toxicological recommended value.



Please, see page 35a for the translation

Figure 8. Influence of the physicochemical parameter water-solubility [g.m^{-3}] on the relation between C-soil value and the human toxicological recommended value.

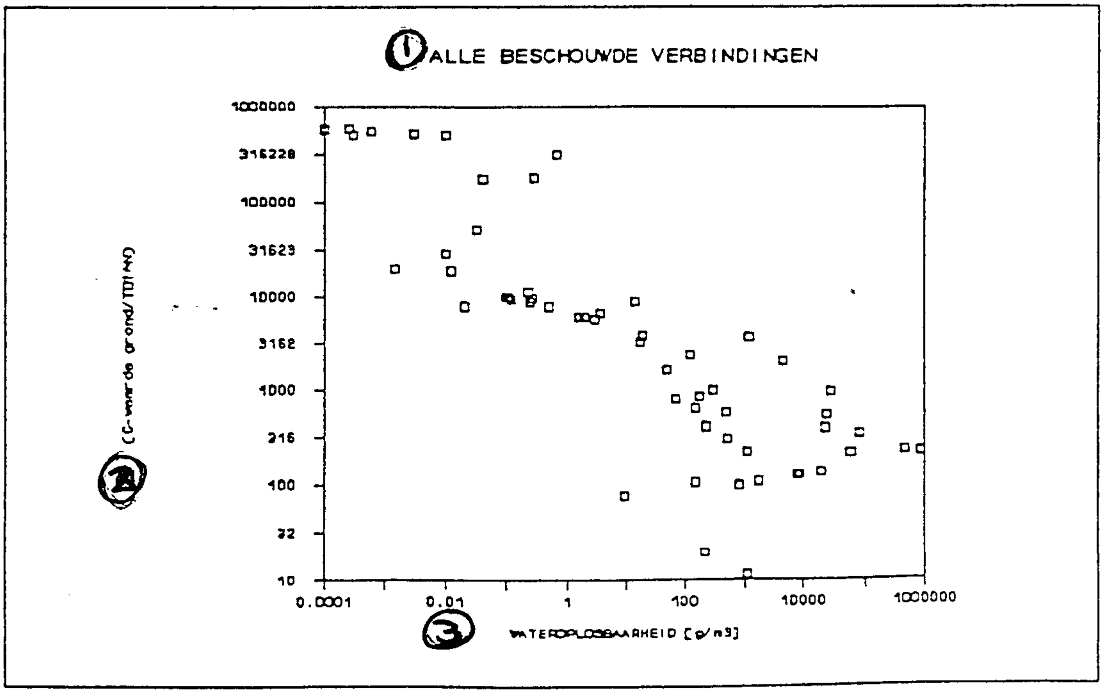


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Figure 9A. Influence of the extent of chlorination on the proposed C-soil value for cholorobenzenes

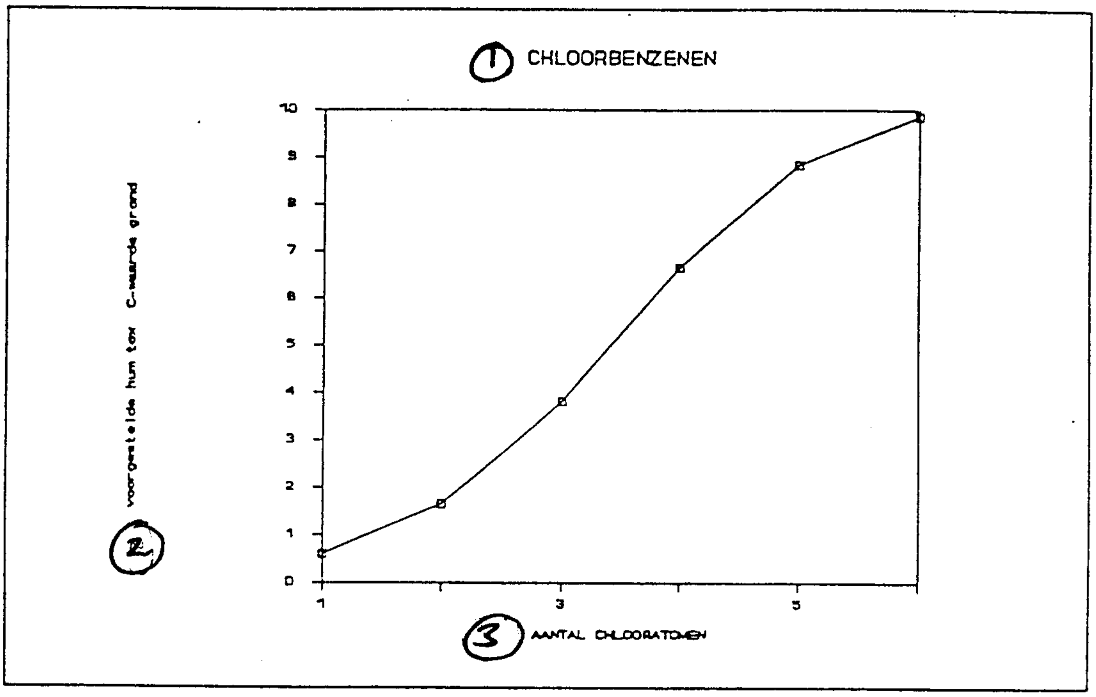

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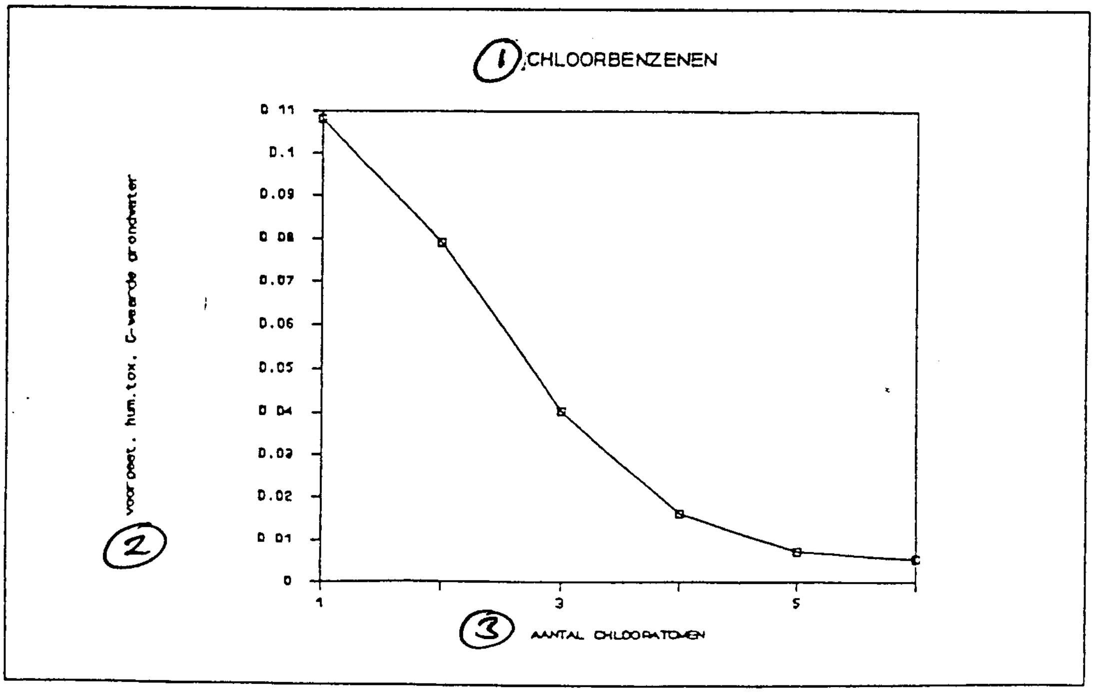
figure 9B. Influence of the extent of chlorination on the proposed C-soil water value for cholorobenzenes.



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Regarding the BCF-values (Table 8) given by Baes et al (1984), it must be observed that in general comparable or lower, but particularly for mercury, much higher BCF-values are given than by Sauerbeck (1988), namely 0.9 instead of 0.03. This could lead to a lower C-value (3.75 instead of 87.1 mg.kg^{-1}), but this has not been done, as further evidence is lacking.

4.5.2 Inorganic compounds

As was the case for metals, only crop consumption and soil-ingestion play a role here. The importance of soil-ingestion is determinined solely by water-solubility. If a substance is not water-soluble, plant uptake can only take place through deposition.
As the speciation of these inorganic compounds is not yet known, calculations have followed the 'worst-case' scenario, assuming that the substance is completely water-soluble, or in other words, that the substance is present in the soil moisture. Finally, for a number of substances only C-soil-water standard values are given, and none for soil.

4.5.3 Aromatics

For the non-hydroxyl-aromatics, inhalation is by far the most important factor. For the hydroxyl-aromatics, including chlorophenols, crop consumption constitutes the major contribution. Relatively high contributions through crop consumption derive from a relatively low soil-air concentration and relatively high rates in crops, caused by high concentrations in the soil moisture.

4.5.4 Polycyclic Aromatic Hydrocarbons (PAHs)

Only in the case of the most volatile and water-soluble PAH, naphthalene, a small inhalatory contribution is found, contrary to other PAHs. Generally, crop consumption plays an important role for percentages below the water-solubility level, but above that soil-ingestion becomes increasingly important. The relatively high crop contribution for percentages below water-solubility despite low water-solubility, is explained by the high root-uptake, caused by high log-Kow values. When water-solubility is exceeded, relatively high C-standard values will be derived.

4.5.5 Volatile chlorinated aliphates

As is to be expected for this group of substances, inhalation plays a major role. The relative contributions of inhalation and crop consumption correspond with the relation between volatility and water-solubility in this group of compounds.

4.5.6 Chlorobenzenes

For the group of chlorobenzenes, water-solubilty increases, volatility decreases and the log-Kow value increases with the degree of chlorination. This is directly reflected by the contributions of the various routes, where the share of crop consumption, which is a function of the water-solubility and log Kow, increases with an increasing degree of chlorination, whereas the share of inhalatory exposure decreases in the same situation. (Figure 11).

4.5.7 Drins

The fact that the uptake of drins through soil ingestion remains relatively low compared to the vegetation consumption route, is related to the high intake volume of crops compared to soil, where relatively high percentages are found in crops as a result of root accumulation.

4.5.8 Pesticides

For pesticides, crop consumption generally plays the most important role. Inhalation is of minor importance. When water-solubility is exceeded, as is the case for maneb, DDT and DDE, soil-ingestion becomes prominent.

4.5.9 Other compounds

For octane it should be observed that exceeding of the water-solubility strongly affects the C-value. At the water-solubility level, corresponding with a soil content of 158 $mg.kg^{-1}$, 89% of the TDI has already been filled. As an individual TDI for octane has not been derived, the derived C-standard value should be used prudently.
For cyclohexanone, the drinking water consumption leads to a relative contribution of 16% for children. This is caused by a high permeation coefficient and high water-solubility.

4.6 Uncertainties

Each parameter, tranfer process or exposure route presented in the CSOIL model, contains uncertainties, up to a factor of 10 or more. These uncertainties in part determine the absolute reliability of this model. The qualitative and quantitative uncertainties of the parameters and processes considered, have been discussed previously.
The CSOIL model has been developed on the basis of best available knowledge of the separate parts, while fairly uncomplicated descriptions were used, as adequate data allowing more comlex descriptions are not available. Concerning the way in which the uncertainties are approached, a distinction should be made between the various aims of the model. On the one hand, is is used as a policy instrument to derive C-standard values while on the other hand, it is used both as a research-regulating and policy instrument for the actual exposure analysis. By choosing middle-range parameters and average situations, an attempt has been made to avoid such 'worst-case' approaches that would reduce the significance of C-standard values and disqualify them as a test isntrument for 'serious danger' to man.
Uncertainties regarding the actual exposure analysis should also be stressed here. Although the assessment of actual risks may be performed on the basis of local parameter values and exposure routes, this does not guarantee that the results of the model will be reliable. The use of measurements is recommended in those cases where the present model anticipates the highest exposure in combination with uncertainties. The results of an estimation of the actual risks as a consequence of exposure to soil contamination can be readily used for a comparative analysis. These results may obviously be used in setting priorities for research and clean-up operations.
In view of the discussion in section 4.5 on the relative contributions and the uncertainties as discussed in section 4.4 for the individual processes, it may be concluded that the largest uncertainties are found in twp of the most important exposure routes: accumulation in crops and soil-evaporation fluxes (inhalation).

Figure 10. Influence of the BCF-value of metals on the contribution of crop consumption and ingestion to the total dose (by children).

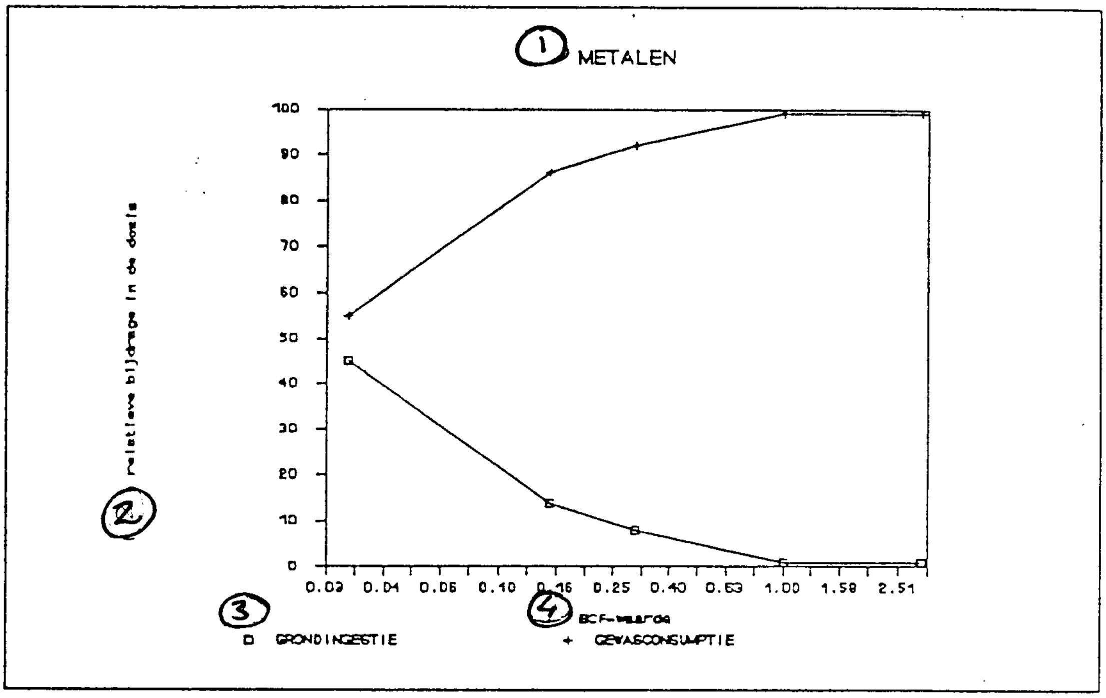

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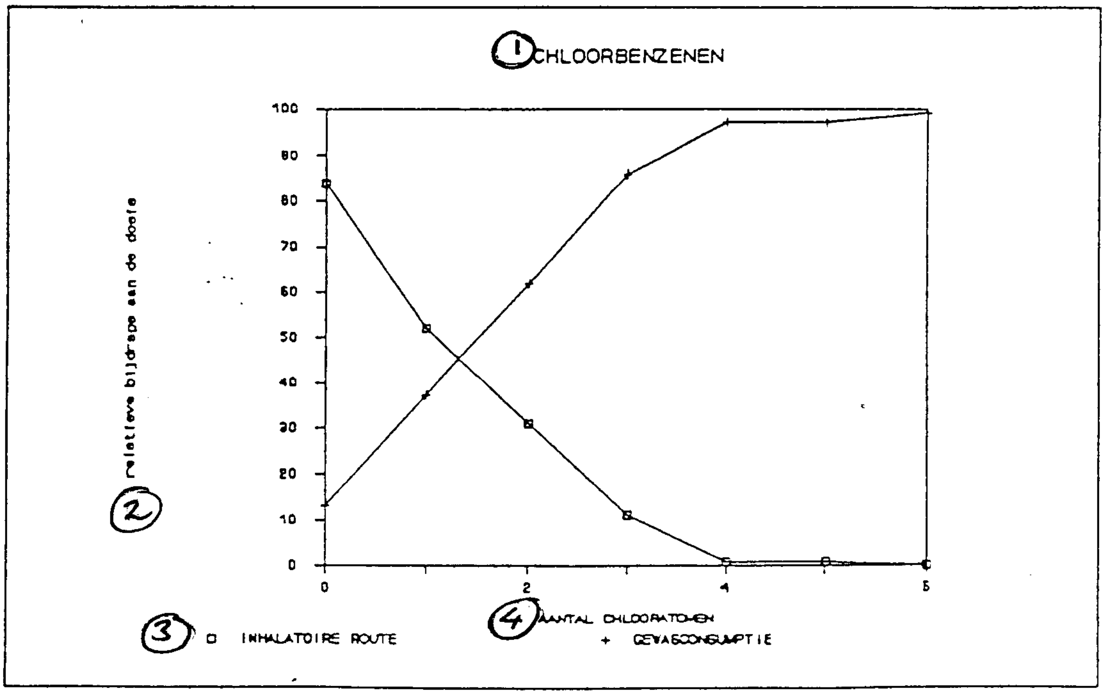
Figure 11. Influence of the extent of chlorination in the group of cholorobenzenes on the contribution of crop consumption and inhalatory exposure to the total dose (for adults).



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As for the derivation of proposals for human toxicological C-values, the toxicological recommended values are characterized by a degree of uncertainty.

The uncertainties in the quantification of the various parts are about as large. The more quantification steps are needed in order to calculate the exposure, the larger the uncertainty. Classification of substances in categories of uncertainty or reliabiltity does not seem useful. All substances would end up in the same category. It is possible that the uncertainties are larger for metals and inorganic substances, because a relation with the soil properties is lacking for these substances, although sure to be there. This refers particularly to crop-uptake.

The CSOIL model can be verified on the basis of the present description and argumentations. Moreover, owing to advancing knowledge, periodical updates of the model will be possible. The model elements desribed here, however, must be validated by field tests. In this context the description and verification of the following items should be given priority:
- Jury theory soil fluxes;
- equilibrium theory;
- accumulation in crops;
- gathering of data on the behaviour of metals and inorganic compounds in the soil.

5. FINAL CONCLUSIONS AND RECOMMENDATIONS

With the help of the model described here and based on the human toxicological recommended values (Vermeire et al., 1991), proposals have been made for human C-standard values.

These C-standard values have been adjusted in order to meet certain sub-criteria (odour threshold and toxicologically tolerable concentrations in air: TCL) for a number of substances.

The model can also be used for the structuring of further research into the actual risks (Figure 1, see also section 4.6). An estimation can be made of the most important routes and thus it can be determined in which contact media measurements should be conducted.

The model consists of a large number of theories and empirical and mechanical relations. In all its simplicity it is 'state-of-the-art'; substance-specifical deviations are of course possible. Verification of (parts of) theories, empirical and mechanical relations, as well as the development of new theories and relations will certainly lead to improvements in the future. Periodical adjustment of the model and the C-standard values is recommended when necessary.

The discussion of the uncertainties already indicated where the weaknesses lie. These weak spots should be remedied in the short term, not so much by specific laboratory research, but rather by **verification on the basis of field tests**. Areas that should be given special attention are:

- verification of the Jury-theory on soil fluxes;
- verification of the equilibrium theory;
- description of the accumulation in crops;
- description of and data gathering for the behaviour of metals and inorganic compounds in the soil.

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Glossary

actual exposure: site-specific exposure as it operates in reality

bioconcentration factor(BCF): Relation between the concentrations of a compound in the various compartments - in this report generally content in crop as compared to content in soil or pore water

exposure route: the way in which humans (or animals) come into contact with a substance: by ingestion (oral), breathing (inhalation) and/or via the skin (dermal)

C-standard value: soil-quality criterion; the content of a contaminant in the soil which indicates "serious danger for the public health or the environment"; when the content is higher than the C-standard value, soil clean-up is required and actual exposure analyses as well as a clean-up (research) must be conducted

odour threshold value (OT-value): content of a substance in air, which induces odour nuisance when this limit is exceeded

maximum tolerable risk: by the maximum tolerable risk level of a substance we mean the concentration of a substance in the environment that leads to intolerable effects for man or the environment;
for substances with a **threshold value** this has been set at the same level as the ADI, while for substances **without threshold value** it has been equated with a risk of one extra cancer case per 10,000 life-long exposed individuals

maximum tolerable risk for carcinogens: the quantity of a substance, expressed on the basis of body weight for oral exposure and on the basis of air volume for inhalatory exposure, with a risk of one extra case of cancer per 10,000 lifelong exposed individuals.

uncertainty reduction factor N: a multiplication factor applied to the TDI in the derivation of proposals for human toxicological C-standard values in order to express the uncertainties in the safety factors used in the derivation of the TDI, in the relation TDI- "serious danger for the public health"

potential exposure: the exposure that might occur, with no routes excluded

risk: unwanted effects of a certain activity in relation to the possibility that this situation will occur

toxicologically tolerated concentration in air (TCL-value): the volume of a substance expressed in terms of body weight which may be breathed in by man on a daily basis during his entire life, without damaging effects to health

toxicologically tolerable daily intake (TDI): the volume of a substance expressed in terms of body weight which may be taken up by man on a daily basis during his entire life, without damaging effects to health (equivalent of the ADI)

transfer processes: processes by which a substance may move from one compartment to the other

Table 4. Physicochemical properties of the compounds considered.

name	solub. [$g.m^{-3}$]	mol.weight [$g.mol^{-1}$]	Henry-cst [-]	vap.pres [Pa]	log-kow [-]	permeat.coeff. [$*10^{-7}m^{2}.d^{-1}$]	airdiff.coeff. [$m^{2}.h^{-1}$]
arsenic		74.9					
barium		137.3					
cadmium		112.4					
chromium (III)		52.0					
chromium (VI)		52.0					
cobalt		58.9					
copper		63.5					
mercury		200.6					
lead		207.2					
molybdenum		95.9					
nickel		58.7					
tin		118.7					
zinc		65.4					
ammonium compounds		15.0					
bromides		79.9					
cyanides free		26.0					
cyanides complex		26.0					
fluorides		19.0					
phosphates		95.0					
sulfides		32.0					
thiocyanates		58.0					
benzene	1.78E+03	78.0	1.89E-01	1.01E+04	2.13E+00	1.40E+01	2.95E-02
ethylbenzene	1.52E+02	102.0	2.66E-01	9.33E+02	3.15E+00	2.10E+01	2.43E-02
phenol	8.20E+04	94.0	1.30E-05	2.67E+01	1.46E+00	8.50E-03	
cresol(p)	2.40E+04	108.0	1.02E-05	5.33E+00	2.00E+00	1.00E+01	
toluene	5.15E+02	90.0	2.18E-01	2.94E+03	2.69E+00	1.20E+01	2.65E-02
xylene(m)	1.80E+02	102.0	1.93E-01	8.01E+02	3.20E+00	1.60E+01	2.43E-02
catechol	4.51E+05	110.0	1.38E-05	1.33E+02	8.80E-01	1.00E+00	
resorcinol	8.40E+05	110.0	7.43E-06	1.33E+02	7.80E-01	1.00E+00	
hydroquinol	5.90E+04	110.0	1.06E-04	1.34E+02	5.50E-01	1.00E+00	
anthracene	7.50E-02	178.0	1.31E-04	1.30E-04	4.49E+00	5.00E+00	
benzo(a)anthracene	1.00E-02	228.0	5.34E-05	5.51E-06	5.61E+00	2.00E+00	
benzo(k)fluoranthene	6.00E-04	252.0	4.64E-07	2.60E-09	6.84E+00	2.00E+00	
benzo(a)pyrene	3.00E-04	252.0	4.67E-06	1.31E-08	6.35E+00	2.00E+00	
chrysene	1.50E-03	228.0	1.68E-05	2.60E-07	6.64E+00	2.00E+0o	
phenanthrene	1.60E+00	178.0	1.14E-04	2.41E-03	4.54E+00	5.00E+00	
fluoranthene	2.65E-01	202.0	7.48E-05	2.31E-04	5.33E+00	2.00E+00	
indene(1#2#3cd)pyrene	1.00E-04	276.0	3.05E-06	2.60E-09	7.43E+00	2.00E+00	
benzo(ghi)perylene	2.60E-04	276.0	1.17E-06	2.59E-09	6.00E+00	2.00E+00	
pyrene	3.20E-02	202.0	6.98E-09	2.60E-09	6.00E+00	2.00E+00	
naphthalene	3.00E+01	130.0	4.18E-03	2.27E+00	3.36E+00	5.00E+00	2.31E-02
1#2-dichloroethane	8.69E+03	99.0	3.94E-02	8.14E+03	1.45E+00	3.00E+00	3.02E-02
dichloromethane	2.00E+04	85.0	f.41E-02	4.66E+04	1.87E+00	5.00E+00	
tetrachloromethane	8.00E+02	154.0	9.82E-01	1.20E+04	2.64E+00	8.00E+00	2.70E-02
tetrachloroethene	1.50E+02	165.8	8.77E-01	1.87E+03	2.60E+00	7.70E+00	2.51E-02
trichloromethane	8.00E+03	119.5	1.36E-01	2.14E+04	1.97E+00	1.00E+01	
trichloroethene	1.10E+03	131.5	4.07E-01	8.01E+03	2.71E+00	1.60E+01	2.75E-02
vinyl chloride	1.10E+03	62.5	8.57E+oo	3.55E+05	2.71E+00	1.00E+01	
monochlorobenzene	5.00E+02	112.5	1.12E-01	1.17E+03	2.81E+00	3.50E+01	2.62E-02
p-dichlorobenzene	4.90E+01	147.0	1.02E-01	8.00E+01	3.40E+00	2.00E+01	2.40E-02
trichlorobenzene(1#2#4)	1.90E+01	181.5	7.58E-02	1.87E+01	4.06E+00	1.00E+01	2.07E-02
tetrachlorobenzene(1#2#3#4)	3.50E+00	216.0	1.40E-02	5.34E-01	4.70E+00	1.00E+01	
pentachlorobenzene	2.40E-01	250.5	5.52E-02	1.33E-01	5.17E+00	1.00E+01	
hexachlorobenzene	1.10E-01	285.0	1.47E-03	1.33E-03	5.34E+00	1.00E+01	
monochlorophenol (2)	2.85E+04	128.5	2.05E-04	1.07E+02	2.39E+00	4.80E-02	
dichlorophenol (2#4)	4.60E+03	163.0	2.01E-04	1.33E+01	3.15E+00	1.00E+00	
trichlorophenol (2#3#4)	1.19E+03	197.5	7.53E-05	1.07E+00	3.88E+00	5.40E-00	
tetrachlorophenol (2#3#4#5)	1.25E+02	232.0	1.05E-04	1.33E-01	3.35E+00	1.00E+01	
pentachlorophenol	1.40E+01	266.5	1.19E-04	1.47E-02	5.13E+00	2.24E+01	
chloronaphthalene	2.24E+01	162.5	1.62E-02	5.25E+00	3.85E+00	5.00E+00	
trichlorobiphenyl (2#5#2')	2.25E-01	257.5	3.40E-04	6.99E-04	5.60E+00	5.00E+00	
hexachlorobiphenyl	1.20E-02	361.0	8.95E-03	7.00E-04	6.57E+00	2.00E+00	
DDT	3.10E-03	354.5	1.23E-03	2.53E-05	6.18E+00	5.00E+00	
DDE	4.00E-02	318.0	4.51E-05	1.33E-05	5.73E+00	5.00E+00	
aldrin	1.00E-02	365.0	4.76E-02	3.07E-03	7.40E+00	5.00E+00	
dieldrin	1.00E-01	381.0	3.89E-05	2.40E-05	5.36E+00	5.00E+00	
endrin	2.00E-02	393.0	2.23E-04	2.67E-05	4.95E+00	5.00E+00	
HCH	1.70E+01	291.0	3.48E-05	4.78E-03	3.72E+00	5.00E+00	
carbaryl	1.20E-01	201.0	4.75E-01	6.67E-01	5.37E+00	2.00E+00	
carbofuran	5.00E-01	221.0	5.08E-04	2.70E-03	4.95E+00	2.00E+00	

propoxur	2.00E+00	209.0	1.78E-05	4.01E-04	4.55E+00	2.00E+00	
maneb	1.OOE-04	265.0	1.13E-01	1.00E-04	7.43E+00	2.00E+00	
atrazine	7.00E+01	215.5	5.24E-08	4.00E-05	2.18E+00	2.00E+00	
heptane	9.50E+00	98.0	2.05E+01	4.68E+03	3.92E+00	4.00E+01	2.33E-02
octane	6.60E-01	110.0	1.04E+02	1.47E+03	4.44E+00	3.40E+01	2.17E-02
cyclohexanone	2.30E+04	98.0	9.66E-04	5.33E+02	1.83E+00	2.00E+01	
butylbenzylphtalic acid	2.90E+00	312.0	5.25E-05	1.15E-03	4.44E+00	2.00E+01	
di(2-ethylhexyl)phtalic acid	2.85E-01	390.0	5.00E-04	8.60E-04	5.12E+00	2.00E+01	
pyridine	2.33E+02	79.0	4.48E-01	3.11E+03	3.16E+00	2.00E+01	
styrene	3.00E+02	104.0	9.83E-02	6.67E+02	3.09E+00	2.00E+01	
tetrahydrofuran	2.18E+02	72.0	1.43E+01	1.02E+05	3.18E+00	2.00E+01	
tetrahydrothiophene	1.06E+01	88.0	8.52E+00	2.41E+03	4.06E+00	2.00E+01	

Table 5. Base information in relation to the soil condition parameters and comparison with input other models.

parameter	symb.	unit	CSOIL	RIVM a)	HESP b)	SOILR c)
fraction organic carbon	foc	[kg.kg^{-1}]	0.02		0.02	0.017
mass volume dry soil	SD	[kg.dm^{-3}]	1.5	1.4	1.5	1.5
porosity	P	[-]	0.4		0.5	0.3
moisture fraction	Vw	[-]	0.2	0.4	0.2	0.15
air fraction	Va	[-]	0.2		0.3	0.15

a) RIVM - Linders (1990), b) HESP - ECETOC (1990). c) SOILRISK - Ten Berge (1990‘

Table 6. Base information in relation to the parameters of the exposed and comparison with the data from other models.

parameter		symb.	unit	CSOIL	RIVM a)	HESP b)	SOILR c)	Hawley d)	#	BNSe)
weight	adult	Wa	[kg]	70	60	70		70		71
	child	Wc	[kg]	15	14	10	17	21	13	29
breath.vol.	adult	AVa	[m^3.d^{-1}]	20	20	23		19.8*		
	child	AVc	[m^3.d^{-1}]	7.6	7.6	5	10	11.4*	7.5*	
age	adult	La	[y]			30				>15
	child	Lc	[y]		1-4	3	1-10	6	2.5	1-15
tot. body surf.area	adult	A to a	[m^2]	1.8		1.8		1.8		
	child	A to c	[m^2]	0.95		0.95	0.8	0.8	0.6	
crop consumption	adult	Qfv'a	[kg nw.d^{-1}]	0.558	0.558	0.6				
	child	Qfv'c	[kg nw.d^{-1}]	0.295	0.295	0.3	0.6			
leafy crop cons.	adult	Qfv a	[kg dw.d^{-1}]	0.01843						
		Qfv'a	[kg nw.d^{-1}]	0.1578						
	child	Qfv c	[kg dw.d^{-1}]	0.00890						
		Qfv'c	[kg nw.d^{-1}]	0.0761						
root crop consumpt.	adult	Qfv a	[kg dw.d^{-1}]	0.02761						
		Qfv'a	[kg nw.d^{-1}]	0.1367						
	child	Qfv c	[kg dw.d^{-1}]	0.01511						
		Qfv'c	[kg nw.d^{-1}]	0.0748						
drinking water cons.	adult	Qdw a	[dm3.d^{-1}]	2	2	2				
	child	Qdw c	[dm3.d^{-1}]	1	1	1	1			

a) RIVM - Linders (1990), b) HESP - ECETOC (1990), c) SOILRISK - Ten Berge (1990), d) Hawley (1985), e) BNS (De Nijs en Vermeire, 1990)

#) Hawley (1985) gives parameters for two ages for children

*) Hawley (1985) considered both active and passive breathing; for this calculation it has been assumed that this goes on in both cases for 12 hours.

@) The dry-weight consumption has been calculated by Bockting and Van den Berg (1992) from data on the net weight consumption of crops and relevant moisture contents for the crops (0.117 leafy crops, 0.202 root crops). (Ref. in annex 1).

Table 7. Input data for the various exposure models.

parameter		symb.	unit	CSOIL	RIVM a)	HESP b)	SOILR c)	Hawley d)	#
TIME FRACTIONS FOR EXPOSURE (measured at 24-hr. basis)									
adult	outdoor	ft ao	[-]	0.05	0.08	0.048	1	0.04	
	indoor (incl. sl.)	ft ai	[-]	0.71[1]	1	0.714	1	0.67	
	work	ft aw	[-]	0.24[1]		0.238		0.24	
	sleep	ft as	[-]	0.33		0.5		0.5	
children	outdoor	ft co	[-]	0.12	0.43	0.119	1	0.18	0.09
	indoor (incl. sl.)	ft ci	[-]	0.88	1	0.881	1	0.83	0.67
	poss. school	ft cw	[-]						0.28
	sleep	ft cs	[-]	0.5		0.5		0.5	0.5
INGESTION SOIL									
contact time adult	outdoor	t ao	[h]	24		8		8	
	indoor	t ai	[h]			24		16	
contact time child	outdoor	t co	[h]	24		8		12	5
	indoor	t ci	[h]			24		24	16
time fraction adult	outdoor	tf ao	[-]	1		0.14		0.12	
	indoor	tf ai	[-]			0.71		1	
time fraction child	outdoor	tf co	[-]	1	0.43	0.36	1	0.36	0.42
	indoor	tf ci	[-]			0.88		0.83	1
soil ingestion adult	outdoor	AID ao	[mg.d^{-1}]	50		95		480	
	indoor	AID ai	[mg.d^{-1}]	@		44		0.56	
soil ingestion child	outdoor	AID co	[mg.d^{-1}]	150	200	248	250	250	50
	indoor	AID ci	[mg.d^{-1}]	@		116		90	3
@ these are included in outdoor soil intake.									
SOIL INGESTION time-related soil ingestion									
soil ingestion adult		AID a	[mg.d^{-1}]	50		45		61	
soil ingestion child		AID c	[mg.d^{-1}]	150	86	191	250	24	165
DERMAL CONTACT SOIL									
exposition surface adult	outdoor	A exp ao	[m^2]	0.17	0.17	0.17		0.17	
	indoor	A exp ai	[m^2]	0.09		0.09		0.09	
exposition surface child	outdoor	A exp co	[m^2]	0.28	0.21	0.105	0.16	0.16	0.21
	indoor	A exp ci	[m^2]	0.05		0.05		0.04	0.05
soil matrix factor		fm	[-]	0.15	0.15	0.15	1	0.15	0.15
covering degree adult	outdoor	DAE ao	[mg.cm^{-2}]	3.75	1.8	1.5		3.5	
	indoor	DAE ai	[mg.cm^{-2}]	0.056		0.7		0.056	
covering degree child	outdoor	DAE co	[mg.cm^{-2}]	0.51	0.51	1.5	0.1	0.51	0.51
	indoor	DAE ci	[mg.cm^{-2}]	0.056		0.7		0.056	0.056
dermal absorption velocity	adult	DAR a	[h^{-1}]	0.005	0.005	0.005		0.005	
dermal absorption velocity	child	DAR c	[h^{-1}]	0.01	0.01	0.01		0.01	0.01
contact time adult	outdoor	t ao	[h]	8	24	8		8	
	indoor	t ai	[h]	8		24		12	
contact time child	outdoor	t co	[h]	8	24	8	24	12	5
	indoor	t ci	[h]	8		24		12	4
time fraction adult	outdoor	tf ao	[-]	0.12	0.08	0.14		0.12	
	indoor	tf ai	[-]	1.857[2]		0.21		1	
time fraction child	outdoor	tf co	[-]	0.36	0.43	0.36	1	0.36	0.42
	indoor	tf ci	[-]	1.143		0.88		1	1
INHALATION OF SOIL PARTICLES									
conc. particl. in outdoor air		TSPo	[ug.m^{-3}]	70		50	100	70	
conc. particl. in indoor air		TSPi	[ug.m^{-3}]	53		37.5	100	53	
fraction soil in particl.	outdoor	frso	[-]	0.5		0.5	0.5	0.5	

fraction soil in particl.	indoor	frso	[-]	0.8		0.75	0.5	0.8	
retention factor lung		fr	[-]	0.75	0.75	0.75	1	0.75	
contact time adult	outdoor	t ao	[h]	8	24	8		8	
	indoor	t ai	[h]	8	24	24		16	
contact time child	outdoor	t co	[h]	8	24	8	24	8	5
	indoor	t ci	[h]	16	24	24		24	16
time fraction adult	outdoor	tf ao	[-]	0.14	0.3	0.14		0.12	
	indoor	tf ai	[-]	2.86^{2}	0.7	0.71		1	
time fraction child	outdoor	tf co	[-]	0.36	0.3	0.36	1	0.36	0.42
	indoor	tf ci	[-]	1.32	0.7	0.88		0.83	

INHALATION VAPOURS

surface area crawl space	Bo	[m^{2}]	50		100	100
volume crawl space	Bv	[m^{3}]	25		200	100
ventilation mult. f. cr-sp.	Vv	[h^{-1}]	1.25		2	2
fraction indoor air/crawl space	fbi	[-]	0.1		0.1	0.1
length contam. location	L	[m]	100		300	300

CONSUMPTION CROP

fraction contamination food	fv	[-]	0.1	0.1	0.1	0.1
interception fraction	fin	[-]	0.4		0.4	0.4
crop yield	Yv	[kg.m^{-2}]	0.28	0.6 *	0.28	0.28
efflorescence veloc.	fEi	[d^{-1}]	0.033	0.03 *	0.033	0.033
deposition veloc.	DRo	[m.d^{-1}]	864	300. *	230	864
expos. duration	te	[d]			180	

EXPOSURE VIA DRINKING WATER, SHOWERING AND BATHING

inside diameter of the pipe	r	[mm]	19.6		25	25
thickness of the pipe	d	[mm]	2.7		3.5	3.5
water consumption showering	Vw	[m^{3}]	0.15	0.05	0.15	0.15
volume bathroom	Vbk	[m^{3}]	15	10	25	2^{c}
time showering	td	[h]	0.5	0.17	0.5	0.25 4)
time bathing	tb	[h]	0.5		0.5	0.5
fraction exposed surface area	f exp	[-]	0.4		1	0.4
dermal abs. velocity	DAR	[dm^{3}.m^{-2}.h^{-1}]	form. &		10	form. &

a) RIVM - Linders (1990), b) HESP - ECETOC (1990), c) SOILRISK- Ten Berge (1990). d) Hawley (1985)
*) data BNS (De Nijs and Vermeire, 1990), geometric averages of ranges
#) Hawley (1985) gives parameters for two ages for children
&) formula according to annex 7
@) in case of inhalatory exposure: t = 0.5 (0.25+0.25)

1) on the basis of TCB-recommendation 1992 these are taken together to: ft ai = 0.95
2) on the basis of TCB-recommendation 1992 as under 1) change in factors

reference TCB in annex 1

Table 8. Bioconcentration factors (BCF) for a number of metals according to Sauerbeck (1988) and Baes et al. (1984) and as used in CSOIL according to Bockting and Van den Berg (1992; ref. in annex 1 [BCF as (mg/kg ds)/(mg/kg ds)]

metal	BCF-range according to Sauerbeck	CSOIL version 1	BCF according to Baes et al.	CSOIL version 2 root crop	CSOIL version 2 leafy crop
As	0.01 - 0.1	0.03	0.04	0.03	0.015
Cr	0.01 - 0.1	0.03	0.008	0.02	0.002
Hg	0.01 - 0.1	0.03	0.9	0.03	0.015
Pb	0.01 - 0.1	0.03	0.045	0.03	0.001
Cu	0.1 - 1.0	0.3	0.4	0.1	0.1
Ni	0.1 - 1.0	0.3	0.06	0.1	0.07
Cd	1.0 - 10.0	3.0	0.55	0.7	0.15
Tl	1.0 - 10.0	3.0		3	3
Zn	1.0 - 10.0	3.0	1.5	0.4	0.1
Co	0.01 - 0.1	0.03	0.02	0.03	0.015
F	0.01 - 0.1	0.03	0.06		
V	0.1 - 1.0	0.3	0.006	0.3	0.3
Mo	0.1 - 10.0	1.0	0.25	0.3	0.015
Se	0.1 - 10.0	1.0	0.025		
B	1.0 - 10.0	3.0			
Be	0.01 - 0.1	0.03			
Sn	0.01 - 0.1	0.03	0.03	0.03	0.015
Ba			0.15	0.1	0.005

Table 10. Testing against the drinking water norm (dwn) of the drinking water concentration (cdw) and the soil water concentration (cgr) at a content of the contamination in the soil equal to the proposed human toxicological C-standard values (Cs).

Cs [mg/kg]	cdw [ug/l]	cgr [ug/l]	dwn [ug/l]	cdw/dwn	cgr/dwn	name
300	0	5070	50		101	arsenic
698	0	13900	500		28	barium
1.84	0	130	5		26	cadmium
2140	0	21400	50		428	chromium (III)
0.0999	0	0.998	50		428	chromium (VI)
400	0	3990				cobalt
5020	0	8640	100		86	copper
87.1	0	870	1		870	mercury
514	0	5350	50		107	lead
36.8	0	734				molybdenum
1790	0	81000	50		1620	nickel
571000	0	11400000				tin
1840	0	19100	100		191	zinc
314	0	2350000	160		14688	ammonium compounds
185	0	1380000				bromides
18.5	0	138000	50		2760	cyanides free
7.2	0	54000				cyanides complex
12.9	0	96900	1100		88	fluorides
25800	0	1.9E+08	2000		97000	phosphates
						sulfides
2.03	0	15200				thiocyanates
18.9	95	14900	0.5 *	190.0	29800	benzene
263	214	22300	0.5 *	428.0	44600	ethylbezene
62.9	0.659	170000	0.5	1.3	340000	phenol
84.4	403	88300				cresol(p)
132	173	31600	0.5 *	346.0	63200	toluene
25.8	14.3	1960	0.5 *	28.6	3920	xylene(m)
28.3	66.1	145000				catechol
13.7	34.3	75200				resorcinol
16.4	46.1	101000				hydroquinol
						anthracene
10100	0.00912	10	0.2		50	benzo(a)anthracene
10900	0.000547	0.6	0.2		3	benzo(k)fluoranthene
996	0.000274	0.3	0.2		2	benzo(a)pyrene
39.2	0.000997	1.09	0.2		5	chrysene
121	0.964	423	0.2	4.8	2115	phenanthrene
196	0.102	112	0.2		560	fluoranthene
11400	0.000091	0.1	0.2			indene(1#2#3cd)pyrene
11800	0.000237	0.26	0.2		1.3	benzo(ghi)perylene
1040	0.0292	32	0.2		160	pyrene
						napthalene
1.82	6.73	4920	1	6.7	4920	1#2-dichloroethane
16.5	49.9	21900	1	49.9	21900	dichloromethane
0.812	0.769	211	1		211	tetrachloromethane
5.13	5.12	1460	1	5.1	1460	tetrachloroethene
11.6	57.5	12600	1	57.5	12600	trichloromethane

Cs [mg/kg]	cdw [ug/l]	cgr [ug/l]	dwn [ug/l]	cdw/dwn	cgr/dwn	name
247	410	56200	1	410.0	56200	trichloroethene
0.04	0.0332	7.28	1		7	vinyl chloride
0.588	1.72	108	1	1.7	108	monochlorobenzene
1.64	0.72	79	1		79	p-dichlorobenzene
3.81	0.184	40.3	1		40	trichlorobenzene(1#2#4)
6.64	0.0735	16.1	1		16	tetrachlorobenzene(1#2#3#4)
8.83	0.0331	7.26	1		7	pentachlorobenzene
9.85	0.025	5.48	1		5	hexachlorobenzene
5.78	0.0588	2690	0.5		5380	monochlorophenol (2)
12.2	0.473	1040	0.5		2080	dichlorophenol (2#4)
22.4	0.884	359	0.5	1.8	718	trichlorophenol (2#3#4)
14.3	3.51	769	0.5	7.0	1538	tetrachlorophenol (2#3#4#5)
521	4.8	470	0.5	9.6	940	pentachlorophenol
						chloronaphthalene
3.07	0.00214	0.938	0.1		9	trichlorobiphenyl (2#5#2#)
5.11	0.000153	0.167	0.1		2	hexachlorobipenyl
10400	0.00707	3.1	0.1		31	DDT
3450	0.0912	40	0.1		400	DDE
5.77	0.000063	0.028	0.1		400	aldrin
2	0.00242	1.06	0.1		11	dieldrin
1.58	0.00492	2.16	0.1		22	endrin
6.63	0.35	153	0.1	3.5	1530	HCH
186	0.0882	96.7	0.1		967	carbaryl
158	0.196	215	0.1	2.0	2150	carbofuran
246	0.768	841	0.1	7.7	8410	propoxur
58800	0.000091	0.1	0.1		1	maneb
4.92	3.26	3570	0.1	32.6	35700	atrazine
472	121	6630	10	12.1	663	heptane
1940000	10.2	660	10	1.0	66	octane
3700	49000	5380000				cyclohexanone
282	11.4	1250				butylbenzylphtalic acid
8890	2.6	285				di(2-ethylhexyl)phtalic acid
1.24	0.939	103				pyridine
153	136	14900				styrene
0.58	0.365	40.1				tetrahydrofuran
						tetrahydrothiophene

* no drinking water norm, but adopted from the Inspectierichtlijn (VROM, 1989)

** at this content in the soil the water solubility is exceeded.

Annex 1. Formulas for the calculation of proposals for human toxicological intervention values and actual exposure of man.

Attention! These formulas have been adjusted on the basis of the 1992 TCB recommendations;the information on the uptake of heavy metals by plants has been adjusted to Bockting and Van den Berg, 1992 as well as other information. Mistakes have been corrected.
The consequences in the shape of the proposals for the human toxicological intervention values formulated on this basis are shown in annex 1.11 The proposals for the final intervention values as presented in the Memorandum Intervention Values Soil Clean Up (VROM, 1993) to Parliament, are also given here.

Annex 1.1	Formulas fugacity calculations.
Annex 1.2	Formulas air flux calculations.
Annex 1.3	Formulas dilution air flux outdoor
Annex 1.4	Formulas air concentration calculation .
Annex 1.5	Formulas crop content.
Annex 1.6	Formulas calculation concentration in drinking water after permeation.
Annex 1.7	Formulas for the calculation of the air concentration in the bathroom during showering.
Annex 1.8	Formulas for the quantification of the exposure.
Annex 1.9	Primary set of data.
Annex 1.10	Conversion formulas.
Annex 1.11	The "new" proposed human toxicological intervention values and the final proposals from the Memorandum Intervention Values Soil Clean-Up.

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Annex 1.1. Formulas fugacity calculations.

organic substances

Za = 1 / (R*T)

Za : fugacity capacity constant air [molm^{-3}.Pa^{-1}]
R : gas constant [8.3144 Pa.m^{3}.mol^{-1}.K^{-1}]
T : temperature [K]

Zw = S/Vp

Zw : fugacity constant water mol.m^{-3}.Pa^{-1}]
S : water-solubility [mol.m^{-3}]
Vp : vapour pressure pure substance [Pa]

Zs = Kd * SD * Zw/Vs

Zs : fugacity capacity constant soil [mol.m^{-3}.Pa$^{-1'}$]
Kd : distribution coefficient soil-water [(mol.kg^{-1} dry soil)/(mol.dm^{-3})]
SD : mass volume of the dry soil [kg dry soil.dm^{-3} humid soil]
Vs : volume fraction solid phase [-]

Vs = 1 - porosity
= 1 - Va- Vw

Va : volume fraction air [-]
Vw : volume fraction water [-]

Kd = Koc * foc

Koc : distribution coefficient soil-water corrected for organic carbon [(mol.kg^{-1} org. C)/(mol.dm^{-3})]
foc : fraction organic carbon [kg org.C.kg^{-1} dry soil]

Koc = 0.411 * Kow or: log Koc = 0.989 * log Kow - 0.346

Kow : octanol-water distribution coefficient [(mol.dm^{-3}3)/(mol.dm^{-3}3)]

Klw = Za / Zw
= Vp / (S * R * T)

Klw : air-water distribution coefficient [(mol.m^{-3} air)/(mol.m^{-3} ~ 3 water)] [-]

for dissociating substances

Kd = Kd * fnd

fnd : fraction non-dissociated substance

fnd $= 1 / (1 + 10^{[ph - pKa]})$

pH : acid content of the soil (4-8, as default: 6)
pKa : acid dissociation constant of the substance

Calculation mass fractions

Pa $= (Za * Va) / (Za * Va + Zw * Vw + Zs * Vs)$
Pw $= (Zw * Vw) / (Za * Va + Zw * Vw + Zs * Vs)$
Ps $= (Zs * Vs) / (Za * Va + Zw * Vw + Zs * Vs)$

Pa : mass fraction in soil air [-]
Pw : mass fraction in soil moisture [-]
Ps : mass fraction in solid phase soil [-]

<u>inorganic substances</u>

$Za = 0$; $Csa = 0$; $Pa = 0$

$Pw = 1$; $Ps = 0$

<u>metals and arsenic</u>

$Za = 0$; $Csa = 0$; $Pa = 0$

$Pw = Vw / (Vw + Kd * SD)$

$Ps = 1 - Pw$

calculation concentrations

Csa $= Cs * SD * Pa / Va$

Csa : soil air concentration [mol.dm^{-3} or g.m^{-3}]
Cs : initial soil content [mol.kg^{-1} dry soil or mg.kg^{-1}]
Cpw $= Cs * SD * Pw / Vw$

if : $Cpw > S$ then: $Cpw = S$
$Csa = S * Vw * Pa/(Pw * Va)$

Cpw : soil moisture concentration [mol.dm^{-3} or g.m^{-3}]

Annex 1.2. Formulas air flux calculations.

Dsa $= Va^{10/3} * Da / (1-Vs)^2$ with $Da = .036 * (76/M)^{1/2}$

Dsa : diffusion coefficient in the soil-gas phase [$m^2.h^{-1}$]
Da : diffusion coefficient in free air [$m^2.h^{-1}$]
M : molecular mass [$g.mol^{-1}$]

Dsw $= Vw^{10/3} * Dw / (1-Vs)^2$ with $Dw = 3.6 * 10^{-6} * (76/M)^{1/2}$

Dsw : diffusion coefficient in the soil-water phase [$m^2.h^{-1}$]
Dw : diffusion coefficient in free water [$m^2.h^{-1}$]

Du $= (Pa * Dsa / Va) + (Pw * Dsw / Vw)$

Du : diffusion coefficient in the soil [$m^2.h^{-1}$]

J2 $= Da * Csa/d$
J3 $= Cpw * Ev / 24$
J4 $= Du * Cs * SD / dp$
J5 $= Du * Cs * SD / (dp - Bh)$

if : $Cpw > S$ then : $J4 = Du * S * Vw/ (dp * Pw)$
if : $Cpw > S$ then : $J5 = Du * S * Vw / [(dp - Bh)* Pw]$

J2 : boundary layer flux [$g.m^{-2}.h^{-1}$]
J3 : water-evaporation flux [$g.m^{-1}.h^{-1}$]
J4 : diffusion flux water-soil to surface level [$g.m^{-2}h^{-1}$]
J5 : diffusion flux water-soil to crawl space [$g.m^{-2}h^{-1}$]
Ev : flux of evaporating water [Fast et al., 1987: 0.0001 $m^3.m^{-2}.d^{-1}$]
d : thickness boundary layer [Jury et al., 1985: 0.005 m]
dp : mean depth of the contamination [1.25 m]
Bh : height of the crawl space [0.5 m]

if : $J3+J4 < J2$ then: $Jo = J4 + J3$
if : $J3+J4 >= J2$ then: $Jo = J2$

if : $J3+J5 < J2$ then: $Ji = J5 + J3$
if : $J3+J5 >= J2$ then: $Ji = J2$

Jo : total soil flux to outdoor air [$g.m^{-2}.h^{-1}$]
Ji : total soil flux to crawl space [$g.m^{-2}.h^{-1}$]

Annex 1.3. Formulas dilution air flux outdoor.

SOILRISK (applied in CSOIL)

$Vf = Vg * Sz / Lp$

Vf : dilution velocity [m.h^{-1}]
Vfa : dilution velocity adult [m.h^{-1}]
Vfc : dilution velocity child [m.h^{-1}]
Vg : mean wind velocity [m.h^{-1}]
Sz : vertical Pasquill dispersion coefficient, related to Pasquill weather stability class D [m]
Lp : diameter contaminated soil [100 m]

$Vg = (Vx + V')/2$

Vx : wind velocity at x m altitude [m.h^{-1}]
V' : friction velocity [m.h^{-1}]

$Vx = \ln [Z/Zo] * V' / k$

Z : breathing altitude [x m]
Zo : roughness of the surface area (residential area) [1.0 -]
k : Karman constant [0.4 -]

$V' = k * V10 / \ln (Z10/Zo)$

Z10 : altitude [10 m]
V10 : wind velocity at 10 m altitude [18000 m.h^{-1}]

$Sz = Co * 0.20 * Lp^{0.76}$

$Co = (10 * Zo)\ \hat{}\ (0.53 * Lp^{-0.22})$

Co : correction factor for the roughness length [-]

model calculation for Lp = 100 m:

		children	adults	
z	=	1.0	1,5	[m]
V'	=	3127	3127	[m.h^{-1}]
V1	=	0	3170	[m.h^{-1}]
Vg	=	1563	3148	[m.h^{-1}]
Co	=	1.56	1.56	[-]
Sz	=	10.31	10.31	[m]
Vfc	=	161.3		[m.h^{-1}]
Vfa	=		324.6	[m.h^{-1}]

HESP

$Vf = 1 / [1/Kg - 1/Kgs - \ln (Y/Xa) / (Prc * V')]$

Vf : dilution velocity [m.h^{-1}]
J : flux from the soil [g.m^{-2}.h^{-1}]
Kg : gas phase mass transport coefficient [m.h^{-1}]
Kgs : mass transport coefficient for diffuse substrata [m.h^{-1}]
Y : breathing zone altitude above soil surface [1.5 m]
Xa : thickness of the boundary layer [m]
Prc : Prandtl constant [0.4 -]
V' : friction velocity air [m.h^{-1}]

$Kg = 0.029 * V10^{0.78} * L^{-0.11} * Sc^{-0.67}$

V10 : wind velocity at 10 m altitude [27000 m.h^{-1}]
L : length of the intestinal surface [300 m]
Sc : Schmidt-figure for the gas phase [-]

$Sc = u / (P * Da)$

u : air viscosity [65.8 g.m^{-1}.h^{-1}]
P : air density [1280 g.m^{-3}]
Da : air density coefficient [m^{2}.h^{-1}]

$Kgs = Da / Xa$

$Xa = 26 * Sc^{1/3} * Vk / V'$

Vk : kinetic viscosity of air [0.05137 m^{2}.h-$^{-1}$]

$V' = (V10 * k) / \ln [(h+sr)/sr]$

k : Karman constant [0,4 -]
h : altitude [10 m]
sr : surface roughness [0.28 -]

calculation for Da: 0.0295 m^{2}.h^{-1}:

Sc = 1.74 [-]
Kg = 30.53 [m.h^{-1}]
Xa = 0.00037 [m]
Kgs = 79.67 [m.h^{-1}]
V' = 2997 [m.h^{-1}]
Vf = 75.4 [m.h^{-1}]

Annex 1.4. Formulas air concentration calculation.

$Coaa = Jo / Vfa$

Coaa : concentration in the outdoor air for an adult at 1.5 m altitude [g.m^{-3}]
Vfa : dilution velocity adult [m.h^{-1}]

$Coac = Jo / Vfc$

Coac : concentration in the outdoor air for a child at 1 m altitude [g.m^{-3}]
Vfc : dilution velocity child [m.h^{-1}]

$Cba = Ji * Bo / (Bv * Vv)$

Cba : concentration in the crawl space air [g.m^{-3}]
Bo : surface area of the crawl space [50 m^{2}]
Bv : volume of the crawl space [25 m^{3}]
Vv : ventilation multiplication [1.25 h^{-1}]
(experimental data (Fast et al., 1987): min. 0.03 - max. 7.4 - av. 1.25)

$Cia = fbi * Cba$

Cia : concentration in the indoor air [g.m^{-3}]
fbi : contribution on the crawl space to the indoor air as fraction [0.1 -]
(experimental data (Fast et al., 1987): min. 0 - max. 0.68 - av. 0.11 - 95 perc. 0.39)

if : $Cia < Coac$ then: $Cia = Coac$

Annex 1.5. Formulas crop content.

Deposition

$$\mathrm{Cdp} = \mathrm{TSPo} * \mathrm{DRo} * \mathrm{frs} * \mathrm{Cs} * [\, \mathrm{fin} / (\mathrm{Yv} * \mathrm{fEi})\,] * \{ 1 - (1 - \exp[- \mathrm{fEi} * \mathrm{te}]) / (\mathrm{fEi} * \mathrm{te}) \}$$

Cdp	: crop content compared to deposition	[mg subst.kg^{-1} dw crop]
fin	: fraction interception by crop	[0.4 -]
Yv	: crop yield	[0.28 kg dw.m^{-2}]
fEi	: efflorescence constant	[0.033 d^{-1}]
TSPo	: concentration particles in outdoor air	[0.07 mg.m^{-3}]
frs	: fraction particles in soil	[0.5 -]
DRo	: deposition velocity	[1 cm.s^{-1} = 864 m.d^{-1}]
te	: growing period crop	[180 d]

$\mathrm{Cdp} = 1.089 * 10^{-3} * \mathrm{Cs}$ [mg.kg^{-1} dw crop]

Crop content

Metals

root crops:

$\mathrm{Cpr} = \mathrm{BCFr} * \mathrm{Cs}$

Cpr	: content of the root crop	[mg subst.kg^{-1} dw crop]
BCFr	: bioconcentration factor rootl (see Table 8)	[(mg subst.kg^{-1} dw crop)/(mg subst.kg^{-1} dry soil)]

leafy crops:

$\mathrm{Cps} = \mathrm{BCFs} * \mathrm{Cs} + \mathrm{Cdp}$

Cps	: content of the leafy crop	[mg subst.kg^{-1} dw crop]
BCFs	: bioconcentration factor crop (see Table 8)	[(mg subst.kg^{-1} dw crop)/(mg subst.kg^{-1} dry soil)]

if no BCFr or BCFs are given:

$\ln \mathrm{BCFr/s} = 2.67 - 1.12 * \ln \mathrm{Kd}$

Other inorganic substances

based on high water-solubility: concentration in pore water = concentration in plant moisture

root crops:

$\mathrm{Cpr'} = \mathrm{Cpw} * (1\text{-}\mathrm{fdwr})$

Cpr' : content of the root crop [mg stof.kg^{-1} fresh weight crop]
fdwr = ratio dry weight-fresh weight root crops [0.202 kg dw.kg^{-1} fresh]

BCFr' = (l -fdwr)

BCFr' : bioconcentration factor root [(mg subst.kg^{-1} fresh crop)/(mg subst.dm^{-3} soil moisture)]

leafy crops:

Cps' = Cpw * (l-fdws) + Cdp * fdws

Cps' : content of the leafy crop [mg subst.kg^{-1} fresh weight crop]
fdws = ratio dry weight -fresh weight leafy crops [0.117 kg dw.kg^{-1}l fresh]

BCFs' = (l-fdws)

BCFs' : bioconcentration factor stem [(mg subst.kg^{-1} fresh crop)/(mg subst.dm^{-3} soil moisture)]

Organic substances

roots:

BCFr = $10^{(0.77 * \log Kow - 1.52)} + 0.82$

BCFr' : bioconcentration factor root [(mg subst.kg^{-1} fresh crop)/(mg subst.dm^{-3} soil moisture)]

Cpr' = BCFr' * Cpw

Cpr' : content of the root crop [mg subst.kg^{-1}l fresh weight crop]

stems:

BCFs' : $[10^{(0.95 * \log Kow - 2.05)} + 0.82] * [0.784 * 10^{(-0.434 * (\log Kow - 1.78)\hat{}2/2.44)}]$

BCFs' : bioconcentration factor stem [(mg subst.kg^{-1} fresh crop)/(mg subst.dm^{-3} soil moisture)]

Cps' = BCFs' * Cpw + Cdp * fdws

Cps' : content of the leafy crop [mg subst.kg^{-1} fresh weight crop]

Annex 1.6. Formulas calculation concentration in drinking water after permeation.

$$Cmax = Cpw * 2 * Dpe * t / (r * d)$$

Cmax	: maximum concentration in the drinking water after t days stagnation	[$mg.dm^{-3}$]
Dpe	: permeation coefficient	[$m^2.d^{-1}$]
t	: time period of water stagnation	[Vonk, 1985: 8 h = 1/3 d]
r	: radius of the pipe	[0.0098 m]
d	: thickness of pipe wall	[0.0027 m]

24 hrs permeation:

$$Cdw = Cmax * 3 * pi * r^2 * L / Qwd$$

Cdw	: 24-hrs mean drinking water concentration	[$mg.dm^{-3}$]
t	: in this case 24 h = 1 d, hence correction factor 3	
L	: length of the pipe along which permeation can occur = size location	[100 m]
Qwd	: mean daily water consumption	[500 dm^3]

$Cdw = 4.56 * 10^3 * Dpe * Cpw$ [$mg.dm^{-3}$]

Annex 1.7. Formulas for the calculation of air concentration in the bathroom during showering.

kwa = $[(H_{sh}/RT_{sh}) * kL * kG]/[(H_{sh}/RT_{sh}) * kG + kL)] * [Ad/Vd] * tf$

kwa : degree of evaporation of the contaminant [-]
(H_{sh}/RT_{sh}) : air-water distribution coefficient at a temperature of 313 K (T_{sh}) [-]
T_{sh} : water temperature shower water [313 K]
kL : water mass transport coefficient [$m.s^{-1}$]
kG : vapour mass transport coefficient [$m.s^{-1}$]
Ad : surface area water drop [m^2]
Vd : volume water drop [m^3]
tf : dropping time drop [1 s]

temperature correction for the Henry-constant:

$\ln H_{sh} = \ln (Klw*R*T_0) + 0.024 * (T_{sh} - T_0)$

H_{sh} : Henry-constant at a temperature of 313 K (T_{sh}) [$Pa.m^3.mol^{-1}$]
H_0 : Henry-constant for the reference situation (T_0 = 283-293 K) [$Pa.m^3.mol^{-1}$]

Ad $= 4 * pi * r^2$
Vd $= 4/3 * pi * r^3$
Ad/Vd $= 3 / r$

r : radius of the drop [0.5 mm = 0.0005 m]

kL $= Kl * (44/M)^{1/2} / 3600$ [$m.s^{-1}$]
kG $= Kg * (18/M)^{1/2} / 3600$ [$m.s^{-1}$]

Kl : liquid phase exchange velocity [$0.2\ m.h^{-1}$]
Kg : gas phase mass transport coefficient [$29.88\ m.h^{-1}$]
Cbk = kwa * Vwb * Cdw / (2 * Vbk)

Cbk : concentration in the bathroom air [g $subst.m^{-3}$]
Vwb : volume water consumption [$0.15\ m^3$]
Vbk : volume bathroom [l*b*h = 3*2*2.5 = 15 m^3]

Cbk $= kwa * Cdw * 5 * 10^{-3}$ [$g.m^{-3}$]

Annex 1.8. Formulas quantification exposure.

Soil ingestion

DI = AID * Cs * fa/W

DI : uptake via soil-ingestion $[\text{mg subst.kg}^{-1}.\text{d}^{-1}]$
AID : daily intake amount soil $[\text{kg dry subst.d}^{-1}]$
adults : $50 * 10^{-6}$
children : $150 * 10^{-6}$
W : body weight (Table 3)
fa : relative absorption factor, set at 1 [-]
Cs : content in the soil $[\text{mg.kg}^{-1}]$

DIa = $50 * 10^{-6}$ * Cs/Wa
DIc = $150 * 10^{-6}$ * Cs / Wc

Dermal contact soil

Outdoor exposure via soil, indoor via soil in dust; during sleep no exposure.

DA = A exp * fm * DAE * DAR * Cs * t * tf * frs / W

DA : uptake via dermal contact with soil $[\text{mg.kg}^{-1}.\text{d}^{-1}]$
A exp : exposed surface area $[\text{m}^2]$

	indoor	outdoor
adult	0.09	0.17
children	0.05	0.28

fm : matrix factor [0.15 -]
DAE : degree of coverage $[\text{mg soil.cm}^{-2} = * 0.01\ \text{kg.m}^{-2}]$

	indoor	outdoor
adults	0.056	3.75
children	0.056	0.51

DAR : absorption velocity $[\text{h}^{-1}]$
adults 0.005
children 0.01
t : duration of exposure $[\text{h d}^{-1}]$

	indoor	outdoor
adults	8	8
children	8	8

tf : time fraction exposure [-]
correction of daily to annual average exposure

	indoor	outdoor
adults	1.857	0.143
children	1.143	0.357

frs : fraction soil in dust [-]
frsi: indoor: 0.8

DAa = $5.92 * 10^{-6} * Cs / Wa$
DAc = $6.43 * 10^{-6} * Cs /Wc$

Inhalation of soil (particles)

IP = ITSP * Cs * fr * fa/W

IP : uptake of inhaled soil particles [mg.kg^{-1}.d^{-1}]
ITSP : amount of inhaled soil particles [kg.d^{-1}]
fr : retention factor particles in lung [0.75 -]

ITSP = TSP * frs * AV * t * ft

TSP : amount of air-suspended particles [mg.m^{-3}]
TSPo: outdoor: 70 ug.m^{-3}
TSPi: indoor: 0.75 * 70 = 52,5 ug.m^{-3}
frs : soil-fraction in particles in the air [-]
frso: outdoor: 0.5
frsi: indoor: 0.8
AV : breathing volume [m^{3}d^{-1}]
AVa: adults : 20 = 0.83 m^3.h^{-1}
AVc: children : 7.6 = 0.32 m^3.h^{-1}
t : duration of exposure [h]

	indoor	outdoor
adults	8	8
children	16	8

tf : time fraction exposure [-]
correction from daily to annual average exposure

	indoor	outdoor
adults	2.856	0.143
children	1.322	0.357

IPa = $0.625 * 10^{-6} * Cs / Wa$
IPc = $0.235 * 10^{-6} * Cs / Wc$

Inhalation of air

IV = $[AV * Cia * tfi * ti + AV * Coa * tfo * to] * fa * 10^3/ W$

IV : uptake of contamination via vapours mg.kg^{-1}.d^{-1}]
Cia : concentration in the indoor air [g.m^{-3}]
Coa : concentration in the outdoor air [g.m^{-3}]
Coaa : concentration in the outdoor air for an adult [g.m^{-3}]
Coac : concentration in the outdoor air for a child [g.m^{-3}]
ti/to : daily duration of exposure indoor resp. outdoor (see Table under inhalation soil particles [h]
tfi/tfo : annual average time fractions for stay indoor resp. outdoor (see Table under inhalation of soil particles) [-]

IVa = (22.86 * Cia + 1.14 * Coaa) * 0.83 * 1000 / Wa

IVc $= (21.14 * Cia + 2.86 * Coac) * 0.32 * 1000 / Wc$

Ingestion of crops: leafy and root crops

metals

VI $= (Qfvk * Cpr + Qfvb * Cps) * fv * fa / W$

VI : uptake of contaminant via crop [mg.kg^{-1}.d^{-1}]
Qfvk : daily consumption of root crops [kg dry weight.d^{-1}]
  adults : 0.02761
  children : 0.01511
Qfvb : daily consumption of leafy crops [kg dry weight.d^{-1}]
  adults : 0.01843
  children : 0.00890
fv : fraction contaminated food [0.1 -]
Cpr : content of the root crop [mg subst.kg^{-1} dw crop]
Cps : content of the leafy crop [mg subst.kg^{-1} dw crop]

VIa $= (0.002761 * Cpr + 0.001843 * Cps) / Wa$
VIc $= (0.001511 * Cpr + 0.000890 * Cps) / Wc$

other (in)organic substances

VI $= (Qfvk' * Cpr' + Qfvb' * Cps') * fv * fa / W$

Qfvk' : daily consumption of root crops [kg fresh weight.d^{-1}]
  adults : 0.1367
  children : 0.0748
Qfvb' : daily consumption of leafy crops [kg fresh weight.d^{-1}]
  adults : 0.1578
  children : 0.0761
Cpr' : content of the root crop [mg subst.kg^{-1} fresh weight crop]
Cps' : content of the leafy crop [mg subst.kg^{-1} fresh weight crop]

VIa $= (0.01367 * Cpr' + 0.01578 * Cps') / Wa$
VIc $= (0.00748 * Cpr' + 0.00761 * Cps') / Wc$

Ingestion of drinking water

DIw $= Qdw * Cdw * fa / W$

DIw : intake of contaminated drinking water by drinking [mg.kg^{-1}.d^{-1}]
Qdw : daily drinking water intake [m^3.d^{-1}]
  adults : 0.002 = 2 dm^3.d^{-1}
  children : 0.001 = 1 dm^3.d^{-1}
Cdw : drinking water concentration [mg dm^{-3} = g.m^{-3}]

DIwa = 2 * Cdw / Wa
DIwc = 1 * Cdw / Wc

<u>Inhalation of vapours during showering</u>

IVw = Cbk * AV * td * fa * 1000 / W

IVw : intake contamination by inhaling vapour during showering [mg.kg^{-1}.d^{-1}]
Cbk : concentration in the bathroom air [g.m^{-3}]
td : duration of stay in the bathroom [h]
15 min. showering + 15 min. drying/dressing = [0.5 h]

IVwa = 2.08 * Cdw * kwa / Wa
IVwc = 0.792 * Cdw * kwa / Wc

<u>Dermal contact during showering</u>

DAw = A to * f exp * DAR * tdc * (l-kwa) * Cdw * fa / W

DAw : uptake as a result of dermal contact during showering [mg.kg^{-1}.d^{-1}]
A to : exposure surface area = entire body [m^2]
adults : 1.8
children : 0.95
f exp : fraction exposed skin [0.4 -]
DAR : dermal absorption velocity [(mg.m^{-2})/(mg.dm^{-3}).h^{-1}]
tdc : contact time = showering time [0.25 h.d^{-1}]
(1-kwa) : substance remaining in water after evaporation [-]

DAR = P1 * P2 according to Fiserova-Bergerova and Pierce (1989), with:

P1 = (0.038 + 0.153 * Kow)
P1 = 5000 * P1 / (5000 + P1), maximation according to Braun
P2 = exp (-0.016 * M) / 1.5

DAwa = 0.18 * DAR * (1-kwa) * Cdw / Wa
DAwc = 0.095 * DAR * (1-kwa) * Cdw / Wc

<u>(Dermal contact during bathing)</u>

DAw = A to * DAR * tb * Cdw * fa / W

DAR : dermal absorption velocity [10 (mg.m^{-2})/(mg.dm^{-3}.h^{-1}]
or the DAR indicated earlier
tb : contact time = duration of bathing [0.5 h.d^{-1}]

Total exposure

TAD = DIa + DAa + IPa + IVa + VIa + DIWa + IVwa + DAwa
TCH = DIc + DAc + IPc + IVc + VIc + DIWc + IVwc + DAwc

TAD : daily exposure adult $[mg.kg^{-1}.d^{-1}]$
TCH : daily exposure child $[mg.kg^{-1}.d^{-1}]$

DOSIS = (6 * TCH + 64 * TAD) / 70

DOSIS : life-time mean daily exposure $[mg.kg^{-1}.d^{-1}]$

Annex 1.9 Primary set of data.

Necessary set of data in order to be able to calculate potential exposure.

S : water-solubility [mol.m^{-3}] or [mg.l^{-1}]
Vp : vapour pressure pure substance [Pa] or [atm] or [mm Hg]
or
Klw : air-water distribution coefficient [-]
(this may also be calculated from the other data, see annex 1.10)
M : molecular mass [g.mol^{-1}]
Kow : octanol-water distribution coefficient (for organic substances)
or
Kd : soil-water distribution coefficient (for metals) [dm^{3}.kg^{-1}]
Dpe : permeation coefficient [m^{2}.d^{-1}]

Annex 1.10 Conversion formulas

$Klw = Vp / (S * R * T)$

$Vp = Klw * S * R * T$

$R_1 = 8.3144\ Pa.m^3.mol^{-1}.K^{-1}$
$R_2 = 8.206*10^{-5}\ m^3.atm.mol^{-1}.K^{-1}$

if H is given as $[Pa.m^3.mol^{-1}]$ then: $Klw = H / (R_1 * T)$

if H is given as $[atm.m^3.mol^{-1}l$ then: $Klw = H / (R_2 * T)$ or:
$Klw = H * 1.013 * 10^5 / (R_1 * T)$

1 mm Hg-pressure = 133.33 Pa = $1.316*10^{-3}$ atm

if S is given in $[mg.l^{-1}]$ then: $S = S / M\ [mol.m^{-3}]$

M : molecular mass $[g.mol^{-1}]$

foc = 0.58 * fom or fom = 1.724 * foc or OS = 172.4 * foc

fom : fraction organic substance mass
OS : percentage organic substance

Annex 1.11 The "new" proposed human toxicological intervention values and the final proposals from the Memorandum Intervention values Soil Clean-Up.

substance	Human-toxicological intervention values		Proposed intervention values	
	soil	soil water	soil	soil water
	[mg kg^{-1}]	[mg l^{-1}]	[mg kg^{-1}]	[μg l^{-1}]
arsenic	678	0.692	55	60
barium	4260	73.3	625	625
cadmium	34.9	0.186	12	6
chromium (III)	2250	0.156	380	30
chromium (VI)	0.315	0.000021		
cobalt	452	3.86	240	100
copper	31300[1]	58.0	190	75
mercury	197	0.0597	10	0.3
lead	301[2]	0.126	530	75
molybdenum	912	47.6	200	300
nickel	6580	11.6	210	75
tin	646000	2630		
zinc	56500	226	720	800
ammonium compounds	571	4280		
bromides	336	2520		
cyanides free	16.8	126	20	1500
cyanides complex	4.36	32.7		
pH < 5			650	1500
pH >= 5			50	1500
fluorides	23.5	176		
phosphates	23500	176000		
sulfides	0.336	2.52		
thiocyanates	3.69	27.7	20	1500
benzene	1.09	0.322	1	30
ethylbenzene	49.9[3]	1.47	50	150
phenol	46.4[4]	56.5	40	2000
cresol	4.76[4]	1.87	5	200
toluene	339	28.6	130	1000
xylene	25.6	0.674	25	70
catechol	22.8	72.7	20	1250
resorcinol	10.4	37.5	10	600
hydroquinol	10.8	49.4	10	800
PAH (sum of 10)			40	
anthracene **	29000	0.075		5
benzo(a)anthracene **	11200	0.01		0.5
benzo(k)fluoranthene **	11600	0.0006		0.05
benzo(a)pyrene **	1110	0.0003		0.05
chrysene **	420	0.0015		0.05
phenanthrene	661	0.8		5
fluoranthene	1070	0.21		1
indene(1#2#3cd)pyrene **	11800	0.0001		0.05
benzo(ghi)perylene **	12000	0.00026		0.05
pyrene **	6630	0.032		
napthalene	603	11		70
1#2-dichloroethane	3.86	4.76	4	400
dichloromethane	18.9	9.9	20	1000
tetrachloromethane	0.921	0.0863	1	10
tetrachloroethene	3.89	0.4	4	40
trichloromethane	8.83	3.72	10	400
trichloroethene	303	24.4	60	500
vinyl chloride	0.0772	0.00572	0.1	0.7
chlorobenzenes (sum)			30	
monochlorobenzene	521	33.5		180
p-dichlorobenzene	1150	19.2		50
trichlorobenzene(1#2#4)	9.04	0.033		10
tetrachlorobenzene(1#2#3#4)	18	0.0151		2.5
pentachlorobenzene	23.7	0.00673		1
hexachlorobenzene	26.8	0.00514		0.5

chlorophenols (sum)			10	
monochlorophenol	14	2.35		100
dichlorophenol	32.5	0.962		30
trichlorophenol	56.3	0.34		10
tetrachlorophenol	18.3	0.993		10
pentachlorophenol	79.8	0.476	5	3
chloronaphthalene	9.11	0.054	10	6
polychlorobiphenyles (sum of 7)			1	0.01
trichlorobiphenyl	5.53	0.000582		
hexachlorobiphenyl	8.72	0.000098		
DDT/DDE/DDD			4	0.01
DDT **	11300	0.0031		
DDE **	7830	0.04		
drins (sum)			4	0.1
aldrin	13.8	0.000023		
dieldrin	5.45	0.000997		
endrin	4.36	0.00205		
HCH/compounds			2	1
α-HCH	21.1	0.111		
β-HCH	0.423	0.00223		
γ-HCH	21.1	0.111		
δ-HCH	24.8	0.0824		
carbaryl	461	0.0826	5	0.1
carbofuran	435	0.205	2	0.1
propoxur	680	0.804		
maneb **	29800	0.0001	35	0.1
atrazine	21	5.62	6	150
minimal oil			5000	600
heptane	528	2.63		
octane	371	0.553		
cyclohexanone	270[3]	155	270	15000
phtalates (sum)			60	5
butylbenzylphtalic acid	776	1.18		
di(2-ethylhexyl)phtalic acid **	4630	0.285		
pyridine	1.06	0.0306	1	3
styrene	102[4]	3.47	100	300
tetrahydrofuran	0.4	0.0105	0.4	1
tetrahydrothiophene	94	0.342	90	30

1	raised in view of maximum exposure content crops
2	lowered in view of specific child-TDI
3	lowered in view of exceeding of indoor air concentration of TCL
4	lowered in view of exceeding of indoor air concentration of odour threshold value
**	at this value for soil, water-solubility is exceeded

Annex 9. Results of the exposure calculations.

A content in the soil Cs [mg.kg^{-1}] equal to the proposed human toxicological C-standard value was chosen as basis for all calculations.
The indication ** behind the substance name means that given this content in the soil, water-solubility is exceeded.

Table 9.1	Mass fractions of the contamination in soil moisture, soil air and solid phase, calculated according to formulas annex 1.1.
Table 9.2	Concentrations of the contamination soil moisture, soil air and solid phase, calculated according to formulas annex 1.1.
Table 9.3	Data on soil evaporation fluxes and resultant outdoor and indoor air concentrations, calculated on the basis of the formulas in annexes 1.2 up to 1.4.
Table 9.4	Data on bioaccumulation factors and contents in crops calculated on the basis of formulas given in annex 1.5.
Table 9.5	Data with reference to exposure via drinking water, calculated on the basis of formulas in annexes 1.6, 1.7 and 1.8.
Table 9.6	Contributions in percentages of the various exposure routes for adults (a) and children (c); the exposure has been calculated on the basis of the formulas in annex 1.8.
Table 9.7	Absolute contributions of the various exposure routes to the total dose for adults; the exposure has been calculated on the basis of formulas in annex 1.8.
Table 9.8	Absolute contributions of the various exposure routes to the total dose for children; the exposure has been calculated on the basis of formulas in annex 1.8.

Table 9.1 Mass fractions of the contamination in soil moisture, soil air and solid phase, calculated according to formulas annex 1.1.

A content in the soil Cs [mg.kg^{-1}] equal to the proposed human toxicological C-standard value was chosen as basis for the calculation.

The indication ** behind the substance name means that given this content in the soil, water-solubility is exceeded.

Pa : mass fraction in soil air [-]
Pw : mass fraction in soil moisture [-]
Ps : mass fraction in solid phases of the soil [-]

cs	pa	pw	ps	name
3.00E+02	0.00E+00	2.25E-03	9.98E-01	arsenic
6.98E+02	0.00E+00	2.66E-03	9.97E-01	barium
1.84E+00	0.00E+00	9.43E-03	9.91E-01	cadmium
2.14E+03	0.00E+00	1.33E-03	9.99E-01	chromium (III)
9.99E-02	0.00E+00	1.33E-03	9.99E-01	chromium (VI)
4.00E+02	0.00E+00	1.33E-03	9.99E-01	cobalt
5.02E+03	0.00E+00	2.29E-04	1.00E+00	copper
8.71E+01	0.00E+00	1.33E-03	9.99E-01	mercury
5.14E+02	0.00E+00	1.39E-03	9.99E-01	lead
3.68E+01	0.00E+00	2.66E-03	9.97E-01	molybdenum
1.79E+03	0.00E+00	6.02E-03	9.94E-01	nickel
5.71E+05	0.00E+00	2.66E-03	9.97E-01	tin
1.84E+03	0.00E+00	1.39E-03	9.99E-01	zinc
3.14E+02	0.00E+00	1.00E+00	0.00E+00	ammonium compounds
1.85E+02	0.00E+00	1.00E+00	0.00E+00	bromides
1.85E+01	0.00E+00	1.00E+00	0.00E+00	cyanides free
7.20E+00	0.00E+00	1.00E+00	0.00E+00	cyanides complex
1.29E+01	0.00E+00	1.00E+00	0.00E+00	fluorides
2.58E+04	0.00E+00	1.00E+00	0.00E+00	phosphates
1.00E+01	0.00E+00	1.00E+00	0.00E+00	sulfides
2.03E+00	0.00E+00	1.00E+00	0.00E+00	thiocyanates
1.89E+01	1.99E-02	1.05E-01	8.75E-01	benzene
2.63E+02	3.01E-03	1.13E-02	9.86E-01	ethylbenzene
6.29E+01	4.68E-06	3.60E-01	6.40E-01	phenol
8.44E+01	1.42E-06	1.40E-01	8.60E-01	cresol(p)
1.32E+02	6.94E-03	3.18E-02	9.61E-01	toluene
2.58E+01	1.95E-03	1.01E-02	9.88E-01	xylene(m)
2.83E+01	9.40E-06	6.81E-01	3.19E-01	catechol
1.37E+01	5.42E-06	7.29E-01	2.71E-01	resorcinol
1.64E+01	8.70E-05	8.20E-01	1.79E-01	hydroquinol
1.00E+01	6.87E-08	5.25E-04	9.99E-01	anthracene
1.01E+04	2.13E-09	3.98E-05	1.00E+00	benzo(a)anthracene **
1.09E+04	1.09E-12	2.34E-06	1.00E+00	benzo(k)fluoranthene **
9.96E+02	3.38E-11	7.25E-06	1.00E+00	benzo(a)pyrene **
3.92E+01	6.24E-11	3.72E-06	1.00E+00	chrysene
1.21E+02	5.33E-08	4.68E-04	1.00E+00	phenanthrene
1.96E+02	5.67E-09	7.59E-05	1.00E+00	fluoranthene
1.14E+04	1.84E-12	6.03E-07	1.00E+00	indene(1#2#3cd)pyrene **
1.18E+04	1.90E-11	1.62E-05	1.00E+00	benzo(ghi)perylene **
1.04E+03	1.13E-13	1.62E-05	1.00E+00	pyrene **
1.00E+01	2.94E-05	7.03E-03	9.93E-01	napthalene

cs	pa	pw	ps	name
1.82E+00	1.42E-02	3.60E-01	6.26E-01	1#2-dichloroethane
1.65E+01	1.49E-02	1.77E-01	8.08E-01	dichloromethane
8.12E-01	3.40E-02	3.46E-02	9.31E-01	tetrachloromethane
5.13E+00	3.32E-02	3.78E-02	9.29E-01	tetrachloroethene
1.16E+01	1.97E-02	1.45E-01	8.35E-01	trichloromethane
2.47E+02	1.23E-02	3.03E-02	9.57E-01	trichloroethene
4.00E-02	2.08E-01	2.43E-02	7.68E-01	vinyl chloride
5.88E-01	2.74E-03	2.44E-02	9.73E-01	monochlorobenzene
1.64E+00	6.54E-04	6.41E-03	9.93E-01	p-dichlorobenzene
3.81E+00	1.07E-04	1.41E-03	9.98E-01	trichlorobenzene(1#2#4)
6.64E+00	4.53E-06	3.24E-04	1.00E+00	tetrachlorobenzene(1#2#3#4)
8.83E+00	6.49E-06	1.10E-04	1.00E+00	pentachlorobenzene
9.85E+00	1.09E-07	7.41E-05	1.00E+00	hexachlorobenzene
5.78E+00	1.27E-05	6.20E-02	9.38E-01	monochlorophenol (2)
1.22E+01	2.28E-06	1.14E-02	9.89E-01	dichlorophenol (2#4)
2.24E+01	1.61E-07	2.13E-03	9.98E-01	trichlorophenol (2#3#4)
1.43E+01	7.55E-07	7.19E-03	9.93E-01	tetrachlorophenol (2#3#4#5)
5.21E+02	1.43E-08	1.20E-04	1.00E+00	pentachlorophenol
1.00E+01	3.70E-05	2.29E-03	9.98E-01	chloronaphthalene
3.07E+00	1.39E-08	4.07E-05	1.00E+00	trichlorobiphenyl (2#5#2#)
5.11E+00	3.91E-08	4.37E-06	1.00E+00	hexachlorobipenyl
1.04E+04	1.32E-08	1.07E-05	1.00E+00	DDT **
3.45E+03	1.36E-09	3.02E-05	1.00E+00	DDE **
5.77E+00	3.07E-08	6.46E-07	1.00E+00	aldrin
2.00E+00	2.75E-09	7.08E-05	1.00E+00	dieldrin
1.58E+00	4.06E-08	1.82E-04	1.00E+00	endrin
6.63E+00	1.07E-07	3.08E-03	9.97E-01	HCH
1.86E+02	3.29E-05	6.92E-05	1.00E+00	carbaryl
1.58E+02	9.24E-08	1.82E-04	1.00E+00	carbofuran
2.46E+02	8.13E-09	4.57E-04	1.00E+00	propoxur
5.88E+04	6.81E-08	6.03E-07	1.00E+00	maneb **
4.92E+00	5.07E-09	9.68E-02	9.03E-01	atrazine
4.72E+02	3.84E-02	1.87E-03	9.60E-01	heptane
1.94E+06	5.77E-02	5.55E-04	9.42E-01	octane **
3.70E+03	1.87E-04	1.93E-01	8.06E-01	cyclohexanone
2.82E+02	3.09E-08	5.89E-04	9.99E-01	butylbenzylphtalic acid
8.89E+03	6.15E-08	1.23E-04	1.00E+00	di(2-ethylhexyl)phtalic acid **
1.24E+00	4.95E-03	1.10E-02	9.84E-01	pyridine
1.53E+02	1.28E-03	1.30E-02	9.86E-01	styrene
5.80E-01	1.32E-01	9.21E-03	8.59E-01	tetrahydrofuran
1.00E+01	1.19E-02	1.39E-03	9.87E-01	tetrahydrothiophene

Tabel 9.2 Concentrations of the contamination in the soil moisture, soil air and solid phase, calculated according to formulas annex 1.1.
A content in the soil Cs [mg.kg^{-1}] equal to the proposed human toxicological C-standard value was chosen as basis for all calculations.
The indication ** behind the substance name means that given this content in the soil, water-solubility is exceeded.

Csa : soil air concentration [g.m^{-3}]
Cs : soil content [mg.kg^{-1} dry soil]
Cpw : soil moisture concentration [g.m^{-3}]

cs	csa	cpw	name
3.00E+02	0.00E+00	5.07E+00	arsenic
6.98E+02	0.00E+00	1.39E+01	barium
1.84E+00	0.00E+00	1.30E-01	cadmium
2.14E+03	0.00E+00	2.14E+01	chromium (III)
9.99E-02	0.00E+00	9.98E-04	chromium (VI)
4.00E+02	0.00E+00	3.99E+00	cobalt
5.02E+03	0.00E+00	8.64E+00	copper
8.71E+01	0.00E+00	8.70E-01	mercury
5.14E+02	0.00E+00	5.35E+00	lead
3.68E+01	0.00E+00	7.34E-01	molybdenum
1.79E+03	0.00E+00	8.10E+01	nickel
5.71E+05	0.00E+00	1.14E+04	tin
1.84E+03	0.00E+00	1.91E+01	zinc
3.14E+02	0.00E+00	2.35E+03	ammonium compounds
1.85E+02	0.00E+00	1.38E+03	bromides
1.85E+01	0.00E+00	1.38E+02	cyanides free
7.20E+00	0.00E+00	5.40E+01	cyanides complex
1.29E+01	0.00E+00	9.69E+01	fluorides
2.58E+04	0.00E+00	1.94E+05	phosphates
1.00E+01	0.00E+00	7.50E+01	sulfides
2.03E+00	0.00E+00	1.52E+01	thiocyanates
1.89E+01	2.81E+00	1.49E+01	benzene
2.63E+02	5.94E+00	2.23E+01	ethylbenzene
6.29E+01	2.21E-03	1.70E+02	phenol
8.44E+01	9.01E-04	8.83E+01	cresol(p)
1.32E+02	6.89E+00	3.16E+01	toluene
2.58E+01	3.78E-01	1.96E+00	xylene(m)
2.83E+01	2.00E-03	1.45E+02	catechol
1.37E+01	5.59E-04	7.52E+01	resorcinol
1.64E+01	1.07E-02	1.01E+02	hydroquinol
1.00E+01	5.15E-06	3.93E-02	anthracene
1.01E+04	5.34E-07	1.00E-02	benzo(a)anthracene **
1.09E+04	2.78E-10	6.00E-04	benzo(k)fluoranthene **
9.96E+02	1.40E-09	3.00E-04	benzo(a)pyrene **
3.92E+01	1.84E-08	1.09E-03	chrysene
1.21E+02	4.82E-05	4.23E-01	phenanthrene
1.96E+02	8.35E-06	1.12E-01	fluoranthene
1.14E+04	3.05E-10	1.00E-04	indene(1#2#3cd)pyrene **
1.18E+04	3.04E-10	2.60E-04	benzo(ghi)perylene **
1.04E+03	2.23E-10	3.20E-02	pyrene **
1.00E+01	2.20E-03	5.27E-01	napthalene

cs	csa	cpw	name
1.82E+00	1.94E-01	4.92E+00	1#2-dichloroethane
1.65E+01	1.84E+00	2.19E+01	dichloromethane
8.12E-01	2.07E-01	2.11E-01	tetrachloromethane
5.13E+00	1.28E+00	1.46E+00	tetrachloroethene
1.16E+01	1.71E+00	1.26E+01	trichloromethane
2.47E+02	2.29E+01	5.62E+01	trichloroethene
4.00E-02	6.24E-02	7.28E-03	vinyl chloride
5.88E-01	1.21E-02	1.08E-01	monochlorobenzene
1.64E+00	8.05E-03	7.90E-02	p-dichlorobenzene
3.81E+00	3.05E-03	4.03E-02	trichlorobenzene(1#2#4)
6.64E+00	2.26E-04	1.61E-02	tetrachlorobenzene(1#2#3#4)
8.83E+00	4.30E-04	7.26E-03	pentachlorobenzene
9.85E+00	8.05E-06	5.48E-03	hexachlorobenzene
5.78E+00	5.50E-04	2.69E+00	monochlorophenol (2)
1.22E+01	2.09E-04	1.04E+00	dichlorophenol (2#4)
2.24E+01	2.70E-05	3.59E-01	trichlorophenol (2#3#4)
1.43E+01	8.07E-05	7.69E-01	tetrachlorophenol (2#3#4#5)
5.21E+02	5.59E-05	4.70E-01	pentachlorophenol
1.00E+01	2.78E-03	1.71E-01	chloronaphthalene
3.07E+00	3.19E-07	9.38E-04	trichlorobiphenyl (2#5#2#)
5.11E+00	1.50E-06	1.67E-04	hexachlorobipenyl
1.04E+04	3.81E-06	3.10E-03	DDT **
3.45E+03	1.80E-06	4.00E-02	DDE **
5.77E+00	1.33E-06	2.80E-05	aldrin
2.00E+00	4.13E-08	1.06E-03	dieldrin
1.58E+00	4.81E-07	2.16E-03	endrin
6.63E+00	5.33E-06	1.53E-01	HCH
1.86E+02	4.59E-02	9.67E-02	carbaryl
1.58E+02	1.09E-04	2.15E-01	carbofuran
2.46E+02	1.50E-05	8.41E-01	propoxur
5.88E+04	1.13E-05	1.00E-04	maneb **
4.92E+00	1.87E-07	3.57E+00	atrazine
4.72E+02	1.36E+02	6.63E+00	heptane
1.94E+06	6.86E+01	6.60E-01	octane **
3.70E+03	5.19E+00	5.38E+03	cyclohexanone
2.82E+02	6.54E-05	1.25E+00	butylbenzylphtalic acid
8.89E+03	1.43E-04	2.85E-01	di(2-ethylhexyl)phtalic acid **
1.24E+00	4.61E-02	1.03E-01	pyridine
1.53E+02	1.46E+00	1.49E+01	styrene
5.80E-01	5.73E-01	4.01E-02	tetrahydrofuran
1.00E+01	8.91E-01	1.05E-01	tetrahydrothiophene

Table 9.3 Data on soil evaporation fluxes and resultant outdoor and indoor air concentrations, calculated on the basis of the formulas in annexes 1.2 up to 1.4.
A content in the soil Cs [mg.kg^{-1}] equal to the proposed human toxicological C-standard value was chosen as basis for all calculations.
The indication ** behind the substance name means that given this content in the soil, water-solubility is exceeded.

J2 : boundary layer flux [g.m^{-2}.h^{-1}]
J3 : water-evaporation flux [g.m^{-2}.h^{-1}]
J4 : diffusion flux water-soil [g.m^{-2}.h^{-1}]

Noa : total soil flux [g.m^{-2}.h^{-1}]
Coa : concentration in the outdoor air (child) [g.m.$^{-3}$]
Cia : concentration in the indoor air [g.m.$^{-3}$]

cs	j2	j4	j3	noa	coa	cia		name
3.00E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		arsenic
6.98E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		barium
1.84E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		cadmium
2.14E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		chromium (III)
9.99E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		chromium (VI)
4.00E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		cobalt
5.02E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		copper
8.71E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		mercury
5.14E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		lead
3.68E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		molybdenum
1.79E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		nickel
5.71E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		tin
1.84E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		zinc
3.14E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		ammonium compounds
1.85E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		bromides
1.85E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		cyanides free
7.20E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		cyanides complex
1.29E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		fluorides
2.58E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		phosphates
1.00E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		sulfides
2.03E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		thiocyanates
1.89E+01	2.00E+01	3.90E-03	6.20E-05	3.96E-03	2.46E-05	6.34E-04	j4	benzene
2.63E+02	3.69E+01	7.19E-03	9.30E-05	7.29E-03	4.52E-05	1.17E-03	j4	ethylbenzene
6.29E+01	1.43E-02	2.42E-05	7.08E-04	7.32E-04	4.54E-06	1.17E-04	j4	phenol
8.44E+01	5.44E-03	1.15E-05	3.68E-04	3.79E-04	2.35E-06	6.07E-05	j4	cresol(p)
1.32E+02	4.56E+01	8.88E-03	1.32E-04	9.02E-03	5.59E-05	1.44E-03	j4	toluene
2.58E+01	2.35E+00	4.56E-04	8.15E-06	4.66E-04	2.89E-06	7.45E-05	j4	xylene(m)
2.83E+01	1.20E-02	1.92E-05	6.03E-04	6.23E-04	3.86E-06	9.96E-05	j4	catechol
1.37E+01	3.34E-03	9.42E-06	3.13E-04	3.23E-04	2.00E-06	5.16E-05	j4	resorcinol
1.64E+01	6.42E-02	2.43E-05	4.21E-04	4.46E-04	2.76E-06	7.13E-05	j4	hydroquinol
1.00E+01	2.42E-05	8.34E-09	1.64E-07	1.72E-07	1.07E-09	2.76E-08	j4	anthracene
1.01E+04	2.22E-06	1.24E-09	4.17E-08	4.29E-08	2.66E-10	6.87E-09	j4	benzo(a)anthracene **
1.09E+04	1.10E-09	4.65E-11	2.50E-09	1.10E-09	6.83E-12	1.76E-10	j2	benzo(k)fluoranthene **
9.96E+02	5.54E-09	2.42E-11	1.25E-09	1.27E-09	7.90E-12	2.04E-10	j4	benzo(a)pyrene **
3.92E+01	7.63E-08	1.03E-10	4.56E-09	4.66E-09	2.89E-11	7.45E-10	j4	chrysene
1.21E+02	2.27E-04	8.30E-08	1.76E-06	1.84E-06	1.14E-08	2.95E-07	j4	phenanthrene
1.96E+02	3.69E-05	1.68E-08	4.65E-07	4.82E-07	2.99E-09	7.71E-08	j4	fluoranthene
1.14E+04	1.15E-09	7.59E-12	4.17E-10	4.24E-10	2.63E-12	6.79E-11	j4	indene(1#2#3cd)pyrene **

cs	j2	j4	j3	noa	coa	cia		name
1.18E+04	1.15E-09	1.94E-11	1.08E-09	1.10E-09	6.84E-12	1.76E-10	j4	benzo(ghi)perylene **
1.04E+03	9.86E-10	2.76E-09	1.33E-07	9.86E-10	6.12E-12	1.58E-10	j2	pyrene **
1.00E+01	1.21E-02	2.42E-06	2.20E-06	4.62E-06	2.86E-08	7.39E-07	j4	napthalene
1.82E+00	1.22E+00	2.39E-04	2.05E-05	2.59E-04	1.61E-06	4.15E-05	j4	1#2-dichloroethane
1.65E+01	1.25E+01	2.44E-03	9.11E-05	2.53E-03	1.57E-05	4.06E-04	j4	dichloromethane
8.12E-01	1.05E+00	2.04E-04	8.78E-07	2.05E-04	1.27E-06	3.28E-05	j4	tetrachloromethane
5.13E+00	6.22E+00	1.21E-03	6.07E-06	1.22E-03	7.56E-06	1.95E-04	j4	tetrachloroethene
1.16E+01	9.83E+00	1.92E-03	5.25E-05	1.97E-03	1.22E-05	3.15E-04	j4	trichloromethane
2.47E+02	1.25E+02	2.44E-02	2.34E-04	2.46E-02	1.53E-04	3.94E-03	j4	trichloroethene
4.00E-02	4.85E-01	9.65E-05	3.03E-08	9.65E-05	5.99E-07	1.54E-05	j4	vinyl chloride
5.88E-01	7.14E-02	1.39E-05	4.49E-07	1.44E-05	8.92E-08	2.30E-06	j4	monochlorobenzene
1.64E+00	4.17E-02	8.13E-06	3.29E-07	8.46E-06	5.25E-08	1.35E-06	j4	p-dichlorobenzene
3.81E+00	1.42E-02	2.78E-06	1.68E-07	2.95E-06	1.83E-08	4.71E-07	j4	trichlorobenzene(1#2#4)
6.64E+00	9.63E-04	1.89E-07	6.71E-08	2.56E-07	1.59E-09	4.10E-08	j4	tetrachlorobenzene(1#2#3#4)
8.83E+00	1.70E-03	3.33E-07	3.02E-08	3.63E-07	2.25E-09	5.81E-08	j4	pentachlorobenzene
9.85E+00	2.99E-05	6.23E-09	2.28E-08	2.91E-08	1.80E-10	4.65E-09	j4	hexachlorobenzene
5.78E+00	3.05E-03	8.84E-07	1.12E-05	1.21E-05	7.49E-08	1.93E-06	j4	monochlorophenol (2)
1.22E+01	1.03E-03	2.99E-07	4.32E-06	4.62E-06	2.87E-08	7.40E-07	j4	dichlorophenol (2#4)
2.24E+01	1.21E-04	5.48E-08	1.50E-06	1.55E-06	9.62E-09	2.48E-07	j4	trichlorophenol (2#3#4)
1.43E+01	3.33E-04	1.27E-07	3.20E-06	3.33E-06	2.06E-08	5.33E-07	j4	tetrachlorophenol (2#3#4#5)
5.21E+02	2.15E-04	7.71E-08	1.95E-06	2.03E-06	1.26E-08	3.25E-07	j4	pentachlorophenol
1.00E+01	1.37E-02	2.68E-06	7.14E-07	3.40E-06	2.11E-08	5.43E-07	j4	chloronaphthalene
3.07E+00	1.25E-06	3.15E-10	3.91E-09	4.22E-09	2.62E-11	6.76E-10	j4	trichlorobiphenyl (2#5#2#)
5.11E+00	4.95E-06	9.75E-10	6.97E-10	1.67E-09	1.04E-11	2.67E-10	j4	hexachlorobipenyl
1.04E+04	1.27E-05	2.68E-09	1.29E-08	1.56E-08	9.67E-11	2.50E-09	j4	DDT **
3.45E+03	6.35E-06	3.98E-09	1.67E-07	1.71E-07	1.06E-09	2.73E-08	j4	DDE **
5.77E+00	4.37E-06	8.54E-10	1.17E-10	9.71E-10	6.02E-12	1.55E-10	j4	aldrin
2.00E+00	1.33E-07	9.23E-11	4.42E-09	4.51E-09	2.80E-11	7.22E-10	j4	dieldrin
1.58E+00	1.52E-06	4.30E-10	8.98E-09	9.41E-09	5.84E-11	1.51E-09	j4	endrin
6.63E+00	1.96E-05	1.48E-08	6.39E-07	6.54E-07	4.05E-09	1.05E-07	j4	HCH
1.86E+02	2.03E-01	3.96E-05	4.03E-07	4.00E-05	2.48E-07	6.41E-06	j4	carbaryl
1.58E+02	4.62E-04	1.08E-07	8.97E-07	1.00E-06	6.23E-09	1.61E-07	j4	carbofuran
2.46E+02	6.50E-05	8.39E-08	3.51E-06	3.59E-06	2.23E-08	5.74E-07	j4	propoxur
5.88E+04	4.36E-05	8.50E-09	4.17E-10	8.92E-09	5.53E-11	1.43E-09	j4	maneb **
4.92E+00	8.00E-07	2.98E-07	1.49E-05	8.00E-07	4.96E-09	1.28E-07	j2	atrazine
4.72E+02	8.61E+02	1.68E-01	2.76E-05	1.68E-01	1.04E-03	2.69E-02	j4	heptane
1.94E+06	4.11E+02	8.01E-02	2.75E-06	8.01E-02	4.97E-04	1.28E-02	j4	octane **
3.70E+03	3.29E+01	7.08E-03	2.24E-02	2.95E-02	1.83E-04	4.72E-03	j4	cyclohexanone
2.82E+02	2.33E-04	1.32E-07	5.19E-06	5.32E-06	3.30E-08	8.52E-07	j4	butylbenzylphtalic acid
8.89E+03	4.53E-04	1.06E-07	1.19E-06	1.29E-06	8.02E-09	2.07E-07	j4	di(2-ethylhexyl)phtalic acid **
1.24E+00	3.26E-01	6.35E-05	4.29E-07	6.39E-05	3.96E-07	1.02E-05	j4	pyridine
1.53E+02	9.00E+00	1.76E-03	6.20E-05	1.82E-03	1.13E-05	2.91E-04	j4	styrene
5.80E-01	4.23E+00	8.25E-04	1.C7E-07	8.26E-04	5.12E-06	1.32E-04	j4	tetrahydrofuran
1.00E+01	5.96E+00	1.16E-03	4.36E-07	1.16E-03	7.21E-06	1.86E-04	j4	tetrahydrothiophene

Table 9.4 Data on bioaccumulation factors and contents in crops calculated on the basis of formulas given in annex 1.5.

A content in the soil Cs [mg.kg^{-1}] equal to the proposed human toxicological C-standard value was chosen as basis for all calculations.

The indication ** behind the substance name means that given this content in the soil, water-solubility is exceeded.

Cdep : content in crop as a result of deposition [mg.subst.kg^{-1} dw crop]
BCFpl : bioconcentration factor plant [(mg subst.kg^{-1} dw crop)/(mg subst.kg dry soil)]
Cpl : content in crop [mg.kg^{-1} nw]
BCFr : bioconcentration factor root [(mg subst.kg^{-1} fresh crop)/(mg subst.dm^{-3} soil moisture)]
BCFs : bioconcentratie factor stem [(mg subst.kg^{-1} fresh crop)/(mg subst.dm^{-3} soil moisture)]
Croot : content in the roots [mg.kg^{-1} dw]
Cstem : content in leaf and stems [mg.kg^{-1} dw]

cs	bcfpl	bcfr	bcfs	croot	cstem	cdep	cpl	name
3.00E+02	3.00E-02	0.00E+00	0.00E+00	1.80E+00	1.80E+00	4.66E-02	1.82E+00	arsenic
6.98E+02	1.50E-01	0.00E+00	0.00E+00	2.09E+01	2.09E+01	1.09E-01	2.10E+01	barium
1.84E+00	3.00E+00	0.00E+00	0.00E+00	1.10E+00	1.10E+00	2.86E-04	1.10E+00	cadmium
2.14E+03	3.00E-02	0.00E+00	0.00E+00	1.28E+01	1.28E+01	3.33E-01	1.30E+01	chromium (III)
9.99E-02	3.00E-02	0.00E+00	0.00E+00	6.00E-04	6.00E-04	1.55E-05	6.07E-04	chromium (VI)
4.00E+02	3.00E-02	0.00E+00	0.00E+00	2.40E+00	2.40E+00	6.22E-02	2.43E+00	cobalt
5.02E+03	3.00E-01	0.00E+00	0.00E+00	3.01E+02	3.01E+02	7.81E-01	3.02E+02	copper
8.71E+01	3.00E-02	0.00E+00	0.00E+00	5.22E-01	5.22E-01	1.35E-02	5.29E-01	mercury
5.14E+02	3.00E-02	0.00E+00	0.00E+00	3.08E+00	3.08E+00	8.00E-02	3.12E+00	lead
3.68E+01	3.00E+00	0.00E+00	0.00E+00	2.21E+01	2.21E+01	5.73E-03	2.21E+01	molybdenum
1.79E+03	3.00E-01	0.00E+00	0.00E+00	1.08E+02	1.08E+02	2.79E-01	1.08E+02	nickel
5.71E+05	3.00E-02	0.00E+00	0.00E+00	3.43E+03	3.43E+03	8.88E+01	3.47E+03	tin
1.84E+03	3.00E+00	0.00E+00	0.00E+00	1.10E+03	1.10E+03	4.01E-02	1.10E+03	zinc
3.14E+02	0.00E+00	4.00E+00	4.00E+00	1.88E+03	1.88E+03	4.88E-02	1.88E+03	ammonium compounds
1.85E+02	0.00E+00	4.00E+00	4.00E+00	1.11E+03	1.11E+03	2.87E-02	1.11E+03	bromides
1.85E+01	0.00E+00	4.00E+00	4.00E+00	1.11E+02	1.11E+02	2.87E-03	1.11E+02	cyanides free
7.20E+00	0.00E+00	4.00E+00	4.00E+00	4.32E+01	4.32E+01	1.12E-03	4.32E+01	cyanides complex
1.29E+01	0.00E+00	4.00E+00	4.00E+00	7.75E+01	7.75E+01	2.01E-03	7.75E+01	fluorides
2.58E+04	0.00E+00	4.00E+00	4.00E+00	1.55E+05	1.55E+05	4.02E+00	1.55E+05	phosphates
1.00E+01	0.00E+00	4.00E+00	4.00E+00	6.00E+01	6.00E+01	1.56E-03	6.00E+01	sulfides
2.03E+00	0.00E+00	4.00E+00	4.00E+00	1.22E+01	1.22E+01	3.16E-04	1.22E+01	thiocyanates
1.89E+01	0.00E+00	2.14E+00	1.31E+00	3.18E+01	1.95E+01	2.94E-03	2.57E+01	benzene
2.63E+02	0.00E+00	8.86E+00	3.48E+00	1.98E+02	7.77E+01	4.09E-02	1.38E+02	ethylbenzene
6.29E+01	0.00E+00	1.22E+00	7.80E-01	2.08E+02	1.32E+02	9.79E-03	1.70E+02	phenol
8.44E+01	0.00E+00	1.87E+00	1.17E+00	1.65E+02	1.04E+02	1.31E-02	1.34E+02	cresol(p)
1.32E+02	0.00E+00	4.38E+00	2.25E+00	1.38E+02	7.10E+01	2.06E-02	1.05E+02	toluene
2.58E+01	0.00E+00	9.61E+00	3.64E+00	1.88E+01	7.11E+00	4.01E-03	1.30E+01	xylene(m)
2.83E+01	0.00E+00	9.64E-01	4.96E-01	1.40E+02	7.18E+01	4.41E-03	1.06E+02	catechol
1.37E+01	0.00E+00	9.40E-01	4.52E-01	7.07E+01	3.40E+01	2.14E-03	5.24E+01	resorcinol
1.64E+01	0.00E+00	9.00E-01	3.58E-01	9.10E+01	3.63E+01	2.56E-03	6.36E+01	hydroquinol
1.00E+01	0.00E+00	8.74E+01	6.39E+00	3.44E+00	2.52E-01	1.56E-03	1.85E+00	anthracene
1.01E+04	0.00E+00	6.31E+02	3.67E+00	6.31E+00	3.67E-02	1.58E+00	3.96E+00	benzo(a)anthracene **
1.09E+04	0.00E+00	5.56E+03	6.14E-01	3.35E+00	3.68E-04	1.70E+00	2.53E+00	benzo(k)fluoranthene **
9.96E+02	0.00E+00	2.34E+03	1.45E+00	7.03E-01	4.36E-04	1.55E-01	4.29E-01	benzo(a)pyrene **

cs	bcfpl	bcfr	bcfs	croot	cstem	cdep	cpl	name
3.92E+01	0.00E+00	3.92E+03	8.94E-01	4.28E+00	9.77E-04	6.10E-03	2.14E+00	chrysene
1.21E+02	0.00E+00	9.54E+01	6.37E+00	4.03E+01	2.69E+00	1.88E-02	2.15E+01	phenanthrene
1.96E+02	0.00E+00	3.85E+02	4.64E+00	4.29E+01	5.18E-01	3.05E-02	2.17E+01	fluoranthene
1.14E+04	0.00E+00	1.59E+04	1.68E-01	1.59E+00	1.68E-05	1.78E+00	1.68E+00	indene(1#2#3cd)pyrene **
1.18E+04	0.00E+00	1.26E+03	2.38E+00	3.28E-01	6.19E-04	1.83E+00	1.08E+00	benzo(ghi)perylene **
1.04E+03	0.00E+00	1.26E+03	2.38E+00	4.03E+01	7.62E-02	1.62E-01	2.03E+01	pyrene **
1.00E+01	0.00E+00	1.25E+01	4.14E+00	6.59E+00	2.18E+00	1.56E-03	4.39E+00	napthalene
1.82E+00	0.00E+00	1.21E+00	7.74E-01	5.98E+00	3.81E+00	2.83E-04	4.89E+00	1#2-dichloroethane
1.65E+01	0.00E+00	1.65E+00	1.06E+00	3.61E+01	2.31E+01	2.57E-03	2.96E+01	dichloromethane
8.12E-01	0.00E+00	4.08E+00	2.14E+00	8.59E-01	4.51E-01	1.26E-04	6.55E-01	tetrachloromethane
5.13E+00	0.00E+00	3.85E+00	2.05E+00	5.61E+00	2.99E+00	7.98E-04	4.30E+00	tetrachloroethene
1.16E+01	0.00E+00	1.81E+00	1.15E+00	2.28E+01	1.44E+01	1.80E-03	1.86E+01	trichloromethane
2.47E+02	0.00E+00	4.51E+00	2.29E+00	2.53E+02	1.29E+02	3.85E-02	1.91E+02	trichloroethene
4.00E-02	0.00E+00	4.51E+00	2.29E+00	3.28E-02	1.67E-02	6.22E-06	2.48E-02	vinyl chloride
5.88E-01	0.00E+00	5.22E+00	2.53E+00	5.63E-01	2.73E-01	9.15E-05	4.18E-01	monochlorobenzene
1.64E+00	0.00E+00	1.34E+01	4.27E+00	1.05E+00	3.37E-01	2.55E-04	6.96E-01	p-dichlorobenzene
3.81E+00	0.00E+00	4.12E+01	6.06E+00	1.66E+00	2.44E-01	5.93E-04	9.52E-01	trichlorobenzene(1#2#4)
6.64E+00	0.00E+00	1.26E+02	6.22E+00	2.04E+00	1.00E-01	1.03E-03	1.07E+00	tetrachlorobenzene(1#2#3#4)
8.83E+00	0.00E+00	2.90E+02	5.15E+00	2.10E+00	3.74E-02	1.37E-03	1.07E+00	pentachlorobenzene
9.85E+00	0.00E+00	3.91E+02	4.61E+00	2.14E+00	2.52E-02	1.53E-03	1.09E+00	hexachlorobenzene
5.78E+00	0.00E+00	2.91E+00	1.67E+00	7.82E+00	4.49E+00	8.99E-04	6.15E+00	monochlorophenol (2)
1.22E+01	0.00E+00	8.86E+00	3.48E+00	9.20E+00	3.61E+00	1.90E-03	6.41E+00	dichlorophenol (2#4)
2.24E+01	0.00E+00	3.02E+01	5.68E+00	1.08E+01	2.04E+00	3.49E-03	6.44E+00	trichlorophenol (2#3#4)
1.43E+01	0.00E+00	1.23E+01	4.11E+00	9.45E+00	3.16E+00	2.22E-03	6.30E+00	tetrachlorophenol (2#3#4#5)
5.21E+02	0.00E+00	2.70E+02	5.27E+00	1.27E+02	2.48E+00	8.10E-02	6.47E+01	pentachlorophenol
1.00E+01	0.00E+00	2.86E+01	5.60E+00	4.91E+00	9.60E-01	1.56E-03	2.94E+00	chloronaphthalene
3.07E+00	0.00E+00	6.20E+02	3.71E+00	5.82E-01	3.48E-03	4.78E-04	2.93E-01	trichlorobiphenyl (2#5#2#)
5.11E+00	0.00E+00	3.46E+03	1.01E+00	5.79E-01	1.69E-04	7.95E-04	2.90E-01	hexachlorobipenyl
1.04E+04	0.00E+00	1.73E+03	1.87E+00	5.37E+00	5.80E-03	1.62E+00	3.50E+00	DDT **
3.45E+03	0.00E+00	7.81E+02	3.26E+00	3.12E+01	1.30E-01	5.37E-01	1.60E+01	DDE **
5.77E+00	0.00E+00	1.51E+04	1.80E-01	4.21E-01	5.05E-06	8.98E-04	2.11E-01	aldrin
2.00E+00	0.00E+00	4.06E+02	4.54E+00	4.30E-01	4.81E-03	3.11E-04	2.18E-01	dieldrin
1.58E+00	0.00E+00	1.96E+02	5.76E+00	4.23E-01	1.24E-02	2.46E-04	2.18E-01	endrin
6.63E+00	0.00E+00	2.29E+01	5.25E+00	3.51E+00	8.05E-01	1.03E-03	2.16E+00	HCH
1.86E+02	0.00E+00	4.13E+02	4.51E+00	3.99E+01	4.36E-01	2.90E-02	2.02E+01	carbaryl
1.56E+02	0.00E+00	1.96E+02	5.76E+00	4.23E+01	1.24E+00	2.45E-02	2.18E+01	carbofuran
2.46E+02	0.00E+00	9.71E+01	6.37E+00	8.17E+01	5.36E+00	3.82E-02	4.35E+01	propoxur
5.88E+04	0.00E+00	1.59E+04	1.68E-01	1.59E+00	1.68E-05	9.15E+00	5.37E+00	maneb **
4.92E+00	0.00E+00	2.26E+00	1.37E+00	8.07E+00	4.90E+00	7.65E-04	6.48E+00	atrazine
4.72E+02	0.00E+00	3.23E+01	5.77E+00	2.14E+02	3.83E+01	7.35E-02	1.26E+02	heptane
1.94E+06	0.00E+00	8.00E+01	6.40E+00	5.28E+01	4.22E+00	3.02E+02	1.80E+02	octane **
3.70E+03	0.00E+00	1.59E+00	1.02E+00	8.57E+03	5.51E+03	5.76E-01	7.04E+03	cyclohexanone
2.82E+02	0.00E+00	8.00E+01	6.40E+00	9.97E+01	7.98E+00	4.39E-02	5.39E+01	butylbenzylphtalic acid
8.89E+03	0.00E+00	2.65E+02	5.30E+00	7.56E+01	1.51E+00	1.38E+00	3.93E+01	di(2-ethylhexyl)phtalic acid **
1.24E+00	0.00E+00	9.01E+00	3.51E+00	9.27E-01	3.62E-01	1.93E-04	6.45E-01	pyridine
1.53E+02	0.00E+00	8.05E+00	3.30E+00	1.20E+02	4.91E+01	2.38E-02	8.45E+01	styrene
5.80E-01	0.00E+00	9.30E+00	3.57E+00	3.73E-01	1.43E-01	9.03E-05	2.58E-01	tetrahydrofuran
1.00E+01	0.00E+00	4.12E+01	6.06E+00	4.31E+00	6.33E-01	1.56E-03	2.47E+00	tetrahydrothiophene

Table 9.5 Data with reference to exposure via drinking water, calculated on the basis of formulas in annexes 1.6, 1.7 and 1.8.
A content in the soil Cs [mg.kg^{-1}] equal to the proposed human toxicological C-standard value was chosen as basis for all calculations.
The indication ** behind the substance name means that given this content in the soil, water-solubility is exceeded.

Cdw	: 24-hrs mean drinking water concentration	[mg.dm^{-3}]
kwa	: degree of evaporation of the contaminant	[-]
Cbk	: concentration in the bathroom air	g subst. m^{-3}]
DAR	: dermal absorption velocity according to Fiserova-Bergerova and Pierce (1989): (0.038 + 0.153 * Kow) * exp (-0.016 * M) /1.5	[(mg.m^{-2})/(mg.dm^{-3}).h^{-1}]

cs	cdw	kwa	cbk	DAR	name
3.00E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	arsenic
6.96E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	barium
1.84E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	cadmium
2.14E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	chromium (III)
9.99E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	chromium (VI)
4.00E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	cobalt
5.02E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	copper
8.71E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	mercury
5.14E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	lead
3.68E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	molybdenum
1.79E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	nickel
5.71E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	tin
1.84E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	zinc
3.14E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ammonium compounds
1.85E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	bromides
1.85E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	cyanides free
7.20E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	cyanides complex
1.29E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	fluorides
2.58E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	phosphates
1.00E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	sulfides
2.03E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	thiocyanates
1.89E+01	9.50E-02	2.36E-01	6.73E-05	3.94E+00	benzene
2.63E+02	2.14E-01	2.10E-01	1.35E-04	2.70E+01	ethylbenzene
6.29E+01	6.59E-04	2.56E-04	5.06E-10	6.59E-01	phenol
8.44E+01	4.03E-01	1.87E-04	2.26E-07	1.81E+00	cresol(p)
1.32E+02	1.73E-01	2.21E-01	1.15E-04	1.17E+01	toluene
2.58E+01	1.43E-02	2.07E-01	8.85E-06	3.02E+01	xylene(m)
2.83E+01	6.61E-02	2.51E-04	4.98E-08	1.37E-01	catechol
1.37E+01	3.43E-02	1.35E-04	1.39E-08	1.10E-01	resorcinol
1.64E+01	4.61E-02	1.91E-03	2.65E-07	6.66E-02	hydroquinol
1.00E+01	6.97E-05	1.85E-03	4.99E-10	9.39E+01	anthracene
1.01E+04	9.12E-06	6.72E-04	1.84E-11	8.04E+01	benzo(a)anthracene **
1.09E+04	5.47E-07	5.58E-06	9.17E-15	5.89E+01	benzo(k)fluoranthene **
9.96E+02	2.74E-07	5.62E-05	4.61E-14	5.83E+01	benzo(a)pyrene **
3.92E+01	9.97E-07	2.12E-04	6.35E-13	8.62E+01	chrysene
1.21E+02	9.64E-04	1.62E-03	4.68E-09	9.95E+01	phenanthrene
1.96E+02	1.02E-04	9.99E-04	3.05E-10	1.14E+02	fluoranthene
1.14E+04	9.12E-08	3.51E-05	9.60E-15	4.02E+01	indene(1#2#3cd)pyrene **

cs	cdw	kwa	cbk	DAR	name
1.18E+04	2.37E-07	1.35E-05	9.57E-15	3.90E+01	benzo(ghi)perylene **
1.04E+03	2.92E-05	9.38E-08	8.22E-15	1.27E+02	pyrene **
1.00E+01	1.20E-03	5.15E-02	1.86E-07	2.73E+01	napthalene
1.82E+00	6.73E-03	1.72E-01	3.47E-06	5.94E-01	1#2-dichloroethane
1.65E+01	4.99E-02	2.11E-01	3.16E-05	1.94E+00	dichloromethane
8.12E-01	7.69E-04	1.76E-01	4.06E-07	3.74E+00	tetrachloromethane
5.13E+00	5.12E-03	1.69E-01	2.60E-06	2.83E+00	tetrachloroethene
1.16E+01	5.75E-02	1.86E-01	3.21E-05	1.41E+00	trichloromethane
2.47E+02	4.10E-01	1.87E-01	2.31E-04	6.28E+00	trichloroethene
4.00E-02	3.32E-05	2.79E-01	2.78E-08	1.90E+01	vinyl chloride
5.88E-01	1.72E-03	1.89E-01	9.75E-07	1.07E+01	monochlorobenzene
1.64E+00	7.20E-04	1.64E-01	3.54E-07	2.26E+01	p-dichlorobenzene
3.81E+00	1.84E-04	1.42E-01	7.85E-08	4.75E+01	trichlorobenzene(1#2#4)
6.64E+00	7.35E-05	8.24E-02	1.82E-08	6.37E+01	tetrachlorobenzene(1#2#3#4)
8.83E+00	3.31E-05	1.17E-01	1.16E-08	4.96E+01	pentachlorobenzene
9.85E+00	2.50E-05	1.48E-02	1.11E-09	3.03E+01	hexachlorobenzene
5.78E+00	5.88E-05	3.39E-03	5.99E-10	3.18E+00	monochlorophenol (2)
1.22E+01	4.73E-04	2.96E-03	4.20E-09	1.02E+01	dichlorophenol (2#4)
2.24E+01	8.84E-04	1.02E-03	2.70E-09	2.66E+01	trichlorophenol (2#3#4)
1.43E+01	3.51E-03	1.31E-03	1.37E-08	5.22E+00	tetrachlorophenol (2#3#4#5)
5.21E+02	4.80E-03	1.38E-03	1.98E-08	3.77E+01	pentachlorophenol
1.00E+01	3.91E-04	1.01E-01	1.19E-07	4.41E+01	chloronaphthalene
3.07E+00	2.14E-06	3.93E-03	2.52E-11	5.00E+01	trichlorobiphenyl (2#5#2#)
5.11E+00	1.53E-07	5.07E-02	2.32E-11	1.02E+01	hexachlorobipenyl
1.04E+04	7.07E-06	1.13E-02	2.39E-10	1.12E+01	DDT **
3.45E+03	9.12E-05	4.81E-04	1.32E-10	1.94E+01	DDE **
5.77E+00	6.38E-08	9.31E-02	1.78E-11	9.68E+00	aldrin
2.00E+00	2.42E-06	3.79E-04	2.75E-12	6.57E+00	dieldrin
1.58E+00	4.92E-06	2.11E-03	3.11E-11	4.53E+00	endrin
6.63E+00	3.50E-04	3.89E-04	4.08E-10	4.38E+00	HCH
1.86E+02	8.82E-05	1.52E-01	4.03E-08	1.17E+02	carbaryl
1.58E+02	1.96E-04	6.25E-03	3.68E-09	7.10E+01	carbofuran
2.46E+02	7.68E-04	2.35E-04	5.41E-10	6.12E+01	propoxur
5.88E+04	9.12E-08	1.23E-01	3.37E-11	4.80E+01	maneb **
4.92E+00	3.26E-03	6.82E-07	6.66E-12	4.90E-01	atrazine
4.72E+02	1.21E-01	2.23E-01	8.10E-05	1.41E+02	heptane
1.94E+06	1.02E-02	2.11E-01	6.47E-06	2.62E+02	octane **
3.70E+03	4.90E+01	1.72E-02	2.53E-03	1.44E+00	cyclohexanone
2.82E+02	1.14E-02	5.65E-04	1.93E-08	1.04E+01	butylbenzylphtalic acid
8.89E+03	2.60E-03	4.64E-03	3.62E-08	5.21E+00	di(2-ethylhexyl)phtalic acid **
1.24E+00	9.39E-04	2.43E-01	6.83E-07	3.99E+01	pyridine
1.53E+02	1.36E+01	1.94E-01	7.90E-05	2.29E+01	styrene
5.80E-01	3.65E-04	2.60E-01	2.85E-07	4.66E+01	tetrahydrofuran
1.00E+01	9.54E-04	2.35E-01	6.73E-07	2.12E+02	tetrahydrothiophene

Table 9.6 Contributions in percentages of the various exposure routes for adults (a) and children (c); the exposure has been calculated on the basis of the formulas in annex 1.8.
A content in the soil Cs [mg.kg^{-1}] equal to the proposed human toxicological C-standard value was chosen as basis for all calculations.
The indication ** behind the substance name means that given this content in the soil, water-solubility is exceeded.

DI	: uptake via soil-ingestion	[mg.kg^{-1}.d^{-1}]
DA	: uptake via dermal contact with soil	[mg.kg^{-1}.d^{-1}]
IP	: uptake of inhaled soil particles	[mg.kg^{-1}.d^{-1}]
IV	: uptake of contaminant via vapours	[mg.kg^{-1}.d^{-1}]
i	: indoor	
o	: outdoor	
VI	: uptake of contaminant via crop	[mg.kg^{-1}.d^{-1}]
DIw	: uptake of contaminated drinking water via drinking	[mg.kg^{-1}.d^{-1}]
IVw	: uptake of contaminant by inhaling vapour during showering	[mg.kg^{-1}.d^{-1}]
TAD	: daily exposure adult	[mg.kg^{-1}.d^{-1}]
TCH	: daily exposure child	[mg.kg^{-1}.d^{-1}]

cs	perc. contrib. route adult									perc. contrib. route child									
	iva	ipa	ivwa	dia	via	diwa	daa	dawa	tad	ivc	ipc	ivwc	dic	vic	diwc	dac	dawc	tch	name
3.00E+02	0	0	0	13	87	0	0	0	1.67E-03	0	0	0	45	55	0	0	0	6.65E-03	arsenic
6.98E+02	0	0	0	3	97	0	0	0	1.73E-02	0	0	0	14	86	0	0	0	4.89E-02	barium
1.84E+00	0	0	0	0	100	0	0	0	8.85E-04	0	0	0	1	99	0	0	0	2.23E-03	cadmium
2.14E+03	0	0	0	13	87	0	0	0	1.20E-02	0	0	0	45	55	0	0	0	4.75E-02	chromium (III)
9.99E-02	0	0	0	13	67	0	0	0	5.58E-07	0	0	0	45	55	0	0	0	2.22E-06	chromium (VI)
4.00E+02	0	0	0	13	87	0	0	0	2.23E-03	0	0	0	45	55	0	0	0	8.86E-03	cobalt
5.02E+03	0	0	0	1	99	0	0	0	2.45E-01	0	0	0	8	92	0	0	0	6.54E-01	copper
8.71E+01	0	0	0	13	87	0	0	0	4.86E-04	0	0	0	45	55	0	0	0	1.93E-03	mercury
5.14E+02	0	0	0	13	87	0	0	0	2.87E-03	0	0	0	45	55	0	0	0	1.14E-02	lead
3.68E+01	0	0	0	0	100	0	0	0	1.77E-02	0	0	0	1	99	0	0	0	4.45E-02	molybdenum
1.79E+03	0	0	0	1	99	0	0	0	8.75E-02	0	0	0	8	92	0	0	0	2.33E-01	nickel
5.71E+05	0	0	0	13	87	0	0	0	3.19E+00	0	0	0	45	55	0	0	0	1.27E+01	tin
1.84E+03	0	0	0	0	100	0	0	0	8.85E-01	0	0	0	1	99	0	0	0	2.23E+00	zinc
3.14E+02	0	0	0	0	100	0	0	0	1.51E+00	0	0	0	0	100	0	0	0	3.77E+00	ammonium compounds
1.85E+02	0	0	0	0	100	0	0	0	8.86E-01	0	0	0	0	100	0	0	0	2.22E+00	bromides
1.85E+01	0	0	0	0	100	0	0	0	8.86E-02	0	0	0	0	100	0	0	0	2.22E-01	cyanides free
7.20E+00	0	0	0	0	100	0	0	0	3.46E-02	0	0	0	0	100	0	0	0	8.64E-02	cyanides complex
1.29E+01	0	0	0	0	100	0	0	0	6.20E-02	0	0	0	0	100	0	0	0	1.55E-01	fluorides
2.56E+04	0	0	0	0	100	0	0	0	1.24E+02	0	0	0	0	100	0	0	0	3.10E+02	phosphates
2.03E+00	0	0	0	0	100	0	0	0	9.75E-03	0	0	0	0	100	0	0	0	2.44E-02	thiocyanates
1.89E+01	84	0	0	0	13	2	0	0	1.54E-01	82	0	0	0	15	2	0	1	3.44E-01	benzene
2.63E+02	65	0	0	0	30	2	0	3	3.67E-01	62	0	0	0	33	2	0	3	8.44E-01	ethylbenzene
6.29E+01	15	0	0	0	85	0	0	0	1.60E-01	13	0	0	0	67	0	0	0	3.93E-01	phenol
8.44E+01	9	0	0	0	81	9	0	1	1.33E-01	8	0	0	0	82	8	0	1	3.28E-01	cresol(p)
1.32E+02	76	0	0	0	22	1	0	1	3.88E-01	73	0	0	0	24	1	0	1	8.79E-01	toluene
2.58E+01	56	0	0	0	38	2	0	3	2.69E-02	53	0	0	0	41	2	0	3	6.27E-02	xylene(m)
2.83E+01	19	0	0	0	79	2	0	0	1.07E-01	17	0	0	0	61	2	0	0	2.61E-01	catechol
1.37E+01	20	0	0	0	78	2	0	0	5.34E-02	18	0	0	0	80	2	0	0	1.30E-01	resorcinol

cs	perc. contrib. route adult									perc. contrib. route child									
	iva	ipa	ivwa	dia	via	diwa	daa	dawa	tad	ivc	ipc	ivwc	dic	vic	diwc	dac	dawc	tch	name
1.64E+01	22	0	0	0	76	2	0	0	6.68E-02	20	0	0	0	78	2	0	0	1.62E-01	hydroquinol
1.01E+04	0	1	0	65	28	0	7	0	1.12E-02	0	0	0	89	7	0	4	0	1.14E-01	benzo(a)anthracene **
1.09E+04	0	1	0	73	19	0	7	0	1.07E-02	0	0	0	92	4	0	4	0	1.19E-01	benzo(k)fluoranthene **
9.96E+02	0	1	0	63	30	0	6	0	1.13E-03	0	0	0	89	8	0	3	0	1.12E-02	benzo(a)pyrene **
3.92E+01	0	0	0	2	98	0	0	0	1.75E-03	0	0	0	8	91	0	0	0	4.70E-03	chrysene
1.21E+02	0	0	0	0	98	0	0	1	1.76E-02	0	0	0	3	95	0	0	1	4.51E-02	phenanthrene
1.96E+02	0	0	0	1	99	0	0	0	1.76E-02	0	0	0	4	95	0	0	0	4.56E-02	fluoranthene
1.14E+04	0	1	0	78	13	0	8	0	1.04E-02	0	0	0	93	3	0	4	0	1.22E-01	indene(1#2#3cd)pyrene
1.18E+04	0	1	0	82	8	0	8	0	1.02E-02	0	0	0	94	2	0	4	0	1.25E-01	benzo(ghi)perylene **
1.04E+03	0	0	0	4	95	0	0	0	1.71E-02	0	0	0	20	79	0	1	0	5.14E-02	pyrene **
1.82E+00	67	0	0	0	31	2	0	0	1.26E-02	64	0	0	0	34	2	0	0	2.89E-02	1#2-dichloroethane
1.65E+01	76	0	0	0	22	1	0	0	1.08E-01	74	0	0	0	24	1	0	0	2.45E-01	dichloromethane
8.12E-01	92	0	0	0	7	0	0	0	7.25E-03	91	0	0	1	8	0	0	0	1.60E-02	tetrachloromethane
5.13E+00	92	0	0	0	8	0	0	0	4.35E-02	91	0	0	0	9	0	0	0	9.64E-02	tetrachloroethene
1.16E+01	79	0	0	0	18	2	0	0	8.13E-02	77	0	0	0	20	2	0	0	1.83E-01	trichloromethane
2.47E+02	82	0	0	0	16	1	0	1	9.76E-01	80	0	0	0	17	1	0	1	2.19E+00	trichloroethene
4.00E-02	99	0	0	0	1	0	0	0	3.18E-03	99	0	0	0	1	0	0	0	6.96E-03	vinyl chloride
5.88E-01	52	0	1	0	37	5	0	4	8.98E-04	49	0	0	0	40	5	0	5	2.09E-03	monochlorobenzene
1.64E+00	31	0	0	0	62	2	0	4	8.92E-04	28	0	0	1	65	2	0	4	2.15E-03	p-dichlorobenzene
3.81E+00	11	0	0	0	86	1	0	2	8.86E-04	10	0	0	2	86	1	0	2	2.22E-03	trichlorobenzene(1#2#4)
6.64E+00	1	0	0	1	97	0	0	1	8.82E-04	1	0	0	3	95	0	0	1	2.26E-03	tetrachlorobenzene(1#2#3#4)
8.83E+00	1	0	0	1	97	0	0	0	8.81E-04	1	0	0	4	94	0	0	0	2.27E-03	pentachlorobenzene
9.85E+00	0	0	0	1	99	0	0	0	8.80E-04	0	0	0	4	95	0	0	0	2.28E-03	hexachlorobenzene
5.78E+00	7	0	0	0	92	0	0	0	5.32E-03	7	0	0	0	93	0	0	0	1.32E-02	monochlorophenol (2)
1.22E+01	3	0	0	0	96	0	0	0	5.31E-03	2	0	0	1	96	0	0	0	1.33E-02	dichlorophenol (2#4)
2.24E+01	1	0	0	0	97	0	0	1	5.30E-03	1	0	0	2	96	0	0	1	1.34E-02	trichlorophenol (2#3#4)
1.43E+01	2	0	0	0	95	2	0	1	5.31E-03	2	0	0	1	94	2	0	1	1.33E-02	tetrachlorophenol (2#3#4#5)
5.21E+02	0	0	0	1	98	0	0	1	5.28E-02	0	0	0	4	95	0	0	1	1.36E-01	pentachlorophenol
3.07E+00	0	0	0	1	99	0	0	0	2.37E-04	0	0	0	5	95	0	0	0	6.19E-04	trichlorobiphenyl(2#5#2#)
5.11E+00	0	0	0	2	98	0	0	0	2.36E-04	0	0	0	8	92	0	0	0	6.33E-04	hexachlorobipenyl
1.04E+04	0	1	0	67	25	0	7	0	1.11E-02	0	0	0	90	6	0	4	0	1.15E-01	DDT **
3.45E+03	0	0	0	16	82	0	2	0	1.55E-02	0	0	0	51	47	0	2	0	6.78E-02	DDE **
5.77E+00	0	0	0	2	97	0	0	0	1.74E-04	0	0	0	12	88	0	0	0	4.82E-04	aldrin
2.00E+00	0	0	0	1	99	0	0	0	1.76E-04	0	0	0	4	95	0	0	0	4.57E-04	dieldrin
1.58E+00	0	0	0	1	99	0	0	0	1.76E-04	0	0	0	3	96	0	0	0	4.54E-04	endrin
6.63E+00	1	0	0	0	98	1	0	0	1.77E-03	1	0	0	1	97	1	0	0	4.47E-03	HCH
1.86E+02	7	0	0	1	92	0	0	0	1.76E-02	6	0	0	4	89	0	0	0	4.52E-02	carbaryl
1.58E+02	0	0	0	1	99	0	0	0	1.76E-02	0	0	0	3	96	0	0	0	4.54E-02	carbofuran
2.46E+02	0	0	0	0	99	0	0	0	3.53E-02	0	0	0	3	96	0	0	0	9.02E-02	propoxur
5.88E+04	0	1	0	82	8	0	8	0	5.10E-02	0	0	0	94	2	0	4	0	6.23E-01	maneb **
4.92E+00	0	0	0	0	98	2	0	0	5.32E-03	0	0	0	0	97	2	0	0	1.33E-02	atrazine
4.72E+02	98	0	0	0	2	0	0	1	5.62E+00	97	0	0	0	2	0	0	1	1.24E+01	heptane
1.94E+06	61	0	0	32	3	0	3	0	4.31E+00	22	0	0	74	1	0	3	0	2.63E+01	octane **
3.70E+03	12	0	0	0	69	17	0	2	8.19E+00	11	0	0	0	71	16	0	2	2.00E+01	cyclohexanone
2.82E+02	0	0	0	0	98	1	0	1	4.41E-02	0	0	0	3	96	1	0	1	1.13E-01	butylbenzylphtalic acid
8.89E+03	0	0	0	16	81	0	2	0	3.86E-02	0	0	0	52	46	0	2	0	1.71E-01	di(2-ethylhexyl)phtalic
1.24E+00	77	0	0	0	19	1	0	3	2.71E-03	75	0	0	0	21	1	0	3	6.12E-03	pyridine
1.53E+02	43	0	0	0	49	3	0	5	1.38E-01	40	0	0	0	52	3	0	5	3.26E-01	styrene
5.80E-01	99	0	0	0	1	0	0	0	2.72E-02	99	0	0	0	1	0	0	0	5.97E-02	tetrahydrofuran

Table 9.7 Absolute contributions of the various exposure routes to the total dose for adults; the exposure has been calculated on the basis of formulas in annex 1.8.
A content in the soil Cs [mg.kg^{-1}] equal to the proposed human toxicological C-standard value was chosen as basis for all calculations.
The indication ** behind the substance name means that given this content in the soil, water-solubility is exceeded.

DI : intake via soil-ingestion [mg.kg^{-1}.d^{-1}]
DA : intake via dermal contact with soil [mg.kg^{-1}.d^{-1}]
IP : intake of inhaled soil particles [mg.kg^{-1}.d^{-1}]
IV : intake op contminant via vapours [mg.kg^{-1}.d^{-1}]
i : indoor
o : outdoor
VI : intake of contaminant via crop [mg.kg^{-1}.d^{-1}]
DIw : intake by drinking of contaminated drinking water [mg.kg^{-1}.d^{-1}]
IVw : intake of contaminant by inhaling vapour during showering [mg.kg^{-1}.d^{-1}]

TAD : daily exposure adult [mg.kg^{-1}.d^{-1}]
TCH : daily exposure child [mg.kg^{-1}.d^{-1}]

cs	ivai	ivao	ipa	ivwa	dia	via	diwa	daa	dawa	tad	name
3.00E+02	0.00E+00	0.00E+00	2.14E-06	0.00E+00	2.14E-04	1.46E-03	0.00E+00	0.00E+00	0.00E+00	1.67E-03	arsenic
6.98E+02	0.00E+00	0.00E+00	4.98E-06	0.00E+00	4.98E-04	1.68E-02	0.00E+00	0.00E+00	0.00E+00	1.73E-02	barium
1.84E+00	0.00E+00	0.00E+00	1.31E-08	0.00E+00	1.31E-06	8.84E-04	0.00E+00	0.00E+00	0.00E+00	8.85E-04	cadmium
2.14E+03	0.00E+00	0.00E+00	1.53E-05	0.00E+00	1.53E-03	1.04E-02	0.00E+00	0.00E+00	0.00E+00	1.20E-02	chromium (III)
9.99E-02	0.00E+00	0.00E+00	7.14E-10	0.00E+00	7.14E-08	4.86E-07	0.00E+00	0.00E+00	0.00E+00	5.58E-07	chromium (VI)
4.00E+02	0.00E+00	0.00E+00	2.85E-06	0.00E+00	2.85E-04	1.94E-03	0.00E+00	0.00E+00	0.00E+00	2.23E-03	cobalt
5.02E+03	0.00E+00	0.00E+00	3.59E-05	0.00E+00	3.59E-03	2.41E-01	0.00E+00	0.00E+00	0.00E+00	2.45E-01	copper
8.71E+01	0.00E+00	0.00E+00	6.22E-07	0.00E+00	6.22E-05	4.23E-04	0.00E+00	0.00E+00	0.00E+00	4.86E-04	mercury
5.14E+02	0.00E+00	0.00E+00	3.67E-06	0.00E+00	3.67E-04	2.50E-03	0.00E+00	0.00E+00	0.00E+00	2.87E-03	lead
3.68E+01	0.00E+00	0.00E+00	2.63E-07	0.00E+00	2.63E-05	1.77E-02	0.00E+00	0.00E+00	0.00E+00	1.77E-02	molybdenum
1.79E+03	0.00E+00	0.00E+00	1.28E-05	0.00E+00	1.28E-03	8.62E-02	0.00E+00	0.00E+00	0.00E+00	8.75E-02	nickel
5.71E+05	0.00E+00	0.00E+00	4.08E-03	0.00E+00	4.08E-01	2.78E+00	0.00E+00	0.00E+00	0.00E+00	3.19E+00	tin
1.84E+03	0.00E+00	0.00E+00	1.25E-05	0.00E+00	1.31E-03	8.84E-01	0.00E+00	0.00E+00	0.00E+00	8.85E-01	zinc
3.14E+02	0.00E+00	0.00E+00	2.24E-06	0.00E+00	2.24E-04	1.51E+00	0.00E+00	0.00E+00	0.00E+00	1.51E+00	ammoniumcompounds
1.85E+02	0.00E+00	0.00E+00	1.32E-06	0.00E+00	1.32E-04	8.86E-01	0.00E+00	0.00E+00	0.00E+00	8.86E-01	bromides
1.85E+01	0.00E+00	0.00E+00	1.32E-07	0.00E+00	1.32E-05	8.86E-02	0.00E+00	0.00E+00	0.00E+00	8.86E-02	cyanides free
7.20E+00	0.00E+00	0.00E+00	5.14E-08	0.00E+00	5.14E-06	3.45E-02	0.00E+00	0.00E+00	0.00E+00	3.46E-02	cyanides complex
1.29E+01	0.00E+00	0.00E+00	9.23E-08	0.00E+00	9.23E-06	6.20E-02	0.00E+00	0.00E+00	0.00E+00	6.20E-02	fluorides
2.58E+04	0.00E+00	0.00E+00	1.85E-04	0.00E+00	1.85E-02	1.24E+02	0.00E+00	0.00E+00	0.00E+00	1.24E+02	phosphates
1.00E+01	0.00E+00	0.00E+00	7.14E-08	0.00E+00	7.14E-06	4.80E-02	0.00E+00	0.00E+00	0.00E+00	4.80E-02	sulfides
2.03E+00	0.00E+00	0.00E+00	1.45E-08	0.00E+00	1.45E-06	9.74E-03	0.00E+00	0.00E+00	0.00E+00	9.75E-03	thiocyanates
1.89E+01	1.29E-01	1.16E-04	1.35E-07	4.00E-04	1.35E-05	2.05E-02	2.72E-03	1.37E-06	7.36E-04	1.54E-01	benzene
2.63E+02	2.38E-01	2.14E-04	1.88E-06	8.01E-04	1.88E-04	1.10E-01	6.11E-03	1.92E-05	1.17E-02	3.67E-01	ethylbenzene
6.29E+01	2.39E-02	2.15E-05	4.50E-07	3.01E-09	4.50E-05	1.36E-01	1.88E-05	4.59E-06	1.12E-06	1.60E-01	phenol
8.44E+01	1.24E-02	1.11E-05	6.03E-07	1.35E-06	6.03E-05	1.07E-01	1.15E-02	6.15E-06	1.88E-03	1.33E-01	cresol(p)
1.32E+02	2.94E-01	2.65E-04	9.45E-07	6.84E-04	9.45E-05	8.38E-02	4.94E-03	9.64E-06	4.04E-03	3.88E-01	toluene
2.58E+01	1.52E-02	1.37E-05	1.84E-07	5.27E-05	1.84E-05	1.04E-02	4.08E-04	1.88E-06	8.78E-04	2.59E-02	xylene(m)
2.83E+01	2.03E-02	1.83E-05	2.02E-07	2.96E-07	2.02E-05	8.46E-02	1.89E-03	2.06E-06	2.33E-05	1.07E-01	catechol
1.37E+01	1.05E-02	9.47E-06	9.82E-08	8.28E-08	9.82E-06	4.19E-02	9.80E-04	1.00E-06	9.70E-06	5.34E-02	resorcinol
1.64E+01	1.45E-02	1.31E-05	1.17E-07	1.58E-06	1.17E-05	5.09E-02	1.32E-03	1.20E-06	7.89E-06	6.68E-02	hydroquinol

cs	ivai	ivao	ipa	ivwa	dia	via	diwa	daa	dawa	tad	name
1.00E+01	5.62E-06	5.06E-09	7.14E-08	2.97E-09	7.14E-06	1.46E-03	2.56E-06	7.29E-07	2.16E-05	1.51E-03	anthracene
1.01E+04	1.40E-06	1.26E-09	7.25E-05	1.10E-10	7.25E-03	3.17E-03	2.61E-07	7.39E-04	1.88E-06	1.12E-02	benzo(a)anthracene
1.09E+04	3.59E-08	3.23E-11	7.82E-05	5.46E-14	7.82E-03	2.02E-03	1.56E-08	7.98E-04	8.28E-08	1.07E-02	benzo(k)fluoranthene
9.96E+02	4.16E-08	3.74E-11	7.12E-06	2.75E-13	7.12E-04	3.43E-04	7.82E-09	7.26E-05	4.10E-08	1.13E-03	benzo(a)pyrene **
3.92E+01	1.52E-07	1.37E-10	2.80E-07	3.78E-12	2.80E-05	1.72E-03	2.85E-08	2.86E-06	2.21E-07	1.75E-03	chrysene
1.21E+02	6.01E-05	5.41E-08	8.61E-07	2.78E-08	8.61E-05	1.72E-02	2.75E-05	8.78E-06	2.46E-04	1.76E-02	phenanthrene
1.95E+02	1.57E-05	1.41E-08	1.40E-06	1.82E-09	1.40E-04	1.74E-02	2.91E-06	1.43E-05	2.99E-05	1.76E-02	fluoranthene
1.14E+04	1.38E-08	1.25E-11	8.16E-05	5.71E-14	8.16E-03	1.35E-03	2.61E-09	8.32E-04	9.44E-09	1.04E-02	indene(1#2#3cd)pyrene
1.18E+04	3.60E-08	3.24E-11	8.40E-05	5.70E-14	8.40E-03	8.63E-04	6.78E-09	8.57E-04	2.38E-08	1.02E-02	benzo(ghi)perylene
1.04E+03	3.22E-08	2.89E-11	7.43E-06	4.89E-14	7.43E-04	1.62E-02	8.34E-07	7.58E-05	9.57E-06	1.71E-02	pyrene **
1.00E+01	1.51E-04	1.36E-07	7.14E-08	1.10E-06	7.14E-06	3.51E-03	3.44E-05	7.29E-07	8.00E-05	3.78E-03	napthalene
1.82E+00	8.46E-03	7.61E-06	1.30E-08	2.06E-05	1.30E-06	3.91E-03	1.92E-04	1.33E-07	8.52E-06	1.26E-02	1#2-dichlo roethane
1.65E+01	8.27E-02	7.44E-05	1.18E-07	1.88E-04	1.18E-05	2.37E-02	1.43E-03	1.20E-06	1.97E-04	1.08E-01	dichloromethane
8.12E-01	6.68E-03	6.02E-06	5.80E-09	2.42E-06	5.80E-07	5.24E-04	2.20E-05	5.92E-08	6.10E-06	7.25E-03	tetrachloromethane
5.13E+00	3.96E-02	3.58E-05	3.67E-08	1.55E-05	3.67E-06	3.44E-03	1.46E-04	3.74E-07	3.09E-05	4.35E-02	tetrachloroethene
1.16E+01	6.43E-02	5.79E-05	8.27E-08	1.91E-04	8.27E-06	1.49E-02	1.64E-03	8.43E-07	1.69E-04	6.13E-02	trichloromethane
2.47E+02	8.04E-01	7.23E-04	1.77E-06	1.37E-03	1.77E-04	1.53E-01	1.17E-02	1.80E-05	5.39E-03	9.76E-01	trichloroethene
4.00E-02	3.15E-03	2.84E-06	2.86E-10	1.66E-07	2.86E-08	1.98E-05	9.49E-07	2.91E-09	1.17E-06	3.16E-03	vinyl chloride
5.88E-01	4.69E-04	4.22E-07	4.20E-09	5.81E-06	4.20E-07	3.34E-04	4.92E-05	4.28E-08	3.83E-05	8.98E-04	monochlorobenzene
1.64E+00	2.76E-04	2.48E-07	1.17E-08	2.11E-06	1.17E-06	5.57E-04	2.06E-05	1.20E-07	3.51E-05	8.92E-04	p-dichlorobenzene
3.81E+00	9.60E-05	8.64E-08	2.72E-08	4.67E-07	2.72E-06	7.62E-04	5.25E-06	2.77E-07	1.92E-05	8.86E-04	trichlorobenzene(1#2#4)
6.64E+00	8.36E-06	7.52E-09	4.74E-08	1.08E-07	4.74E-06	8.55E-04	2.10E-06	4.84E-07	1.10E-05	8.82E-04	tetrachlorobenzene(1#2#3
8.83E+00	1.18E-05	1.07E-08	6.31E-08	6.91E-08	6.31E-06	8.57E-04	9.46E-07	6.43E-07	3.73E-06	8.81E-04	pentachlorobenzene
9.85E+00	9.47E-07	8.53E-10	7.04E-08	6.58E-09	7.04E-06	8.68E-04	7.14E-07	7.18E-07	1.92E-06	8.80E-04	hexachlorobenzene
5.78E+00	3.94E-04	3.54E-07	4.13E-08	3.56E-09	4.13E-06	4.92E-03	1.68E-06	4.21E-07	4.80E-07	5.32E-03	monochlorophenol
1.22E+01	1.51E-04	1.36E-07	8.71E-08	2.50E-08	8.71E-06	5.13E-03	1.35E-05	8.88E-07	1.24E-05	5.31E-03	dichlorophenol (2#4)
2.24E+01	5.06E-05	4.55E-08	1.60E-07	1.61E-08	1.60E-05	5.15E-03	2.53E-05	1.63E-06	6.05E-05	5.30E-03	trichlorophenol (2#3#4)
1.43E+01	1.09E-04	9.77E-08	1.02E-07	8.17E-08	1.02E-05	5.04E-03	1.00E-04	1.04E-06	4.70E-05	5.31E-03	tetrachlorophenol (2#3#4
5.21E+02	6.63E-05	5.97E-08	3.72E-06	1.18E-07	3.72E-04	5.18E-02	1.37E-04	3.79E-05	4.65E-04	5.28E-02	pentachlorophenol
1.00E+01	1.11E-04	9.97E-08	7.14E-08	7.06E-07	7.14E-06	2.35E-03	1.12E-05	7.29E-07	3.96E-05	2.52E-03	chloronaphthalene
3.07E+00	1.38E-07	1.24E-10	2.19E-08	1.50E-10	2.19E-06	2.34E-04	6.11E-08	2.24E-07	2.74E-07	2.37E-04	trichlorobiphenyl (2#5#2#
5.11E+00	5.45E-08	4.91E-11	3.65E-08	1.38E-10	3.65E-06	2.32E-04	4.36E-09	3.72E-07	3.82E-09	2.36E-04	hexachlorobipenyl
1.04E+04	5.09E-07	4.58E-10	7.43E-05	1.42E-09	7.43E-03	2.80E-03	2.02E-07	7.58E-04	2.02E-07	1.11E-02	DDT **
3.45E+03	5.56E-06	5.01E-09	2.47E-05	7.84E-10	2.47E-03	1.28E-02	2.61E-06	2.51E-04	4.55E-06	1.55E-02	DDE **
5.77E+00	3.17E-08	2.85E-11	4.12E-08	1.06E-10	4.12E-06	1.69E-04	1.82E-09	4.21E-07	1.44E-09	1.74E-04	aldrin
2.00E+00	1.47E-07	1.32E-10	1.43E-08	1.64E-11	1.43E-06	1.74E-04	6.91E-08	1.46E-07	4.08E-08	1.76E-04	dieldrin
1.58E+00	3.07E-07	2.76E-10	1.13E-08	1.85E-10	1.13E-06	1.74E-04	1.40E-07	1.15E-07	5.72E-08	1.76E-04	endrin
6.63E+00	2.13E-05	1.92E-08	4.74E-08	2.43E-09	4.74E-06	1.73E-03	9.99E-06	4.83E-07	3.94E-06	1.77E-03	HCH
1.86E+02	1.31E-03	1.18E-06	1.33E-06	2.40E-07	1.33E-04	1.62E-02	2.52E-06	1.36E-05	2.26E-05	1.76E-02	carbaryl
1.58E+02	3.28E-05	2.95E-08	1.13E-06	2.19E-08	1.13E-04	1.74E-02	5.61E-06	1.15E-05	3.56E-05	1.76E-02	carbofuran
2.46E+02	1.17E-04	1.05E-07	1.75E-06	3.22E-09	1.75E-04	3.48E-02	2.19E-05	1.79E-05	1.21E-04	3.53E-02	propoxur
5.88E+04	2.91E-07	2.62E-10	4.20E-04	2.01E-10	4.20E-02	4.30E-03	2.61E-09	4.28E-03	9.87E-09	5.10E-02	maneb **
4.92E+00	2.61E-05	2.35E-08	3.51E-08	3.96E-11	3.51E-06	5.19E-03	9.30E-05	3.56E-07	4.10E-06	5.32E-03	atrazine
4.72E+02	5.48E+00	4.93E-03	3.37E-06	4.82E-04	3.37E-04	1.01E-01	3.46E-03	3.44E-05	3.41E-02	5.62E+00	heptane
1.94E+06	2.61E+00	2.35E-03	1.39E-02	3.85E-05	1.39E+00	1.44E-01	2.92E-04	1.42E-01	5.45E-03	4.31E+00	octane **
3.70E+03	9.61E-01	8.65E-04	2.65E-05	1.51E-02	2.65E-03	5.63E+00	1.40E+00	2.70E-04	1.78E-01	8.19E+00	cyclohexanone
2.82E+02	1.74E-04	1.56E-07	2.02E-06	1.15E-07	2.02E-04	4.31E-02	3.25E-04	2.06E-05	3.03E-04	4.41E-02	butylbenzylphtalic
8.89E+03	4.22E-05	3.80E-08	6.35E-05	2.15E-07	6.35E-03	3.14E-02	7.43E-05	6.48E-04	3.47E-05	3.86E-02	di(2-ethylhexyl)phtalic
1.24E+00	2.08E-03	1.88E-06	8.88E-09	4.07E-06	8.88E-07	5.16E-04	2.68E-05	9.06E-08	7.30E-05	2.71E-03	pyridine
1.53E+02	5.93E-02	5.34E-05	1.09E-06	4.70E-04	1.09E-04	6.76E-02	3.88E-03	1.11E-05	6.44E-03	1.38E-01	styrene
5.80E-01	2.69E-02	2.42E-05	4.14E-09	1.70E-06	4.14E-07	2.06E-04	1.04E-05	4.23E-08	3.24E-05	2.72E-02	tetrahydrofuran
1.00E+01	3.79E-02	3.41E-05	7.14E-08	4.01E-06	7.14E-06	1.98E-03	2.72E-05	7.29E-07	3.98E-04	4.04E-02	tetrahydrothiophene

Table 9.8 Absolute contributions of the various exposure routes to the total dose for children; the exposure has been calculated on the basis of formulas in annex 1.8.
A content in the soil Cs [mg.kg^{-1}] equal to the proposed human toxicological C-standard value was chosen as basis for all calculations.
The indication ** behind the substance name means that given this content in the soil, water-solubility is exceeded.

DI	: intake via soil-ingestion	[mg.kg^{-1}.d^{-1}]
DA	: intake via dermal contact with soil	[mg.kg^{-1}.d^{-1}]
IP	: intake of inhaled soil particles	[mg.kg^{-1}.d^{-1}]
IV	: intake op contminant via vapours	[mg.kg^{-1}.d^{-1}]
i	: indoor	
o	: outdoor	
VI	: intake of contaminant via crop	[mg.kg^{-1}.d^{-1}]
DIw	: intake by drinking of contaminated drinking water	[mg.kg^{-1}.d^{-1}]
IVw	: intake of contaminant by inhaling vapour during showering	[mg.kg^{-1}.d^{-1}]
TAD	: daily exposure adult	[mg.kg^{-1}.d^{-1}]
TCH	: daily exposure child	[mg.kg^{-1}.d^{-1}]

cs	ivci	ivco	ipc	ivwc	dic	vic	diwc	dac	dawc	tch	name
3.00E+02	0.00E+00	0.00E+00	4.00E-06	0.00E+00	3.00E-03	3.64E-03	0.00E+00	0.00E+00	0.00E+00	6.65E-03	arsenic
6.98E+02	0.00E+00	0.00E+00	9.30E-06	0.00E+00	6.98E-03	4.20E-02	0.00E+00	0.00E+00	0.00E+00	4.89E-02	barium
1.84E+00	0.00E+00	0.00E+00	2.45E-08	0.00E+00	1.84E-05	2.21E-03	0.00E+00	0.00E+00	0.00E+00	2.23E-03	cadmium
2.14E+03	0.00E+00	0.00E+00	2.85E-05	0.00E+00	2.14E-02	2.60E-02	0.00E+00	0.00E+00	0.00E+00	4.75E-02	chromium (III)
9.99E-02	0.00E+00	0.00E+00	1.33E-09	0.00E+00	9.99E-07	1.21E-06	0.00E+00	0.00E+00	0.00E+00	2.22E-06	chromium (VI)
4.00E+02	0.00E+00	0.00E+00	5.33E-06	0.00E+00	4.00E-03	4.86E-03	0.00E+00	0.00E+00	0.00E+00	8.86E-03	cobalt
5.02E+03	0.00E+00	0.00E+00	6.70E-05	0.00E+00	5.02E-02	6.03E-01	0.00E+00	0.00E+00	0.00E+00	6.54E-01	copper
8.71E+01	0.00E+00	0.00E+00	1.16E-06	0.00E+00	8.71E-04	1.06E-03	0.00E+00	0.00E+00	0.00E+00	1.93E-03	mercury
5.14E+02	0.00E+00	0.00E+00	6.85E-06	0.00E+00	5.14E-03	6.25E-03	0.00E+00	0.00E+00	0.00E+00	1.14E-02	lead
3.68E+01	0.00E+00	0.00E+00	4.91E-07	0.00E+00	3.68E-04	4.42E-02	0.00E+00	0.00E+00	0.00E+00	4.45E-02	molybdenum
1.79E+03	0.00E+00	0.00E+00	2.39E-05	0.00E+00	1.79E-02	2.15E-01	0.00E+00	0.00E+00	0.00E+00	2.33E-01	nickel
5.71E+05	0.00E+00	0.00E+00	7.61E-03	0.00E+00	5.71E+00	6.94E+00	0.00E+00	0.00E+00	0.00E+00	1.27E+01	tin
1.84E+03	0.00E+00	0.00E+00	2.88E-05	0.00E+00	1.84E-02	2.21E+00	0.00E+00	0.00E+00	0.00E+00	2.23E+00	zinc
3.14E+02	0.00E+00	0.00E+00	4.18E-06	0.00E+00	3.14E-03	3.76E+00	0.00E+00	0.00E+00	0.00E+00	3.77E+00	ammoniumcompounds
1.85E+02	0.00E+00	0.00E+00	2.46E-06	0.00E+00	1.85E-03	2.21E+00	0.00E+00	0.00E+00	0.00E+00	2.22E+00	bromides
1.85E+01	0.00E+00	0.00E+00	2.46E-07	0.00E+00	1.85E-04	2.21E-01	0.00E+00	0.00E+00	0.00E+00	2.22E-01	cyanides free
7.20E+00	0.00E+00	0.00E+00	9.60E-08	0.00E+00	7.20E-05	8.64E-02	0.00E+00	0.00E+00	0.00E+00	8.64E-02	cyanides complex
1.29E+01	0.00E+00	0.00E+00	1.72E-07	0.00E+00	1.29E-04	1.55E-01	0.00E+00	0.00E+00	0.00E+00	1.55E-01	fluorides
2.58E+04	0.00E+00	0.00E+00	3.44E-04	0.00E+00	2.58E-01	3.10E+02	0.00E+00	0.00E+00	0.00E+00	3.10E+02	phosphates
1.00E+01	0.00E+00	0.00E+00	1.33E-07	0.00E+00	1.00E-04	1.20E-01	0.00E+00	0.00E+00	0.00E+00	1.20E-01	sulfides
2.03E+00	0.00E+00	0.00E+00	2.71E-08	0.00E+00	2.03E-05	2.44E-02	0.00E+00	0.00E+00	0.00E+00	2.44E-02	thiocyanates
1.89E+01	2.83E-01	7.15E-04	2.52E-07	7.10E-04	1.89E-04	5.14E-02	6.34E-03	7.42E-06	1.81E-03	3.44E-01	benzene
2.63E+02	5.20E-01	1.32E-03	3.51E-06	1.42E-03	2.63E-03	2.76E-01	1.43E-02	1.03E-04	2.69E-02	8.44E-01	ethylbenzene
6.29E+01	5.22E-02	1.32E-04	8.39E-07	5.34E-09	6.29E-04	3.40E-01	4.39E-05	2.48E-05	2.75E-06	3.93E-01	phenol
8.44E+01	2.71E-02	6.85E-05	1.13E-06	2.39E-06	8.44E-04	2.69E-01	2.69E-02	3.32E-05	4.62E-03	3.28E-01	cresol(p)
1.32E+02	6.44E-01	1.63E-03	1.76E-06	1.21E-03	1.32E-03	2.09E-01	1.15E-02	5.21E-05	9.95E-03	8.79E-01	toluene
2.58E+01	3.32E-02	8.41E-05	3.44E-07	9.34E-05	2.58E-04	2.59E-02	9.52E-04	1.01E-05	2.16E-03	6.27E-02	xylene(m)
2.83E+01	4.44E-02	1.12E-04	3.78E-07	5.25E-07	2.83E-04	2.11E-01	4.40E-03	1.11E-05	5.75E-05	2.61E-01	catechol
1.37E+01	2.30E-02	5.82E-05	1.83E-07	1.47E-07	1.37E-04	1.05E-01	2.29E-03	5.41E-06	2.39E-05	1.30E-01	resorcinol
1.64E+01	3.18E-02	8.05E-05	2.19E-07	2.79E-06	1.64E-04	1.27E-01	3.08E-03	6.46E-06	1.94E-05	1.62E-01	hydroquinol

cs	ivai	ivao	ipa	ivwa	dia	via	diwa	daa	dawa	tad	name
1.00E+01	1.23E-05	3.11E-08	1.33E-07	5.27E-09	1.00E-04	3.69E-03	5.98E-06	3.93E-06	5.33E-05	3.87E-03	anthracene
1.01E+04	3.06E-06	7.75E-09	1.35E-04	1.94E-10	1.01E-01	7.93E-03	6.08E-07	3.99E-03	4.64E-06	1.14E-01	benzo(a)anthracene
1.09E+04	7.85E-08	1.99E-10	1.46E-04	9.68E-14	1.09E-01	5.05E-03	3.65E-08	4.31E-03	2.04E-07	1.19E-01	benzo(k)fluoranthene
9.96E+02	9.09E-08	2.30E-10	1.33E-05	4.87E-13	9.96E-03	8.58E-04	1.82E-08	3.92E-04	1.01E-07	1.12E-02	benzo(a)pyrene **
3.92E+01	3.32E-07	8.41E-10	5.23E-07	6.70E-12	3.92E-04	4.29E-03	6.65E-08	1.54E-05	5.44E-07	4.70E-03	chrysene
1.21E+02	1.32E-04	3.33E-07	1.61E-06	4.93E-08	1.21E-03	4.30E-02	6.43E-05	4.74E-05	6.06E-04	4.51E-02	phenanthrene
1.96E+02	3.44E-05	8.70E-08	2.62E-06	3.22E-09	1.96E-03	4.35E-02	6.79E-06	7.72E-05	7.35E-05	4.56E-02	fluoranthene
1.14E+04	3.03E-08	7.66E-11	1.52E-04	1.01E-13	1.14E-01	3.37E-03	6.08E-09	4.49E-03	2.32E-08	1.22E-01	indene(1#2#3cd)pyrene
1.18E+04	7.87E-08	1.99E-10	1.57E-04	1.01E-13	1.18E-01	2.16E-03	1.58E-08	4.62E-03	5.86E-08	1.25E-01	benzo(ghi)perylene
1.04E+03	7.04E-08	1.78E-10	1.39E-05	8.67E-14	1.04E-02	4.05E-02	1.95E-06	4.09E-04	2.36E-05	5.14E-02	pyrene **
1.00E+01	3.30E-04	8.34E-07	1.33E-07	1.96E-06	1.00E-04	8.77E-03	8.02E-05	3.93E-06	1.97E-04	9.49E-03	napthalene
1.82E+00	1.85E-02	4.68E-05	2.43E-08	3.66E-05	1.82E-05	9.79E-03	4.49E-04	7.16E-07	2.10E-05	2.89E-02	1#2-dichlo roethane
1.65E+01	1.81E-01	4.58E-04	2.20E-07	3.33E-04	1.65E-04	5.93E-02	3.33E-03	6.49E-06	4.84E-04	2.45E-01	dichloromethane
8.12E-01	1.46E-02	3.70E-05	1.08E-08	4.29E-06	8.12E-06	1.31E-03	5.13E-05	3.19E-07	1.50E-05	1.60E-02	tetrachloromethane
5.13E+00	8.70E-02	2.20E-04	6.84E-08	2.75E-05	5.13E-05	8.61E-03	3.41E-04	2.02E-06	7.61E-05	9.64E-02	tetrachloroethene
1.16E+01	1.41E-01	3.56E-04	1.54E-07	3.39E-04	1.16E-04	3.73E-02	3.83E-03	4.55E-06	4.16E-04	1.83E-01	trichloromethane
2.47E+02	1.76E+00	4.45E-03	3.30E-06	2.43E-03	2.47E-03	3.82E-01	2.73E-02	9.73E-05	1.33E-02	2.19E+00	trichloroethene
4.00E-02	6.89E-03	1.74E-05	5.33E-10	2.94E-07	4.00E-07	4.95E-05	2.21E-06	1.57E-08	2.87E-06	6.96E-03	vinyl chloride
5.88E-01	1.03E-03	2.60E-06	7.84E-09	1.03E-05	5.88E-06	8.36E-04	1.15E-04	2.31E-07	9.44E-05	2.09E-03	monochlorobenzene
1.64E+00	6.04E-04	1.53E-06	2.19E-08	3.74E-06	1.64E-05	1.39E-03	4.80E-05	6.46E-07	8.64E-05	2.15E-03	p-dichlorobenzene
3.81E+00	2.10E-04	5.32E-07	5.08E-08	8.29E-07	3.81E-05	1.90E-03	1.23E-05	1.50E-06	4.74E-05	2.22E-03	trichlorobenzene(1#2#4)
6.64E+00	1.83E-05	4.63E-08	8.85E-08	1.92E-07	6.64E-05	2.14E-03	4.90E-06	2.61E-06	2.72E-05	2.26E-03	tetrachlorobenzene(1#2#3
8.83E+00	2.59E-05	6.55E-08	1.18E-07	1.23E-07	8.83E-05	2.14E-03	2.21E-06	3.47E-06	9.19E-06	2.27E-03	pentachlorobenzene
9.85E+00	2.07E-06	5.24E-09	1.31E-07	1.17E-08	9.85E-05	2.17E-03	1.67E-06	3.87E-06	4.73E-06	2.28E-03	hexachlorobenzene
5.78E+00	8.61E-04	2.18E-06	7.70E-08	6.32E-09	5.78E-05	1.23E-02	3.92E-06	2.27E-06	1.18E-06	1.32E-02	monochlorophenol
1.22E+01	3.30E-04	8.35E-07	1.63E-07	4.43E-08	1.22E-04	1.28E-02	3.16E-05	4.79E-06	3.04E-05	1.33E-02	dichlorophenol (2#4)
2.24E+01	1.11E-04	2.80E-07	2.99E-07	2.85E-08	2.24E-04	1.29E-02	5.90E-05	8.82E-06	1.49E-04	1.34E-02	trichlorophenol (2#3#4)
1.43E+01	2.38E-04	6.01E-07	1.90E-07	1.45E-07	1.43E-04	1.26E-02	2.34E-04	5.61E-06	1.16E-04	1.33E-02	tetrachlorophenol (2#3#4
5.21E+02	1.45E-04	3.67E-07	6.94E-06	2.09E-07	5.21E-03	1.29E-01	3.20E-04	2.05E-04	1.15E-03	1.36E-01	pentachlorophenol
1.00E+01	2.42E-04	6.13E-07	1.33E-07	1.25E-06	1.00E-04	5.87E-03	2.61E-05	3.93E-06	9.81E-05	6.35E-03	chloronaphthalene
3.07E+00	3.01E-07	7.63E-10	4.09E-08	2.66E-10	3.07E-05	5.86E-04	1.43E-07	1.21E-06	6.75E-07	6.19E-04	trichlorobiphenyl (2#5#2#
5.11E+00	1.19E-07	3.02E-10	6.81E-08	2.45E-10	5.11E-05	5.80E-04	1.02E-08	2.01E-06	9.40E-09	6.33E-04	hexachlorobipenyl
1.04E+04	1.11E-06	2.82E-09	1.39E-04	2.53E-09	1.04E-01	7.00E-03	4.71E-07	4.09E-03	4.97E-07	1.15E-01	DDT **
3.45E+03	1.22E-05	3.08E-08	4.60E-05	1.39E-09	3.45E-02	3.19E-02	6.08E-06	1.36E-03	1.12E-05	6.78E-02	DDE **
5.77E+00	6.93E-08	1.75E-10	7.70E-08	1.88E-10	5.77E-05	4.22E-04	4.25E-09	2.27E-06	3.55E-09	4.82E-04	aldrin
2.00E+00	3.22E-07	8.14E-10	2.66E-08	2.91E-11	2.00E-05	4.35E-04	1.61E-07	7.86E-07	1.01E-07	4.57E-04	dieldrin
1.58E+00	6.71E-07	1.70E-09	2.11E-08	3.28E-10	1.58E-05	4.36E-04	3.28E-07	6.21E-07	1.41E-07	4.54E-04	endrin
6.63E+00	4.66E-05	1.18E-07	8.84E-08	4.30E-09	6.63E-05	4.32E-03	2.33E-05	2.61E-06	9.70E-06	4.47E-03	HCH
1.86E+02	2.86E-03	7.23E-06	2.48E-06	4.25E-07	1.86E-03	4.04E-02	5.88E-06	7.33E-05	5.56E-05	4.52E-02	carbaryl
1.58E+02	7.17E-05	1.81E-07	2.10E-06	3.89E-08	1.58E-03	4.36E-02	1.31E-05	6.20E-05	8.78E-05	4.54E-02	carbofuran
2.46E+02	2.56E-04	6.48E-07	3.27E-06	5.71E-09	2.46E-03	8.71E-02	5.12E-05	9.66E-05	2.98E-04	9.02E-02	propoxur
5.88E+04	6.36E-07	1.61E-09	7.84E-04	3.56E-10	5.88E-01	1.07E-02	6.08E-09	2.31E-02	2.43E-08	6.23E-01	maneb **
4.92E+00	5.70E-05	1.44E-07	6.56E-08	7.03E-11	4.92E-05	1.30E-02	2.17E-04	1.93E-06	1.01E-05	1.33E-02	atrazine
4.72E+02	1.20E+01	3.03E-02	6.30E-06	8.55E-04	4.72E-03	2.53E-01	8.06E-03	1.86E-04	8.39E-02	1.24E+01	heptane
1.94E+06	5.71E+00	1.45E-02	2.59E-02	6.83E-05	1.94E+01	3.59E-01	6.82E-04	7.64E-01	1.34E-02	2.63E+01	octane **
3.70E+03	2.10E+00	5.32E-03	4.94E-05	2.67E-02	3.70E-02	1.41E+01	3.27E+00	1.46E-03	4.39E-01	2.00E+01	cyclohexanone
2.82E+02	3.80E-04	9.61E-07	3.76E-06	2.03E-07	2.82E-03	1.08E-01	7.58E-04	1.11E-04	7.45E-04	1.13E-01	butylbenzylphtalic
8.89E+03	9.23E-05	2.33E-07	1.19E-04	3.82E-07	8.89E-02	7.85E-02	1.73E-04	3.50E-03	8.54E-05	1.71E-01	di(2-ethylhexyl)phtalic
1.24E+00	4.56E-03	1.15E-05	1.66E-08	7.21E-06	1.24E-05	1.29E-03	6.26E-05	4.89E-07	1.80E-04	6.12E-03	pyridine
1.53E+02	1.30E-01	3.28E-04	2.04E-06	8.34E-04	1.53E-03	1.69E-01	9.05E-03	6.00E-05	1.59E-02	3.26E-01	styrene
5.80E-01	5.89E-02	1.49E-04	7.73E-09	3.01E-06	5.80E-06	5.16E-04	2.44E-05	2.28E-07	7.98E-05	5.97E-02	tetrahydrofuran
1.00E+01	8.29E-02	2.10E-04	1.33E-07	7.11E-06	1.00E-04	4.94E-03	6.36E-05	3.93E-06	9.79E-04	8.92E-02	tetrahydrothiophene