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Environmental risk limits for various chlorobenzenes

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This investigation has been performed by order and for the account of the Ministry of Housing, Spatial Planning and the Environment, Directorate-General for Environmental Protection, Directorate of Environmental Safety and Risk Management, within the framework of the project 'Standard setting for other relevant substances within the International and National Environmental Quality Standards for Substances in the Netherlands (INS)'

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Abstract

Environmental Risk Limits for several chlorobenzenes

This report documents the derivation of environmental risk limits for several chlorobenzenes in water, groundwater, soil and air. The following substances were selected: monochlorobenzene, dichlorobenzenes and tetrachlorobenzenes. Chlorobenzenes are used as intermediates in the production of other substances. High concentrations of chlorobenzenes are hazardous to the environment.

For deriving the ERLs, RIVM used up-to-date ecotoxicological data in combination with the methodology as required by the European Water Framework Directive. The newly derived ERLs are lower than earlier derived ERLs. However, monitoring data from the river Rhine in the period 2001 – 2006 show only few cases of exceedance of the new ERLs.
ERLs were not derived for the sediment compartment, because sorption to sediment is below the trigger value to derive such risk limits.

Based on the comparable ecotoxicity of the individual isomers of dichlorobenzenens and tetrachlorobenzenes, ERLs for these substances were derived based on combined datasets and the use of sum limits is proposed. The respective chlorobenzenes may occur simultaneously in the environment and an additive effect cannot be excluded.

Environmental risk limits form the scientific basis on which the Interdepartmental Steering Group for substances sets environmental quality standards. The government uses these quality standards for carrying out the national policy concerning substances and the European Water Framework Directive.

Key words:
environmental risk limits, maximum permissible concentration, maximum acceptable concentration, monochlorobenzene, dichlorobenzene, tetrachlorobenzene

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Rapport in het kort

Milieurisicogrenzen voor verscheidene chloorbenzenen

Het RIVM heeft milieurisicogrenzen afgeleid voor een serie chloorbenzenen in water, grondwater, bodem en lucht. De groep stoffen omvat monochloorbenzeen, dichloorbenzenen en tetrachloorbenzenen. Ze worden gebruikt als tussenproduct om andere stoffen te maken. Te hoge concentraties van deze stoffen zijn schadelijk voor het milieu.

Voor dit onderzoek zijn actuele ecotoxicologische gegevens gebruikt, gecombineerd met de methodiek die is voorgeschreven door de Europese Kaderrichtlijn Water (KRW). De nieuwe milieurisicogrenzen zijn lager dan de nu geldende afgeleide normen. Dit komt omdat nu niet alleen de directe schadelijke effecten zijn onderzocht, maar ook de indirecte effecten op mensen en op vogels en zoogdieren door het eten van vis. Tussen 2001 en 2006 zijn de stoffen een enkele keer aangetroffen in de Rijn, maar het is niet waarschijnlijk dat de nieuw afgeleide risicogrenzen langdurig zijn overschreden.
Voor de waterbodem zijn geen milieurisicogrenzen afgeleid, omdat de stoffen naar verwachting nauwelijks aan de waterbodem binden.

Normaal gesproken worden de milieurisicogrenzen afgeleid op basis van de eigenschappen van individuele stoffen. Van de di- en tetrachloorbenzenen bestaan echter verschillende vormen die gelijktijdig voorkomen en een vergelijkbare toxiciteit hebben. Daarom is voor deze stoffen een zogeheten somnorm afgeleid, die voorkomt dat de effecten van individuele stoffen worden gestapeld. Deze somnorm is gebaseerd op de *gezamenlijke* gegevens en effecten van vergelijkbare stoffen.

Milieurisicogrenzen zijn niet bindend, maar zijn de wetenschappelijke basis waarop de Nederlandse Interdepartementale Stuurgroep Stoffen de milieukwaliteitsnormen vaststelt. De overheid hanteert deze normen bij de uitvoering van het nationale stoffenbeleid en de KRW.

Trefwoorden:
milieurisicogrenzen, MTR, MAC, dichloorbenzeen, tetrachloorbenzeen

Preface

The goal of this report is to derive risk limits that protect both man and the environment. This is done in accordance with the methodology of the Water Framework Directive (WFD) that is incorporated in the present INS methodology, following the Guidance for the derivation of environmental risk limits within the INS framework (Van Vlaardingen and Verbruggen, 2007).

The results presented in this report have been discussed by the members of the scientific advisory group for the project 'International and National Environmental Quality Standards for Substances in the Netherlands' (WK-INS). This advisory group provides non binding scientific advice on the final draft of a report in order to advise the Dutch Steering Group for Substances on the scientific merits of the report.

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Summary

Environmental risk limits are derived using ecotoxicological, physico-chemical and human toxicological data. They represent environmental concentrations of a substance offering different levels of protection to man and ecosystems. It should be noted that the ERLs are scientifically derived values. They serve as advisory values for the Dutch Steering Group for Substances, which was appointed to set the Environmental Quality Standards (EQSs) from these ERLs. ERLs should thus be considered as preliminary values that do not have official status.

In this report, the risk limits negligible concentration (NC), maximum permissible concentration (MPC), maximum acceptable concentration for ecosystems (MAC_{eco}) and serious risk concentration for ecosystems (SRC_{eco}) are derived for monochlorobenzene, dichlorobenzenes (1,2-dichlorobenzene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene) and tetrachlorobenzenes (1,2,3,4-tetrachlorobenzene, 1,2,3,5-tetrachlorobenzene and 1,2,4,5-tetrachlorobenzene) in water, groundwater, soil and air. No risk limits were derived for the sediment compartment because the triggers to derive such limits were not met.

For the derivation of the MPC and MAC_{eco} for water, the methodology used is in accordance with the Water Framework Directive. This methodology is based on the Technical Guidance Document on risk assessment for new and existing substances and biocides (European Commission (Joint Research Centre), 2003). For the NC and the SRC_{eco}, the guidance developed for the project ‘International and National Environmental Quality Standards for Substances in the Netherlands’ was used (Van Vlaardingen and Verbruggen, 2007). An overview of the derived environmental risk limits is given in Table 1.

Because of the small difference in the toxicity of the individual isomers, the risk limits for di- and tetrachlorobenzenes refer to a sum limit. In this approach, the sum of the concentrations of the individual di- or tetrachlorobenzenes should not exceed the ERLs for the group. It should be noted that the sum limit only applies when all isomers are monitored. Furthermore, chlorobenzenes may occur simultaneously in the environment and they are considered to have additive effects. Therefore, a toxic unit approach is recommended when monitoring data are compared with risk limits.

Table 1. Derived NC, MPC, MAC_{eco}, and SRC_{eco} values.

ERL	Unit	Substance	NC	MPC	MAC_{eco}	SRC_{eco}
Water	µg/L	monochlorobenzene	0.32	32	40	1.9×10^{3}
Marine	µg/L	monochlorobenzene	3.2×10^{-2}	3.2	4.0	1.9×10^{3}
Soil	µg/kg	monochlorobenzene	4.3	4.3×10^{2}	n.a.	2.6×10^{4}
Groundwater	µg/L	monochlorobenzene	0.32	32	n.a.	1.9×10^{3}
Air	µg/m^3	monochlorobenzene	n.a.	5.0×10^{2}	n.a	n.a.
Drinking water	µg/L	monochlorobenzene	n.a.	2.1×10^{2}	n.a.	n.a.
Water	µg/L	dichlorobenzenes	6.9×10^{-2}	6.9	20	6.8×10^{2}
Marine	µg/L	dichlorobenzenes	2.0×10^{-2}	2.0	2.0	6.8×10^{2}
Soil	µg/kg	dichlorobenzenes	3.1	3.1×10^{2}	n.a.	2.0×10^{4}
Groundwater	µg/L	dichlorobenzenes	0.20	20	n.a.	6.8×10^{2}
Air	µg/m^3	dichlorobenzenes	n.a.	n.d.	n.a.	n.a.
Drinking water	µg/L	dichlorobenzenes	n.a.	3.8×10^{2}	n.a.	n.a.
Water	µg/L	tetrachlorobenzenes	1.6×10^{-5}	1.6×10^{-3}	0.13	58
Marine	µg/L	tetrachlorobenzenes	1.6×10^{-5}	1.6×10^{-3}	1.3×10^{-2}	58
Soil	µg/kg	tetrachlorobenzenes	2.6×10^{-2}	2.6	n.a.	2.5×10^{4}
Groundwater	µg/L	tetrachlorobenzenes	4.6×10^{-3}	0.46	n.a.	58
Air	µg/m^3	tetrachlorobenzenes	n.a.	n.d.	n.a.	n.a.
Drinking water	µg/L	tetrachlorobenzenes	n.a.	0.74	n.a.	n.a.

n.d. = not derived.

n.a. = not applicable.

1 Introduction

1.1 Project framework

In this report, environmental risk limits (ERLs) for surface water (freshwater and marine), soil, groundwater and air are derived for monochlorobenzene, dichlorobenzenes (1,2-dichlorobenzene, 1,3-dichlorobenzene and 1,4-dichlorobenzene) and tetrachlorobenzenes (1,2,3,4-tetrachlorobenzene, 1,2,3,5-tetrachlorobenzene and 1,2,4,5-tetrachlorobenzene). The following ERLs are considered (VROM, 2004):

- Negligible Concentration (NC) – concentration at which effects to ecosystems are expected to be negligible and functional properties of ecosystems must be safeguarded fully. It defines a safety margin which should exclude combination toxicity. The NC is derived by dividing the MPC (see next bullet) by a factor of 100.
- Maximum Permissible Concentration (MPC) – concentration in an environmental compartment at which:
  1. no effect to be rated as negative is to be expected for ecosystems;

  2a no effect to be rated as negative is to be expected for humans (for non-carcinogenic substances);

  2b for humans, no more than a probability of 10^{-6} per year of death can be calculated (for carcinogenic substances). Within the scope of the Water Framework Directive, a probability of 10^{-6} on a life-time basis is used.

Within the scope of the Water Framework Directive, the AA-EQS (equivalent to the MPC) specifically refers to long-term exposure.

- Maximum Acceptable Concentration (MAC_{eco}) – concentration protecting aquatic ecosystems for effects due to short-term exposure or concentration peaks.
- Serious Risk Concentration (SRC_{eco}) – concentration at which possibly serious ecotoxicological effects are to be expected.

These ERLs serve as advisory values that are used by the Steering Group for Substances to set environmental quality standards (EQS) for various policy purposes. EQSs are all legally and non legally binding standards that are used in Dutch environmental policy.

1.2 Selection of substances

ERLs are derived for several chlorobenzenes (Table 2), which are selected by the Netherlands in the scope of '(Inter)national and National Environmental Quality Standards for Substances in the Netherlands' (INS).

Table 2. Selected compounds.

Compound	CAS number
monochlorobenzene	108-90-7
1,2-dichlorobenzene	95-50-1
1,3-dichlorobenzene	541-73-1
1,4-dichlorobenzene	106-46-7
1,2,3,4-tetrachlorobenzene	634-66-2
1,2,3,5-tetrachlorobenzene	634-90-2
1,2,4,5-tetrachlorobenzene	95-94-3

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2 Methods

2.1 Guidance followed for this project

In this report ERLs are derived following the methodology of the project 'International and National Environmental Quality Standards for Substances in the Netherlands' (INS). This INS-guidance by Van Vlaardingen and Verbruggen (2007) is in accordance with the guidance by Lepper (2005), which forms part of the Priority Substances Daughter Directive (2006/0129 (COD)) amending the Water Framework Directive (2000/60/EC).
The WFD guidance applies to the derivation of ERLs for water and sediment, for both the freshwater and marine compartment. The WFD guidance introduces a new ERL, which is the Maximum Acceptable Concentration (MAC_{eco}), a concentration that protects aquatic ecosystems from adverse effects caused by short-term exposure or concentration peaks.
Further, two MPC values are considered for the water compartment that are based on a human toxicological risk limit (TL_{hh}), which might be an ADI or TDI, etc. Discerned are (1) the $MPC_{hh\ food,\ water}$, which is the concentration in water that should protect humans against adverse effects from the substance via fish and shellfish consumption; (2) the $MPC_{dw,\ water}$, which is the concentration in water that should protect humans against adverse effects of the substance in drinking water. Note that each of these two MPCs is allowed to contribute only 10% to the TL_{hh}.
Two other MPCs are derived for the water compartment, based on ecotoxicological data. These are (1) the $MPC_{eco,\ water}$, which is based on direct aquatic ecotoxicological data and (2) the $MPC_{sp,\ water}$, which is derived in case secondary poisoning in the environment is thought to be of concern. It is important to note that MPC and NC derivation integrates both ecotoxicological data and a human toxicological threshold value. The height of the final 'environmental risk limit' can be determined by either one of these protection objectives.

2.2 Data collection and evaluation

An on-line literature search was performed using TOXLINE (literature from 1985 to 2001) and Current contents (literature from 1997 to 2007). In addition to this, all relevant references in the RIVM e-tox base and EPA's ECOTOX database were evaluated. All relevant toxicity data are reported in the Appendices.

Ecotoxicity studies were screened for relevant endpoints (i.e., those endpoints that have consequences at the population level of the test species). All ecotoxicity and bioaccumulation tests were then thoroughly evaluated with respect to the validity (scientific reliability) of the study according to the criteria of Klimisch (1997). A detailed description of the evaluation procedure is given in the INS-Guidance sections 2.2.2 and 2.3.2. In short, the following reliability indices were assigned:

- Ri 1: Reliable without restriction
  'Studies or data … generated according to generally valid and/or internationally accepted testing guidelines (preferably performed according to GLP) or in which the test parameters documented are based on a specific (national) testing guideline … or in which all parameters described are closely related/comparable to a guideline method.'

- Ri 2: Reliable with restrictions
  'Studies or data … (mostly not performed according to GLP), in which the test parameters documented do not totally comply with the specific testing guideline but are sufficient to accept the data or in which investigations are described which cannot be subsumed under a testing guideline but are nevertheless well documented and scientifically acceptable.'
- Ri 3: Not reliable
  'Studies or data … in which there are interferences between the measuring system and the test substance or in which organisms/test systems were used that are not relevant in relation to the exposure (e.g., non physiological pathways of application) or which were carried out or generated according to a method that is not acceptable, the documentation of which is not sufficient for an assessment and is not convincing for an expert judgment.' Since monochlorobenzenes and dichlorobenzenes are volatile substances, studies using an open static or renewal system in which actual concentrations are not monitored are awarded Ri 3. An exception is made for the studies on *Vibrio fischeri*, because the duration of these studies (5-15 minutes) is too short for a significant loss of the test substance due to volatilisation.
- Ri 4: Not assignable
  'Studies or data … which do not give sufficient experimental details and are only listed in short abstracts or secondary literature (books, reviews, etc.).'
- Ri 4*: Data from other sources
  'Studies or data … which are most likely copied from other sources'

All available studies were summarised in data-tables, which are included as Appendices to this report. These tables contain information on species characteristics, test conditions and endpoints. Explanatory notes are included with respect to the assignment of the reliability indices.

Endpoints with Ri 1 or 2 are accepted as valid, but this does not automatically mean that the endpoint is selected for the derivation of ERLs. The validity scores are assigned on the basis of scientific reliability, but valid endpoints may not be relevant for the purpose of ERL-derivation (e.g., due to inappropriate exposure times or test conditions that are not relevant for the Dutch situation).

After data collection and validation, toxicity data were combined into an aggregated data table with one effect value per species according to section 2.2.6 of the INS-Guidance. Results from studies in which test concentrations are measured continuously or at the beginning and end of the test period are always preferred above studies without analyses of concentrations. When several effect data were available for a species, the geometric mean of multiple values for the same endpoint was calculated where possible. Subsequently, when several endpoints were available for one species, the lowest of these endpoints (per species) is reported in the aggregated data table.

2.3 Derivation of ERLs for drinking water and MAC_{marine}

2.3.1 Drinking water

The INS Guidance includes the MPC for surface waters intended for the abstraction of drinking water ($MPC_{dw,\ water}$) as one of the MPCs from which the lowest value should be selected as the general MPC_{water} (see INS-Guidance, section 3.1.6 and 3.1.7). According to the daughter directive Priority Substances, however, the derivation of the AA-EQS (= MPC) should be based on direct exposure, secondary poisoning and human exposure, due to the consumption of fishery products. Drinking water was not included in the proposal and is thus not determinative for the general MPC value. The $MPC_{dw,\ water}$ is therefore presented as a separate value in this report. The MPC_{water} is thus derived considering the individual MPCs based on direct exposure ($MPC_{eco,\ water}$), secondary poisoning ($MPC_{sp,\ water}$) or human consumption of fishery products ($MPC_{hh\ food,\ water}$); the need for derivation of the latter two depends on the characteristics of the compound.

Related to this is the inclusion of water treatment for the derivation of the $MPC_{dw,\ water}$. According to the INS-Guidance (section 3.1.7), a substance specific removal efficiency related to simple water treatment should be derived in case the $MPC_{dw,\ water}$ is lower than the other MPCs. However, since no agreed method is currently available, in this report removal efficiency is set to 0% (= no removal).

2.3.2 $MAC_{eco,\ marine}$

The assessment factor for the derivation of the $MAC_{eco,\ marine}$ is based on:

- the assessment factor for the $MAC_{eco,\ water}$ when acute toxicity data for at least two specific marine taxa are available, or
- the assessment factor for the $MAC_{eco,\ water}$ value with an additional assessment factor of 5 when acute toxicity data for only one specific marine taxon are available (analogous to the derivation of the MPC according to Van Vlaardingen and Verbruggen, 2007), or
- the assessment factor for the $MAC_{eco,\ water}$ value with an additional assessment factor of 10 when no acute toxicity data are available for specific marine taxa.

If freshwater and marine data sets are not combined, the $MAC_{eco,\ marine}$ is derived using the marine toxicity data and the additional assessment factors mentioned above. It has to be noted that this procedure is currently under discussion. Therefore, the $MAC_{eco,\ marine}$ value might need to be re-evaluated once an agreed procedure is available.

3 Monochlorobenzene

3.1 Substance identification, physico-chemical properties, fate and human toxicology

3.1.1 Identity

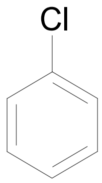


Figure 1. Structural formula of monochlorobenzene.

Table 3. Identification of monochlorobenzene

Parameter	Value	Source
Common/trivial/other name	Chlorobenzene	Mackay et al., 2006
Chemical name	Chlorobenzene	Mackay et al., 2006
CAS number	108-90-7	Mackay et al., 2006
EC number	203-628-5	ECB, ESIS
SMILES code	Clc1ccccc1	Chemsketch
Mode of action	Narcosis	ECB, ESIS

3.1.2 Physico-chemical properties

Table 4. Physico-chemical properties of monochlorobenzene

Parameter	Unit	Value	Remark	Reference[a]
Molecular weight	[g/mol]	112.6		Mackay et al., 2006
Water solubility	[mg/L]	495	10–70 °C	Mackay et al., 2006 (Hovarth and Getzen, 1985)
log K_{OW}	[-]	2.89		Mackay et al., 2006 (Hansch et al., 1995)
log K_{OC}	[-]	2.34		Otte et al., 2001
Vapour pressure	[Pa]	1333	22.2 °C	Mackay et al., 2006 (Stull, 1947)
Melting point	[°C]	-45.31		Mackay et al., 2006 (Lide, 2003)
Boiling point	[°C]	131.72		Mackay et al., 2006 (Lide, 2003)
Henry’s law constant	[Pa.m^3/mol]	297	20 °C	Mackay et al., 2006 (Staudinger and Roberts, 1996)

[a]: reference between brackets refers to citation by Mackay et al., 2006

3.1.3 Behaviour in the environment

Table 5. Selected environmental properties of monochlorobenzene

Parameter	Unit	Value	Remark	Reference[a]
Hydrolysis half-life	DT50 [d]		No hydrolysis at environmentally relevant conditions	Mackay et al., 2006; (Mabey et al., 1982)
Photolysis half-life	DT50 [d]		No photolysis at environmentally relevant conditions	Mackay et al., 2006; (Mabey et al., 1982)
Readily biodegradable		No	OECD 301C	IUCLID, 2000a

[a]: reference between brackets refers to citation by Mackay et al., 2006

In water, volatilisation is the main removal process.

3.1.4 Bioconcentration and biomagnification

An overview of the bioaccumulation data for monochlorobenzene is given in Table 6. Detailed bioaccumulation data for monochlorobenzene are tabulated in Appendix 1.

Table 6. Overview of bioaccumulation data for monochlorobenzene

Parameter	Unit	Value	Remark	Reference
BCF (fish)	[L/kg]	11	*Cyprinus carpio*	METI (http://www.safe.nite.go.jp)
BCF (fish)	[L/kg]	25	*Cyprinus carpio*	METI (http://www.safe.nite.go.jp)
BCF (fish)	[L/kg]	84	*Pimephales promelas*	De Wolf and Lieder, 1998
BMF	[kg/kg]	1	default value for BCF < 2000 L/kg	Van Vlaardingen and Verbruggen, 2007

3.1.5 Human toxicological threshold limits and carcinogenicity

The following R-phrases are assigned to monochlorobenzene: R10, R20 and R51/53 (ECB, ESIS). Based on a NOAEL of 60 mg/kg body weight per day in a 2-year rat study (dosing by gavage), and applying an assessment factor of 500 (100 for inter- and intraspecies variation and 5 for limited evidence of carcinogenicity) a TDI of 85.7 μg/kg body weight for 5 days/week exposure was calculated (WHO, 2004). When corrected for daily intake (7 instead of 5 days/week), the TDI is 61.2 μg/kg bw/day.

3.2 Trigger values

This section reports on the trigger values for ERL water derivation (as required in the WFD framework).

Table 7. Monochlorobenzene: collected properties for comparison to MPC triggers

Parameter	Value	Unit	Method/Source	Derived at section
Log $K_{p,susp-water}$	1.34	[-]	$K_{OC} \times f_{OC,susp}$ [a]	K_{OC}: 3.1.2
BCF	84	[L/kg]		3.1.4
BMF	1	[kg/kg]		3.1.4
Log K_{OW}	2.89	[-]		3.1.2
R-phrases	R10, R20, R51/53	[-]		3.1.5

[a]: $f_{OC,susp}$ = 0.1 kg_{OC}/kg_{solid} (EC, 2003).

- monochlorobenzene has a log $K_{p, susp-water}$ < 3; derivation of $MPC_{sediment}$ is not triggered
- monochlorobenzene has a log $K_{p, susp-water}$ < 3; expression of the MPC_{water} as $MPC_{susp, water}$ is not required
- monochlorobenzene has a BCF < 100 L/kg; assessment of secondary poisoning is not triggered
- monochlorobenzene has no classification (R-phrase) upon which an MPC_{water} for human health via food (fish) consumption ($MPC_{hh food, water}$) should be derived. However, since limited evidence for carcinogenicity of monochlorobenzene is available, the $MPC_{hh food, water}$ is derived
- for monochlorobenzene, no specific A1 value or Drinking Water value is available from Council Directives 75/440, EEC and 98/83/EC, respectively.

3.3 Derivation of ERLs for water

3.3.1 Aquatic toxicity data

An overview of the selected freshwater toxicity data for monochlorobenzene is given in Table 8 and selected marine toxicity data are given in Table 9. Detailed toxicity data for monochlorobenzene are tabulated in Appendix 2.

Table 8. Monochlorobenzene: selected freshwater toxicity data for ERL derivation

Chronic[a] **Taxonomic group**	**NOEC/EC10 (mg/L)**	**Acute**[a] **Taxonomic group**	**L(E)C50 (mg/L)**
Algae		Bacteria	
Pseudokirchneriella subcapitata	6.8[b]	*Pseudomonas fluorescens*	118.5
Crustacea		Algae	
Daphnia magna	**0.32**[c]	*Pseudokirchneriella subcapitata*	12.5
Amphibia		Crustacea	
Ambystoma gracile	0.872	*Ceriodaphnia dubia*	5.29[d]
Pisces		***Daphnia carinata***	**3.99**
Danio rerio	4.8[c]	*Daphnia magna*	10.6[e]
Oncorhynchus mykiss	2.9	Pisces	
		Danio rerio	10.5
		Lepomis macrochirus	5.77[f]
		Oncorhynchus mykiss	4.7[g]
		Pimephales promelas	16.9[g]

[a] For detailed information see Appendix 2. Bold values are used for MPC derivation.

[b] Test duration 96 hours.
[c] Most sensitive endpoint; growth.
[d] Most sensitive endpoint; immobilisation.
[e] Geometric mean of 26 and 4.3 mg/L, measured concentrations.
[f] Geometric mean of 4.5 and 7.4 mg/L, test duration 96 hours.
[g] Based on measured concentration, test duration 96 hours.

Table 9. Monochlorobenzene: selected marine toxicity data for ERL derivation

Chronic[a] **Taxonomic group**	**NOEC/EC10 (mg/L)**	**Acute**[a] **Taxonomic group**	**L(E)C50 (mg/L)**
		<u>Bacteria</u>	
		Vibrio fischeri	15[b]
		<u>Pisces</u>	
		Platichthys flesus	6.6
		Solea solea	5.8

[a] For detailed information see Appendix 2.
[b] Microtox test, test duration 15 minutes. Based on measured concentration.

3.3.2 Treatment of fresh- and saltwater toxicity data

In line with the Fraunhofer Guidance (Lepper, 2005), the datasets for freshwater and marine water are combined.

3.3.3 Mesocosm studies

No mesocosm studies are available for monochlorobenzene.

3.3.4 Derivation of MPC_{water} and MPC_{marine}

3.3.4.1 $MPC_{eco,\ water}$ and $MPC_{eco,\ marine}$

Freshwater
The base set is complete. Additionally, chronic data are available for four taxonomic groups (algae, crustaceans, amphibians and fish). Based on this dataset, the $MPC_{eco,\ water}$ is derived using an assessment factor of 10 on the lowest NOEC value (*Daphnia magna*, 0.32 mg/L), resulting in an $MPC_{eco,\ water}$ of 0.32 mg/L / 10 = 32 µg/L

Marine water
Based on the data in Tables 8 and 9 the $MPC_{eco,\ marine}$ is derived using an assessment factor of 100 on the lowest NOEC value. Thus, the $MPC_{eco,\ marine}$ is 0.32 mg/L / 100 = 3.2 µg/L.

3.3.4.2 $MPC_{sp,\ water}$ and $MPC_{sp,\ marine}$

Since the BCF of monochlorobenzene is < 100 L/kg, ERLs for secondary poisoning are not derived.

3.3.4.3 $MPC_{hh\ food,\ water}$

Based on the limited evidence for carcinogenicity, an $MPC_{hh\ food,\ water}$ should be derived for monochlorobenzene. Using the TDI of 61.2 µg/kg bw day and the formulas in section 3.1.5 of the INS Guidance, the $MPC_{hh\ food,\ water}$ is 44 µg/L. This value is valid for freshwater as well as for the marine compartment.

3.3.5 Selection of MPC_{water} and MPC_{marine}

Freshwater
The lowest value of the routes included is the $MPC_{eco, water}$ (32 μg/L). Therefore, the MPC_{water} for monochlorobenzene is 32 μg/L.

Marine water
The lowest value of the routes included is the $MPC_{eco, marine}$ (3.2 μg/L). Therefore, the MPC_{marine} for monochlorobenzene is 3.2 μg/L.

3.3.6 $MPC_{dw, water}$

Because no A1 value or DWS is available for monochlorobenzene, the $MPC_{dw, water, provisional}$ is derived using the formula in section 3.1.6 of the INS guidance. Using the TDI of 61.2 μg/kg bw day, an average bodyweight of 70 kg and an average uptake of drinking water of 2 L, the $MPC_{dw, water, provisional}$ is 2.1 x 10^2 μg/L. The $MPC_{dw, water, provisional}$ is not taken into account for the derivation of the final MPC_{water}.

3.3.7 Derivation of $MAC_{eco, water}$ and $MAC_{eco, marine}$

Freshwater
The base set is complete and acute data are available for two additional taxonomic groups (bacteria and protozoa). Monochlorobenzene has a BCF < 100 L/kg. Therefore, an assessment factor of 100 is used on the lowest $L(E)C_{50}$ value (3.99 mg/L for *Daphnia carinata*), resulting in a $MAC_{eco, water}$ of 3.99 mg/L / 100 = 40 μg/L.

Marine water
Based on the data in Tables 8 and 9 and the non-bioaccumulative properties of monochlorobenzene, an assessment factor of 1000 is used on the lowest $L(E)C_{50}$ value (3.99 mg/L for *Daphnia carinata*), resulting in a $MAC_{eco, marine}$ of 3.99 mg/L / 1000 = 4.0 μg/L.

3.3.8 Derivation of NC_{water}

Freshwater
The NC is set a factor of 100 below the MPC. The NC_{water} is 32 μg/L / 100 = 0.32 μg/L.

Marine water
The NC is set a factor of 100 below the MPC. The NC_{marine} is 3.2 μg/L / 100 = 3.2 x 10^{-2} μg/L.

3.3.9 Derivation of $SRC_{eco, water}$

The $SRC_{eco, water}$ for monochlorobenzene is based on the geometric mean of the NOEC values, since data are available for algae, *Daphnia* and fish. The $SRC_{eco, water}$ is 1925 = 1.9 x 10^3 μg/L. This value is valid for freshwater as well as for the marine compartment.

3.4 Derivation of ERLs for sediment

The log $K_{p, susp-water}$ of monochlorobenzene is below the trigger value of 3, therefore, ERLs are not derived for sediment.

3.5 Derivation of ERLs for soil

3.5.1 Toxicity data for soil

Table 10. Monochlorobenzene: selected soil toxicity data for ERL derivation

Chronic[a] **Taxonomic group**	**NOEC/EC10 (mg/kg)**	**Acute**[a] **Taxonomic group**	**L(E)C50 (mg/kg)**
		Annelida	
		Eisenia andrei	551
		Eisenia andrei	649
		Lumbricus rubellus	1367
		Lumbricus rubellus	1478

[a] For detailed information see Appendix 3.
[b] Results normalised for Dutch standard soil.

3.5.2 Derivation of MPC_{soil}

3.5.2.1 $MPC_{eco,\ soil}$

The dataset for monochlorobenzene contains two $L(E)C_{50}$ values for two species: 551 and 649 mg/kg_{dwt} standard soil for *Eisenia andrei* and 1367 and 1478 mg/kg_{dwt} for *Lumbricus rubellus*. Since these values are comparable, the geometric means are used: 580 mg/kg_{dwt} for *Eisenia andrei* and 1421 mg/kg_{dwt} for *Lumbricus rubellus*. According to the INS guidance, an assessment factor of 1000 should be applied to the lowest $L(E)C_{50}$ for the derivation of the $MPC_{eco,\ soil}$. Therefore, the $MPC_{eco,\ soil}$ is 580 mg/kg_{dwt} / 1000 = 5.8 x 10^2 $\mu g/kg_{dwt\ standard\ soil}$. Since data for only one taxonomic group are available, this value should be compared with the $MPC_{eco,\ soil}$ derived using the equilibrium partitioning method. The $MPC_{eco,\ soil,\ equilibrium\ partitioning}$ is 4.3 x 10^2 $\mu g/kg_{dwt}$, which is lower than the value based on experimental soil data. The $MPC_{eco,\ soil}$ for monochlorobenzene is set to 4.3 x 10^2 $\mu g/kg_{dwt}$.

3.5.2.2 $MPC_{sp,\ soil}$

The log K_{ow} of monochlorobenzene is below the trigger value of 3, therefore, no $MPC_{sp,\ soil}$ is derived.

3.5.2.3 $MPC_{human,\ soil}$

The $MPC_{human,\ soil}$ is derived using the formulas in section 3.3.6 of the INS Guidance (Van Vlaardingen and Verbruggen, 2007). These calculations result in an $MPC_{human,\ soil}$ of 1236 = 1.2 x 10^2 $\mu g/kg_{dwt}$ for consumption of root crops.

3.5.3 Selection of MPC_{soil}

The lowest value of the routes included is the $MPC_{eco,\ soil}$. The MPC_{soil} for monochlorobenzene is set to 4.3 x 10^2 $\mu g/kg_{dwt}$.

3.5.4 Derivation of NC_{soil}

The NC is set a factor 100 of below the MPC. Therefore, the NC_{soil} is
426 $\mu g/kg_{dwt}$ / 100 = 4.3 $\mu g/kg_{dwt}$.

3.5.5 Derivation of $SRC_{eco, soil}$

Since only acute values for the toxicity of monochlorobenzene in soil are available, the $SRC_{eco, soil}$ is derived by comparing the geometric mean of the $L(E)C_{50}$ values with an assessment factor of 10 with the result of the equilibrium partitioning method using the $SRC_{eco, water}$ (Van Vlaardingen and Verbruggen, 2007). For monochlorobenzene, the geometric mean of the four $L(E)C_{50}$ values is 922 mg/kg_{dwt}. Using an assessment factor of 10, the $SRC_{eco, soil}$ is 92.2 mg/kg_{dwt} = 92200 $\mu g/kg_{dwt}$. The $SRC_{eco, soil}$ derived using the equilibrium partitioning method is 25623 $\mu g/kg_{dwt.}$ Therefore, the $SRC_{eco, soil}$ is 2.6×10^4 $\mu g/kg_{dwt}$ standard soil.

3.6 Derivation of ERLs for groundwater

3.6.1 Derivation of MPC_{gw}

3.6.1.1 $MPC_{eco, gw}$

Since no ecotoxicity data are available for the groundwater compartment, the $MPC_{eco, water}$ for surface water is taken as substitute. The $MPC_{eco, gw}$ for monochlorobenzene is 32 µg/L.

3.6.1.2 $MPC_{human, gw}$

The $MPC_{dw, water, provisional}$ is used as substitute for the $MPC_{human, gw}$. Therefore, the $MPC_{human, gw}$ is 2.1×10^2 µg/L.

3.6.2 Selection of MPC_{gw}

The lowest value of the routes included is the $MPC_{eco, gw}$. Therefore, the MPC_{gw} is 32 µg/L.

3.6.3 Derivation of NC_{gw}

The NC is set a factor of 100 below the MPC. For groundwater, the NC_{gw} is 32 µg/L / 100 = 0.32 µg/L.

3.6.4 Derivation of $SRC_{eco, gw}$

Since no toxicity data are available for the groundwater compartment, the $SRC_{eco, water}$ for surface water is taken as a substitute. Therefore, the $SRC_{eco, gw}$ is 1.9×10^3 µg/L.

3.7 Derivation of ERLs for air

3.7.1.1 $MPC_{eco, air}$

Since no data on the ecotoxicity of monochlorobenzene are available, no $MPC_{eco, air}$ can be derived.

3.7.1.2 $MPC_{human, air}$

The $MPC_{human, air}$ is set at the same value as the Tolerable Concentration in Air (TCA). The TCA and therefore, the $MPC_{human, air}$ is 5.0×10^2 $\mu g/m^3$ (Lijzen et al., 2002).

3.7.2 Selection of MPC_{air}

The only value of the routes included is the $MPC_{human, air}$. Therefore, the MPC_{air} is 5.0×10^2 $\mu g/m^3$.

3.8 Overview of ERLs for monochlorobenzene

In Table 11, an overview of the ERLs derived for monochlorobenzene is given.

Table 11. Monochlorobenzene: derived NC, MPC, MAC_{eco} and SRC_{eco}

ERL	Unit	NC	MPC	MAC_{eco}	SRC_{eco}
Water	µg/L	0.32	32	40	1.9×10^3
Marine	µg/L	3.2×10^{-2}	3.2	4.0	1.9×10^3
Soil	µg/kg	4.3	4.3×10^2	n.a.	2.6×10^4
Groundwater	µg/L	0.32	32	n.a.	1.9×10^3
Air	µg/m^3	n.a.	5.0×10^2	n.a.	n.a.
Drinking water	µg/L	n.a.	2.1×10^2	n.a.	n.a.

n.a. = not applicable

3.9 Comparison of derived ERLs with monitoring data

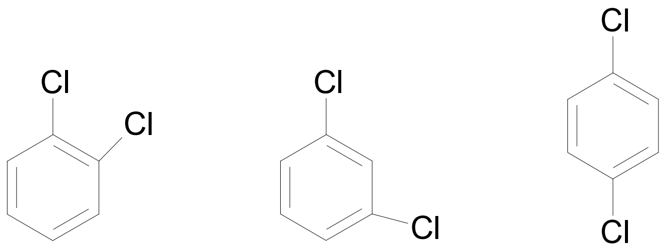
Monitoring data for the Rhine from the years 2001–2006, obtained from RIWA (Association of River Waterworks), show that at all sampling occasions and locations, the concentration of monochlorobenzene in water was usually below detection limits (0.01 µg/L). On two occasions in 2005, a concentration of 0.15 µg/L was measured, a value well below the new MPC_{water}. Therefore, no exceedance is expected.

4 Dichlorobenzenes

Since the differences in toxicity for the individual dichlorobenzenes are small, ERLs are derived for the dichlorobenzenes as a group, based on the combined datasets of 1,2-dichlorobenzene, 1,3-dichlorobenzene and 1,4-dichlorobenzene. ERLs for the group are only derived when relevant for the individual substances, i.e., when an individual substance triggers derivation.

4.1 Substance identification, physico-chemical properties, fate and human toxicology

4.1.1 Identity



a. b. c.

Figure 2. Structural formulas of dichlorobenzenes.
a = 1,2-dichlorobenzene, b = 1,3-dichlorobenzene, c = 1,4-dichlorobenzene.

Table 12. Identification of dichlorobenzenes.

Parameter	Value	Substance	Source
Common/trivial/other name	dichlorobenzenes		Mackay et al., 2006
Chemical name	1,2-dichlorobenzene 1,3-dichlorobenzene 1,4-dichlorobenzene		Mackay et al., 2006
CAS number	95-50-1 541-73-1 106-46-7	1,2-dichlorobenzene 1,3-dichlorobenzene 1,4-dichlorobenzene	Mackay et al., 2006
EC number	202-425-9 208-792-1 203-400-5	1,2-dichlorobenzene 1,3-dichlorobenzene 1,4-dichlorobenzene	ECB, ESIS
SMILES code	Clc1ccccc1Cl Clc1cc(Cl)ccc1 Clc1ccc(Cl)cc1	1,2-dichlorobenzene 1,3-dichlorobenzene 1,4-dichlorobenzene	Chemsketch
Mode of action	Narcosis		ECB, ESIS

4.1.2 Physico-chemical properties

Table 13. Physico-chemical properties of dichlorobenzenes

Parameter	Unit	Value	Remark	Reference[a]
Molecular weight	[g/mol]	147		Mackay et al., 2006
Water solubility	[mg/L]	92.3 124 90.0	25 °C, 1,2-dichlorobenzene 25 °C, 1,3-dichlorobenzene 25 °C, 1,4-dichlorobenzene	Mackay et al., 2006; (Miller, 1984; Hovarth, 1982)
log K_{OW}	[-]	3.45	worst-case, log Kow of 1,4-dichlorobenzene	Mackay et al., 2006; (Sangster, 1993)
log K_{OC}	[-]	2.69	worst-case, log Koc of 1,3-dichlorobenzene	Otte et al., 1991
Vapour pressure	[Pa]	133.8 185.0 170	20 °C, 1,2-dichlorobenzene 20 °C, 1,3-dichlorobenzene 20 °C, 1,4-dichlorobenzene	Mackay et al., 2006; (Roháč et al., 1999)
Melting point	[°C]	-17.0 -24.8 53.09	1,2-dichlorobenzene 1,3-dichlorobenzene 1,4-dichlorobenzene	Mackay et al., 2006; (Lide, 2003)
Boiling point	[°C]	180 183 174	1,2-dichlorobenzene 1,3-dichlorobenzene 1,4-dichlorobenzene	Mackay et al., 2006; (Lide, 2003)
Henry's law constant	[Pa.m^3/mol]	133 288 275	20 °C, 1,2-dichlorobenzene 20 °C, 1,3-dichlorobenzene 20 °C, 1,4-dichlorobenzene	Mackay et al., 2006; (Staudinger and Roberts, 2001)

[a]: references between brackets refers to citation by Mackay et al., 2006

4.1.3 Behaviour in the environment

Table 14. Selected environmental properties of dichlorobenzenes

Parameter	Unit	Value	Remark	Reference
Hydrolysis half-life	DT50 [d]		No hydrolysis at environmentally relevant concentrations	Mackay et al., 2006
Photolysis half-life	DT50 [d]		No photolysis at environmentally relevant concentrations	Mackay et al., 2006
Readily biodegradable		No Yes	1,2-dichlorobenzene 1,4-dichlorobenzene	IUCLID, 2000b EC, 2004

4.1.4 Bioconcentration and biomagnification

An overview of the bioaccumulation data for dichlorobenzenes is given in Table 15. Detailed bioaccumulation data are tabulated in Appendix 1.

Table 15. Overview of bioaccumulation data for dichlorobenzenes

Parameter	Unit	Value	Remark	Reference
BCF (fish)	[L/kg]	178	1,2-dichlorobenzene, *Cyprinus carpio*	METI (http://www.safe.nite.go.jp)
		174	1,2-dichlorobenzene, *Cyprinus carpio*	METI (http://www.safe.nite.go.jp)
		454	1,2-dichlorobenzene, *Pimephales promelas*	Sijm et al., 1993
		138	1,3-dichlorobenzene, *Cyprinus carpio*	METI (http://www.safe.nite.go.jp)
		195	1,3-dichlorobenzene, *Cyprinus carpio*	METI (http://www.safe.nite.go.jp)
		728	1,3-dichlorobenzene, *Pimephales promelas*	De Wolf and Lieder, 1998
		69	1,4-dichlorobenzene, *Cyprinus carpio*	METI (http://www.safe.nite.go.jp)
		80	1,4-dichlorobenzene, *Cyprinus carpio*	METI (http://www.safe.nite.go.jp)
		296	1,4-dichlorobenzene, *Jordanella floridae*	EC, 2004; Smith et al., 1990
BMF	[kg/kg]	1	default value for BCF < 2000 L/kg	Van Vlaardingen and Verbruggen, 2007

4.1.5 Human toxicological threshold limits and carcinogenicity

1,2-dichlorobenzene
The following R-phrases are assigned to 1,2-dichlorobenzene: R22, R36/37/38 and R50/53 (ECB, ESIS). Based on a NOAEL of 60 mg/kg bw per day in a 2-year mouse study (dosing by gavage), and applying an uncertainty factor of 100, a TDI of 429 µg/kg bw/day was derived (WHO, 2004).

1,3-dichlorobenzene
The following R-phrases are assigned to 1,3-dichlorobenzene: R22 and R51/53 (ECB, ESIS). Insufficient reliable toxicological data on 1,3-dichlorobenzene are available to derive an ADI or TDI value.

1,4-dichlorobenzene
The following R-phrases are assigned to 1,4-dichlorobenzene: R36, R40 and R50/53 (ECB, ESIS). 1,4-dichlorobenzene is not considered to be genotoxic and the relevance for humans of the tumours observed in animals is doubtful. It is therefore valid to calculate a guideline value using the TDI approach. A TDI of 107 µg/kg of body weight has been calculated by applying an uncertainty factor of 1000 (100 for inter- and intraspecies variation and 10 for the use of a LOAEL instead of a NOAEL and because the toxic end-point is carcinogenicity) to a LOAEL of 150 mg/kg of body weight per day for kidney effects observed in a 2-year rat gavage study (administration 5 days per week) (WHO, 2004).

The derivation of the $MPC_{sp, water}$ and the $MPC_{hh food, water}$ is based on the worst-case scenario that all dichlorobenzenes are as toxic as 1,4-dichlorobenzene, e.g., on a TDI of 107 µg/kg bw and a NOAEL of 15 mg/kg bw.

4.2 Trigger values

This section reports on the trigger values for ERL water derivation (as demanded in the WFD framework).

Table 16. Dichlorobenzenes: collected properties for comparison to MPC triggers

Parameter	Value	Unit	Method/Source	Derived at section
Log $K_{p,susp-water}$	1.69	[-]	$K_{OC} \times f_{OC,susp}$ [a]	K_{OC}: 4.1.2
BCF	728	[L/kg]	worst-case, BCF of 1,3-dichlorobenzene	4.1.4
BMF	1	[kg/kg]		4.1.4
Log K_{OW}	3.45	[-]	worst-case, log K_{ow} of 1,4-dichlorobenzene	4.1.2
R-phrases	R22, R36/37/38, R50/53 R22, R51/53 R36, R40, R50/53	[-]	1,2-dichlorobenzene 1,3-dichlorobenzene 1,4-dichloroebenzene	4.1.5

[a]: $f_{OC,susp}$ = 0.1 kg_{OC}/kg_{solid} (EC, 2003).

- dichlorobenzenes have a worst-case of log $K_{p, susp-water}$ < 3; derivation of $MPC_{sediment}$ is not triggered
- dichlorobenzenes have a worst-case of log $K_{p, susp-water}$ < 3; expression of the MPC_{water} as $MPC_{susp, water}$ is not required
- dichlorobenzenes have a BCF > 100 L/kg; assessment of secondary poisoning is triggered
- dichlorobenzenes have the potential to bioaccumulate and an R22 classification (1,2- and 1,3-dichlorobenzene). 1,4-dichlorobenze has an R40 classification. Therefore, an MPC_{water} for human health via food (fish) consumption ($MPC_{hh food, water}$) should be derived
- for dichlorobenzenes, no specific A1 values or Drinking Water values are available from Council Directives 75/440, EEC and 98/83/EC, respectively.

4.3 Derivation of ERLs for water

4.3.1 Aquatic toxicity data

An overview of the selected freshwater toxicity data for dichlorobenzenes is given in Table 17 and marine toxicity data are given in Table 18. When selected data were available for multiple dichlorobenzenes, the lowest (worst-case) value was chosen. Detailed toxicity data for dichlorobenzene are tabulated in Appendix 2.

Table 17. Dichlorobenzenes: selected freshwater toxicity data for ERL derivation

Chronic[a] Taxonomic group	NOEC/EC10 (mg/L)	Acute[a] Taxonomic group	L(E)C50 (mg/L)
Algae		Bacteria	
Scenedesmus subspicatus	16[b]	*Pseudomonas fluorescens*	21.6[e]
Crustacea		*Nitrosomonas* spec.	86[b]
Daphnia magna	0.22[b,c]	Algae	
Pisces		*Pseudokirchneriella subcapitata*	1.6[b]
Danio rerio	0.44[b]	*Scenedesmus pannonicus*	17[e]
Jordanella floridae	**0.2**[b]	Crustacea	
Oncorhynchus mykiss	0.56[d]	***Daphnia magna***	**0.74**[e,f]
Pimephales promelas	0.57[b]	Insecta	
		Tanytarsus dissimilis	12[e]
		Pisces	
		Danio rerio	2.1[b]
		Jordanella floridae	2.1[b]
		Oncorhynchus mykiss	1.59[e,h,i]
		Oryzias latipes	9.9[e]
		Pimephales promelas	3.6[b,j]
		Poecilia reticulata	4.8[e]

[a] For detailed information see Appendix 2. Bold values are used for ERL derivation.
[b] Data for 1,4-dichlorobenzene
[c] Most sensitive endpoint; fertility
[d] Data for 1,3-dichlorobenzene
[e] Data for 1,2-dichlorobenzene
[h] Most relevant test duration 96 hours.
[i] Geometric mean of 1.61 and 1.58 mg/L; based on measured concentration.
[j] ELS test

Table 18. Dichlorobenzenes: selected marine toxicity data for ERL derivation

Chronic[a] Taxonomic group	NOEC/EC10 (mg/L)	Acute[a] Taxonomic group	L(E)C50 (mg/L)
		Bacteria	
		Vibrio fischeri	4.4[b,c]
		Pisces	
		Cyprinodon variegatus	7.4[d]
		Platichtys flesus	4.6[b]
		Solea solea	4.2[b]

[a] For detailed information see Appendix 2.
[b] Data for 1,2-dichlorobenzene.
[c] Geometric mean of 6.1 and 3.14 mg/L; most relevant test duration 15 minutes.
[d] Data for 1,4-dichlorobenzene.

4.3.2 Treatment of fresh- and saltwater toxicity data

In line with the Fraunhofer guidance (Lepper, 2005), the datasets for freshwater and marine water are combined.

4.3.3 Mesocosm studies

No mesocosm studies are available for the dichlorobenzenes.

4.3.4 Derivation of MPC_{water} and MPC_{marine}

4.3.4.1 $MPC_{eco,\ water}$ and $MPC_{eco,\ marine}$

Freshwater

Chronic toxicity data are available for three taxonomic groups (algae, crustaceans and fish). Therefore, the $MPC_{eco,\ water}$ is derived using an assessment factor of 10 on the lowest NOEC value (0.2 mg/L for *Jordanella floridae*). Thus, the $MPC_{eco,\ water}$ is 0.2 mg/L / 10 = 0.02 mg/L = 20 µg/L

Marine water

Based on the data in Tables 17 and 18, an additional assessment factor of 10 is used on the lowest NOEC for the derivation of the $MPC_{eco,\ marine}$. Thus, the $MPC_{eco,\ marine}$ is 20 µg/L / 10 = 2.0 µg/L.

4.3.4.2 $MPC_{sp,\ water}$ and $MPC_{sp,\ marine}$

Freshwater

All dichlorobenzenes have a BCF >100 L/kg, thus assessment of secondary poisoning is triggered. The $MPC_{sp,\ water}$ is based on the worst-case scenario that all dichlorobenzenes are as toxic as 1,4-dichlorobenzene. The LOAEL value of 150 mg/kg bw (WHO, 2003) with an additional assessment factor of 10 is used as a NOAEL value for the calculation of the MPC_{oral}. Using an assessment factor of 30, the MPC_{oral} is 5 mg/kg_{food}. Applying the formulas in the INS guidance using the BCF of 728 L/kg, the $MPC_{sp,\ water}$ is 6.9 µg/L.

Marine water

The $MPC_{sp,\ marine}$ is based on the same data as the $MPC_{sp,\ water}$. Therefore, the $MPC_{sp,\ marine}$ is 6.9 µg/L.

4.3.4.3 $MPC_{hh\ food,water}$

Derivation of $MPC_{hh\ food,\ water}$ for dichlorobenzenes is required (Table 16). Based on a TDI of 107 µg/kg bw per day and using the formulas in the INS guidance, the $MPC_{hh\ food,\ water}$ is 8.9 µg/L. This value is valid for freshwater as well as for the marine compartment.

4.3.5 Selection of MPC_{water} and MPC_{marine}

Freshwater

The lowest value of the routes included is the $MPC_{sp,\ water}$. Therefore, the MPC_{water} is 6.9 µg/L.

Marine water

The lowest value of the routes included is the $MPC_{eco,\ water}$. Therefore, the MPC_{marine} is 2.0 µg/L.

4.3.6 $MPC_{dw, water}$

Because no A1 value or DWS is available for dichlorobenzenes, the $MPC_{dw, water, provisional}$ is derived using the formula in section 3.1.6 of the INS guidance. Using the TDI of 107 µg/kg bw per day, an average bodyweight of 70 kg and an average uptake of drinking water of 2 L, the $MPC_{dw, water, provisional}$ is 375 µg/L = 3.8 x 10^2 µg/L. The $MPC_{dw, water, provisional}$ is not taken into account for the derivation of the final MPC_{water}.

4.3.7 Derivation of $MAC_{eco, water}$ and $MAC_{eco, marine}$

Freshwater

The acute dataset contains data for bacteria, algae, crustaceans, insects and fish. All dichlorobenzenes have a BCF > 100 L/kg. Therefore, an assessment factor of 1000 is used on the lowest $L(E)C_{50}$ value (0.74 mg/L, *Daphnia magna*) for the derivation of the $MAC_{eco, water}$, resulting in a $MAC_{eco, water}$ of 0.74 mg/L / 1000 = 0.74 µg/L. This $MAC_{eco, water}$ value is lower than the $MPC_{eco, water}$. Since the $MPC_{eco, water}$ is an ERL which should protect the environment from the adverse effects of long-term exposure to dichlorobenzenes, it is also considered protective for short-term exposure. Therefore, the $MAC_{eco, water}$ is set equal to the $MPC_{eco, water}$ with a value of 20 µg/L.

Marine water

Based on the data in Tables 17 and 18 and the bioaccumulative properties of dichlorobenzenes, the $MAC_{eco, marine}$ is derived by applying an assessment factor of 10000 on the lowest $L(E)C_{50}$ value. Thus, the $MAC_{eco, marine}$ is 0.74 mg/L / 10000 = 0.074 µg/L. This $MAC_{eco, marine}$ value is lower than the $MPC_{eco, marine}$. Since the $MPC_{eco, marine}$ is an ERL which should protect the environment from the adverse effects of long-term exposure to dichlorobenzenes, it is also considered protective for short-term exposure. Therefore, the $MAC_{eco, marine}$ is set equal to the $MPC_{eco, marine}$ with a value of 2.0 µg/L.

4.3.8 Derivation of NC_{water}

Freshwater

The NC is set a factor of 100 below the MPC. Therefore, the NC_{water} is 6.9 µg/L / 100 = 6.9 x 10^{-2} µg/L.

Marine water

The NC is set a factor of 100 below the MPC. Therefore, the NC_{marine} is 2.0 µg/L / 100 = 2.0 x 10^{-2} µg/L.

4.3.9 Derivation of $SRC_{eco, water}$

The $SRC_{eco, water}$ for dichlorobenzenes is based on the geometric mean of the NOEC values using an assessment factor of 1, because NOEC values are available for three taxonomic groups. Thus, the $SRC_{eco, water}$ is 0.68 mg/L = 6.8 x 10^2 µg/L. This value is valid for freshwater as well as for the marine compartment.

4.4 Derivation of ERLs for sediment

The log $K_{p, susp-water}$ of all dichlorobenzenes is below the trigger value of 3, therefore, ERLs are not derived for sediment.

4.5 Derivation of ERLs for soil

4.5.1 Toxicity data for soil

Table 19.Dichlorobenzenes: selected soil toxicity data for ERL derivation

Chronic Taxonomic group	NOEC/EC10 (mg/kg)	Acute Taxonomic group	L(E)C50 (mg/kg)
		Annelida	
		Eisenia andrei	347[a]
		Eisenia andrei	274[a]
		Lumbricus rubellus	497[a]
		Lumbricus rubellus	759[a]

[a] Results are normalised to an organic matter content of 10%.

4.5.2 Derivation of MPC_{soil}

4.5.2.1 $MPC_{eco, soil}$

The dataset of dichlorobenzenes contains four $L(E)C_{50}$ values for two species (all data are for 1,4-dichlorobenzene): 347 and 274 mg/kg_{dwt} for *Eisenia andrei* (geometric mean 308 mg/kg_{dwt}) and 497 and 759 mg/kg_{dwt} for *Lumbricus rubellus* (geometric mean 614 mg/kg_{dwt}). According to the INS guidance, an assessment factor of 1000 should be applied to the lowest $L(E)C_{50}$ for the derivation of the $MPC_{eco, soil}$. Therefore, the $MPC_{eco, soil}$ is 3080 mg/kg_{dwt} / 1000 = 3.1×10^2 $\mu g/kg_{dwt}$

4.5.2.2 $MPC_{sp, soil}$

The log K_{ow} of the dichlorobenzenes exceeds the trigger value of 3 (worst-case 3.45) and the $MPC_{sp, soil}$ should be derived. Since no bioconcentration data are available, a QSAR was used to estimate the BCF for earthworms (Van Vlaardingen and Verbruggen, section 3.3.5). Using an MPC_{oral} of 5 mg/kg_{bw}, and a BCF of 34.66 L/kg for earthworms, an $MPC_{sp, soil}$ of 1.6×10^3 $\mu g/kg_{dwt}$ standard soil was calculated.

4.5.2.3 $MPC_{human, soil}$

The $MPC_{human, soil}$ was derived using the formulas in section 3.3.6 of the INS Guidance (Van Vlaardingen and Verbruggen, 2007). These calculations resulted in an $MPC_{human, soil}$ of 1.4×10^3 $\mu g/kg_{dwt}$ for consumption of root crops.

4.5.3 Selection of MPC_{soil}

The lowest value of the routes included is the $MPC_{eco, soil}$. Therefore, the MPC_{soil} for dichlorobenzenes is 3.1×10^2 $\mu g/kg_{dwt}$.

4.5.4 Derivation of NC_{soil}

The NC is set a factor of 100 below the MPC. Therefore, the NC_{soil} is 308 μg/kg_{dwt} / 100 = 3.1 μg/kg_{dwt}.

4.5.5 Derivation of $SRC_{eco, soil}$

Since only acute values for the toxicity of 1,4-dichlorobenzene in soil are available, the $SRC_{eco, soil}$ is derived by comparing the geometric mean of the $L(E)C_{50}$ values with an assessment factor of 10 with the result of the equilibrium partitioning method (Van Vlaardingen and Verbruggen, 2007). For 1,4-dichlorobenzene, the geometric mean of the $L(E)C_{50}$ values is 435 mg/kg_{dwt}. Using an assessment factor of 10, the $SRC_{eco, soil}$ is 435 mg/kg_{dwt} / 10 = 43500 μg/kg_{dwt}.
The $SRC_{eco, soil}$ derived using the equilibrium partitioning method is 19890 μg/kg_{dwt}, which is lower than the value based on experimental data. Therefore, the $SRC_{eco, soil}$ is 2.0 x 10^4 μg/kg_{dwt}.

4.6 Derivation of ERLs for groundwater

4.6.1 Derivation of MPC_{gw}

4.6.1.1 $MPC_{eco, gw}$

Since no toxicity data are available for the groundwater compartment, the $MPC_{eco, water}$ for surface water is taken as a substitute. Therefore, the $MPC_{eco, gw}$ is 20 μg/L.

4.6.1.2 $MPC_{human, gw}$

The $MPC_{dw, water, provisional}$ is used as a substitute for the $MPC_{human, gw}$. Therefore, the $MPC_{human, gw}$ is 375 μg/L = 3.8 x 10^2 μg/L.

4.6.2 Selection of MPC_{gw}

The lowest value of the routes included is the $MPC_{eco, water}$. Therefore, the MPC_{gw} is 20 μg/L.

4.6.3 Derivation of NC_{gw}

The NC is set a factor 100 below the MPC. For groundwater therefore, the NC_{gw} is 20 μg/L / 100 = 0.20 μg/L.

4.6.4 Derivation of $SRC_{eco, gw}$

Since no toxicity data are available for the groundwater compartment, the $SRC_{eco, water}$ for surface water is taken as a substitute. Therefore, the $SRC_{eco, gw}$ is 6.8 x 10^2 μg/L.

4.7 Derivation of ERLs for air

4.7.1.1 $MPC_{eco, air}$

Since no data on the ecotoxicity of dichlorobenzenes in air are available, no $MPC_{eco, air}$ can be derived.

4.7.1.2 $MPC_{human, air}$

The $MPC_{human, air}$ is set at the same value as the TCA. Since no TCA for dichlorobenzenes is available, no $MPC_{human, air}$ can be derived.

4.7.2 Selection of MPC_{air}

The MPC_{air} for dichlorobenzenes cannot be derived.

4.8 Overview of MPCs for dichlorobenzenes

In Table 20, an overview of the ERLs derived for dichlorobenzenes is given.

Table 20. Dichlorobenzenes: derived NC, MPC, MAC_{eco} and SRC_{eco}

ERL	Unit	NC	MPC	MAC_{eco}	SRC_{eco}
Water	µg/L	6.9×10^{-2}	6.9	20	6.8×10^{2}
Marine	µg/L	2.0×10^{-2}	2.0	2.0	6.8×10^{2}
Soil	µg/kg	3.1	3.1×10^{2}	n.a.	2.0×10^{4}
Groundwater	µg/L	0.20	20	n.a.	6.8×10^{2}
Air	µg/m^3	n.a.	n.d.	n.a.	n.a.
Drinking water	µg/L	n.a.	3.8×10^{2}	n.a.	n.a.

4.9 Comparison of derived ERLs with monitoring data

Monitoring data for the Rhine from the years 2003–2006, obtained from RIWA (Association of River Waterworks), show that at all sampling occasions and locations, the concentration of dichlorobenzenes in water was usually below detection limits (0.01 µg/L).

4.10 Sum limits

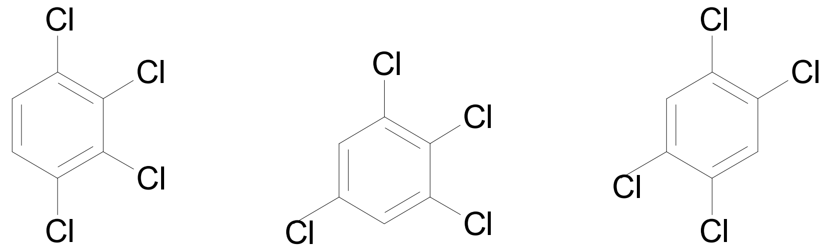
The small difference in toxicity of the individual dichlorobenzenes can result in unacceptable risks when a mixture of dichlorobenzenes is present at one location. In order to prevent this accumulation of toxicity, the use of a sum limit for dichlorobenzenes is proposed. In this approach, the sum of the concentrations of the combination of the three individual dichlorobenzenes should not exceed the ERLs for the grouped dichlorobenzenes (Table 20). It should be noted that the sum limit only applies when all three dichlorobenzenes are monitored.

5 Tetrachlorobenzenes

Since the differences in toxicity for the individual tetrachlorobenzenes are small and data availability is limited, ERLs are derived for the tetrachlorobenzenes as a group based on the combined datasets of 1,2,3,4-tetrachlorobenzene, 1,2,3,5-tetrachlorobenzene, 1,2,4,5-tetrachlorobenze. ERLs for the group are only derived when relevant for the individual substances, i.e., when an individual substance triggers derivation.

5.1 Substance identification, physico-chemical properties, fate and human toxicology

5.1.1 Identity



a. b. c.

Figure 3. Structural formulas of tetrachlorobenzenes.
a = 1,2,3,4-tetrachlorobenzene, b = 1,2,3,5-tetrachlorobenzene, c = 1,2,4,5-tetrachlorobenzene.

Table 21. Identification of tetrachlorobenzenes

Parameter	Value	Substance	Source
Common/trivial/other name	tetrachlorobenzenes		Mackay et al., 2006
Chemical name	1,2,3,4-tetrachlorobenzene 1,2,3,5-tetrachlorobenzene 1,2,4,5-tetrachlorobenzene		Mackay et al., 2006
CAS number	634-66-2 634-90-2 95-94-3	1,2,3,4-tetrachlorobenzene 1,2,3,5-tetrachlorobenzene 1,2,4,5-tetrachlorobenzene	Mackay *et al.*, 2006
EC number	211-214-0 211-217-7 202-466-2	1,2,3,4-tetrachlorobenzene 1,2,3,5-tetrachlorobenzene 1,2,4,5-tetrachlorobenzene	ECB, ESIS
SMILES code	Clc1ccc(Cl)c(Cl)c1Cl Clc1cc(Cl)c(Cl)c(Cl)c1 ClC1=CC(Cl)C(Cl)C=C1Cl	1,2,3,4-tetrachlorobenzene 1,2,3,5-tetrachlorobenzene 1,2,4,5-tetrachlorobenzene	Chemsketch
Mode of action	Narcosis		ECB, ESIS

5.1.2 Physico-chemical properties

Table 22. Physico-chemical properties of tetrachlorobenzenes

Parameter	Unit	Value	Remark	Reference[a]
Molecular weight	[g/mol]	215.9		Mackay *et al.*, 2006
Water solubility	[mg/L]	12.2 2.89 2.35	25 °C, 1,2,3,4-tetrachlorobenzene 25 °C, 1,2,3,5-tetrachlorobenzene 25 °C, 1,2,4,5-tetrachlorobenzene	Mackay *et al.*, 2006; (Miller, 1984)
log K_{OW}	[-]	4.70	worst-case, log Kow of 1,2,4,5-tetrachlorobenzene	Mackay *et al.*, 2006; (Hansch *et al.,* 1995)
log K_{OC}	[-]	3.91	worst-case, log Kow of 1,2,3,4-tetrachlorobenzene	Otte *et al.,* 1991
Vapour pressure	[Pa]	4.11	25°C, geometric mean of 6.29, 5.085 and 2.163 Pa	Mackay *et al.*, 2006; (Rordorf, 1985)
Melting point	[°C]	47.5 54.5 139.5	1,2,3,4-tetrachlorobenzene 1,2,3,5-tetrachlorobenzene 1,2,4,5-tetrachlorobenzene	Mackay *et al.*, 2006; (Lide, 2003)
Boiling point	[°C]	254 246 244.5	1,2,3,4-tetrachlorobenzene 1,2,3,5-tetrachlorobenzene 1,2,4,5-tetrachlorobenzene	Mackay *et al.*, 2006; (Lide, 2003)
Henry's law constant	[Pa.m^3/mol]	58.5 99 101	20 °C, 1,2,3,4-tetrachlorobenzene 1,2,3,5-tetrachlorobenzene 1,2,4,5-tetrachlorobenzene	Mackay *et al.*, 2006; (Staudinger and Roberts, 2001)

[a]: reference between brackets refers to citation by Mackay *et al.*, 2006

5.1.3 Behaviour in the environment

Table 23. Selected environmental properties of tetrachlorobenzenes

Parameter	Unit	Value	Remark	Reference
Hydrolysis half-life	DT50 [d]		No hydrolysis at environmentally relevant concentrations	Mackay *et al.*, 2006
Photolysis half-life	DT50 [d]		No photolysis at environmentally relevant concentrations	Mackay *et al.*, 2006
Readily biodegradable				

5.1.4 Bioconcentration and biomagnification

An overview of the bioaccumulation data for tetrachlorobenzenes is given in Table 24. Detailed bioaccumulation data are tabulated in Appendix 1. Based on the studies by Muir *et al*. (2003) and Kelly *et al.* (2007), BMF values were calculated for the aquatic (BMF_1) and the aquatic-dependent (BMF_2) organisms for the tetrachlorobenzenes.

Table 24. Overview of bioaccumulation data for tetrachlorobenzenes

Parameter	Unit	Value	Remark	Reference
BCF (fish)	[L/kg]	1122	1,2,3,4-tetrachlorobenzene, *Cyprinus carpio*	METI (http://www.safe.nite.go.jp)
		1159	1,2,3,4-tetrachlorobenzene, *Cyprinus carpio*	METI (http://www.safe.nite.go.jp)
		2310	1,2,3,4-tetrachlorobenzene, *Poecilia reticulata*	Sijm *et al.,* 1993
		3888	1,2,3,5-tetrachlorobenzene, *Poecilia reticulata*	Könemann and Van Leeuwen, 1980
		3543	1,2,4,5-tetrachlorobenzene, *Cyprinus carpio*	METI (http://www.safe.nite.go.jp)
		3128	1,2,4,5-tetrachlorobenzene, *Cyprinus carpio*	METI (http://www.safe.nite.go.jp)
		4050	1,2,4,5-tetrachlorobenzene, *Jordamella floridae*	Smith *et al.*, 1990
BMF_1	[kg/kg]	2		
BMF_2	[kg/kg]	3		

5.1.5 Human toxicological threshold limits and carcinogenicity

No R-phrases are assigned to the tetrachlorobenzenes.

1,2,3,4-tetrachlorobenzene

Based on a NOAEL of 34 mg/kg bw/day for male rats exposed by gavage and using an assessment factor of 10000 (10 for intraspecies variation; x 10 for interspecies variation; x 10 for less than chronic study; x 10 for limited data base including lack of adequate data on carcinogenicity and chronic and reproductive toxicity), a TDI of 3.4 µg/kg bw/day was derived (Health Canada, 1993).

1,2,3,5-tetrachlorobenzene

No R-phrases are assigned to 1,2,3,5-tetrachlorobenzene. Based on a NOAEL of 4.1 mg/kg bw/day for male rats exposed via the diet and using an assessment factor of 10000 (10 for intraspecies variation; x 10 for interspecies variation; x 10 for less than chronic study; x 10 for limited database including lack of adequate data on carcinogenicity and chronic and reproductive toxicity), a TDI of 0.41 µg/kg bw/day was derived (Health Canada, 1993).

1,2,4,5-tetrachlorobenzene

No R-phrases are assigned to 1,2,4,5-tetrachlorobenzene. Based on a NOAEL of 2.1 mg/kg bw/day for rats exposed via the diet and using an assessment factor of 10000 (10 for intraspecies variation; x 10 for interspecies variation; x 10 for less than chronic study; x 10 for limited database including lack of adequate data on carcinogenicity and chronic and reproductive toxicity), a TDI of 0.21 µg/kg bw/day was derived (Health Canada, 1993).

The derivation of the $MPC_{sp, water}$ and the $MPC_{hh food, water}$ is based on the worst-case scenario that all tetrachlorobenzenes are as toxic as 1,2,4,5-tetrachlorobenzene, e.g., on a TDI op 0.21 µg/kg bw/day and a NOAEL of 2.1 mg/kg bw/day.

5.2 Trigger values

This section reports on the trigger values for ERL water derivation (as required in the WFD framework).

Table 25. Tetrachlorobenzenes: collected properties for comparison to MPC triggers

Parameter	Value	Unit	Method/Source	Derived at section
Log $K_{p,susp-water}$	2.91	[-]	$K_{OC} \times f_{OC,susp}$ [a]	K_{OC}: 5.1.2
BCF	4050	[L/kg]	worst-case, BCF of 1,2,3,4-tetrachlorobenzene	5.1.4
BMF_1	2	[kg/kg]		5.1.4
BMF_2	3	[kg/kg]		5.1.4
Log K_{OW}	4.70	[-]	worst-case, log K_{ow} of 1,2,4,5-tetrachlorobenzene	5.1.2
R-phrases	-	[-]		5.1.5

[a]: $f_{OC, susp}$ = 0.1 kg_{OC}/kg_{solid} (EC, 2003).

- tetrachlorobenzenes have a worst-case of log $K_{p, susp-water}$ < 3; derivation of $MPC_{sediment}$ is not triggered
- tetrachlorobenzenes have a worst-case of log $K_{p, susp-water}$ < 3; expression of the MPC_{water} as $MPC_{susp, water}$ is not required
- tetrachlorobenzenes have a BCF > 100 L/kg; assessment of secondary poisoning is triggered
- tetrachlorobenzenes have no R classifications. However, since tetrachlorobenzenes have a high BCF value and a large uncertainty factor (10000) in the calculation of the TDI, the $MPC_{hh food water}$ is derived.

5.3 Derivation of ERLs for water

5.3.1 Aquatic toxicity data

An overview of the selected freshwater toxicity data for tetrachlorobenzenes is given in Table 26 and marine toxicity data are given in Table 27. Detailed toxicity data for tetrachlorobenzene are tabulated in Appendix 2.

Table 26. Tetrachlorobenzenes: selected freshwater toxicity data for ERL derivation

Chronic[a] Taxonomic group	NOEC/EC10 (mg/L)	Acute[a] Taxonomic group	L(E)C50 (mg/L)
Crustacea		Bacteria	
Daphnia magna	**0.023**[b]	*Pseudomonas fluorescens*	2.16[d]
Insecta		Crustacea	
Chironomus riparius	0.052	***Ceriodaphnia cf. dubia***	**0.13**
Pisces		*Daphnia carinata*	0.51
Danio rerio	0.1[c]	*Daphnia magna*	0.54
Jordanella floridae	0.067	Pisces	
Oncorhynchus mykiss	0.245[c]	*Jordanella floridae*	2.01
Pimephales promelas	0.25	*Pimephales promelas*	0.3[d]
Poecilia reticulata	0.4	*Poecilia reticulata*	0.4[e]

[a] For detailed information see Appendix 2. Bold values are used for ERL derivation.
[b] Geometric mean of 0.01 and 0.055 mg/L; most sensitive endpoint; reproduction. Data from 1,2,3,4-tetrachlorobenzene.
[c] Most sensitive endpoint; growth.
[d] Data from 1,2,4,5-tetrachlorobenzene.
[e] Test duration 96 hours.

Table 27. Tetrachlorobenzenes: selected marine toxicity data for ERL derivation

Chronic[a] Taxonomic group	NOEC/EC10 (mg/L)	Acute[a] Taxonomic group	L(E)C50 (mg/L)
Pisces		Bacteria	
Cyprinodon variegatus	0.18	*Vibrio fischeri*	1.13[b]
		Pisces	
		Cyprinodon variegatus	0.33

[a] For detailed information see Appendix 2.
[b] Geometric mean of 1.9 and 0.67 mg/L; exposure duration 15 minutes.

5.3.2 Treatment of fresh- and saltwater toxicity data

In line with the Fraunhofer guidance (Lepper, 2005), the datasets for freshwater and marine water are combined.

5.3.3 Mesocosm studies

No mesocosm studies are available for tetrachlorobenzenes.

5.3.4 Derivation of MPC_{water} and MPC_{marine}

5.3.4.1 $MPC_{eco, water}$ and $MPC_{eco, marine}$

Freshwater

Reliable data for algae are lacking in both the acute and the chronic dataset. However, the less reliable (effects above the water solubility) or unassignable data for algae show that algae are a less sensitive taxonomic group. Therefore, ERLs can be derived for the tetrachlorobenzenes.
Chronic values are available for three taxonomic groups (crustaceans, insects and fish). Therefore, the $MPC_{eco, water}$ is derived using an assessment factor of 50 on the lowest NOEC value (0.023 mg/L for *Daphnia*). Thus, the $MPC_{eco, water}$ is 0.023 mg/L / 50 = 0.00046 mg/L = 0.46 µg/L

Marine water

Based on the data in Tables 26 and 27, an additional assessment factor of 10 is used on the lowest NOEC for the derivation of the $MPC_{eco, marine}$. Thus, the $MPC_{eco, marine}$ is 0.46 µg/L / 10 = 4.6×10^{-2} µg/L.

5.3.4.2 $MPC_{sp, water}$ and $MPC_{sp, marine}$

Freshwater

All tetrachlorobenzenes have a BCF >100 L/kg, thus assessment of secondary poisoning is triggered. Based on a worst-case $MPC_{oral, mammal}$ of 0.47 mg/kg fd (based on a 90-day rat study with a NOAEL of 2.1 mg/kg bw per day by NTP, 1991), a BCF of 4050 L/kg and a BMF_1 of 2 kg/kg, the $MPC_{sp, water}$ is 5.8×10^{-2} µg/L (Van Vlaardingen and Verbruggen, 2007, section 3.1.4).

Marine water

The $MPC_{sp, marine}$ is based on the same data as the $MPC_{sp, water}$. In order to account for the longer food chains in the marine environment, an additional biomagnification factor is used. Because of the BCF value of 2310 L/kg, the BMF_2 has a value of 3. Therefore, the $MPC_{sp, marine}$ is 1.9×10^{-2} µg/L.

5.3.4.3 $MPC_{hh food, water}$

Derivation of $MPC_{hh food, water}$ for tetrachlorobenzenes is not triggered (Table 25). However, since tetrachlorobenzenes have a high BCF value and a large uncertainty factor (10000) in the calculation of the TDI (0.21 µg/kg bw day), the $MPC_{hh food, water}$ is calculated. Using the formulas in the INS guidance, the $MPC_{hh food, water}$ is 0.0016 µg/L = 1.6×10^{-3} µg/L. This value is valid for freshwater as well as for the marine compartment.

5.3.5 Selection of MPC_{water} and MPC_{marine}

Freshwater

The lowest value of the routes included is the $MPC_{hh food, water}$. Therefore, the MPC_{water} is 1.6×10^{-3} µg/L.

Marine water

The lowest value of the routes included is the $MPC_{hh food, water}$. Therefore, the MPC_{marine} is 1.6×10^{-3} µg/L.

5.3.6 $MPC_{dw, water}$

Because no A1 value or DWS is available for tetrachlorobenzenes, the $MPC_{dw, water, provisional}$ is derived using the formula in section 3.1.6 of the INS guidance. Using the TDI of 0.21 µg/kg bw day, an average bodyweight of 70 kg and an average uptake of drinking water of 2 L, the $MPC_{dw, water, provisional}$ is 0.74 µg/L. The $MPC_{dw, water, provisional}$ is not taken into account for the derivation of the final MPC_{water}.

5.3.7 Derivation of $MAC_{eco, water}$ and $MAC_{eco, marine}$

Freshwater

The acute dataset contains data for bacteria, crustaceans and fish. Reliable data for algae are lacking in both the acute and the chronic dataset. However, the less reliable (effects above the water solubility) or unassignable data for algae indicate that algae a less sensitive taxonomic group. Therefore, a MAC value is derived for tetrachlorobenzenes. All tetrachlorobenzenes have a BCF > 100 L/kg. Therefore, an assessment factor of 1000 is used on the lowest $L(E)C_{50}$ value (0.13 mg/L, *Ceriodaphnia dubia*) for the derivation of the $MAC_{eco, water}$, resulting in a $MAC_{eco, water}$ of 0.13 mg/L / 1000 = 0.13 µg/L.

Marine water
Based on the data in Tables 32 and 33 and the bioaccumulative properties of 1,2,3,4-tetrachlorobenzene, the $MAC_{eco, marine}$ is derived by applying an assessment factor of 10000 to the lowest $L(E)C_{50}$ value. Thus, the $MAC_{eco, marine}$ is 0.13 mg/L / 10000 = 1.3 x 10^{-2} µg/L.

5.3.8 Derivation of NC

Freshwater
The NC is set a factor of 100 below the MPC. Therefore, the NC_{water} is
1.6 x 10^{-3} µg/L / 100 = 1.6 x 10^{-5} µg/L.
Marine water
The NC is set a factor of 100 below the MPC. Therefore, the NC_{water} is
1.6 x 10^{-3} µg/L / 100 = 1.6 x 10^{-5} µg/L.

5.3.9 Derivation of $SRC_{eco, water}$

The $SRC_{eco, water}$ for tetrachlorobenzenes is based on the geometric mean of the $L(E)C_{50}$ values using an assessment factor of 10, because NOEC values are available for both *Daphnia* and fish and the geometric mean of the $L(E)C_{50}$ value is less than 10 times the geometric mean of the NOEC values. Thus, the $SRC_{eco, water}$ is 0.58 mg/L / 10 = 0.058 mg/L = 58 µg/L. This value is valid for freshwater as well as for the marine compartment.

5.4 Derivation of ERLs for sediment

The log $K_{p, susp\text{-}water}$ of all tetrachlorobenzenes is below the trigger value of 3, therefore, ERLs are not derived for sediment.

5.5 Derivation of ERLs for soil

5.5.1 Toxicity data for soil

Table 28. tetrachlorobenzenes: selected soil toxicity data for ERL derivation

Chronic[a] Taxonomic group	NOEC/EC10 (mg/kg)	Acute[a] Taxonomic group	L(E)C50 (mg/kg)
		Annelida	
		Eisenia andrei	203[b]
		Eisenia andrei	275[b]
		Lumbricus rubellus	248[b]
		Lumbricus rubellus	303[b]

[a] For detailed information see Appendix 3.
[b] Normalised to standard soil.

5.5.2 Derivation of MPC_{soil}

5.5.2.1 $MPC_{eco,\ soil}$

The dataset of tetrachlorobenzenes contains four $L(E)C_{50}$ values for two species: 203 and 275 mg/kg_{dwt} for *Eisenia andrei* (geometric mean 236 mg/kg_{dwt}) and 248 and 303 mg/kg_{dwt} for *Lumbricus rubellus* (geometric mean 274 mg/kg_{dwt}). According to the INS guidance, an assessment factor of 1000 should be applied to the lowest $L(E)C_{50}$ for the derivation of the $MPC_{eco,\ soil}$. Therefore, the $MPC_{eco,\ soil}$ is 236 mg/kg_{dwt} / 1000 = 2.4×10^2 $\mu g/kg_{dwt}$.

5.5.2.2 $MPC_{sp,\ soil}$

The log K_{ow} of the tetrachlorobenzenes exceeds the trigger value of 3 (4.70 for 1,2,4,5-tetrachlorobenzene), so the $MPC_{sp,\ soil}$ should be derived. One BSAF value of 104 g/g lipid was available for earthworms (Belfroid *et al.*, 1994). Using an earthworm lipid content of 1.2% and a correction to standard Dutch soil in the formulas in section 3.3.5 of the INS guidance, the $MPC_{sp,\ soil}$ is 0.488 mg/kg_{dwt} = 4.9×10^2 $\mu g/kg_{dwt}$.

5.5.2.3 $MPC_{human,\ soil}$

The $MPC_{human,\ soil}$ was derived using the formulas in section 3.3.6 of the INS Guidance (Van Vlaardingen en Verbruggen, 2007). These calculations resulted in an $MPC_{human,\ soil}$ of 2.6 $\mu g/kg_{dwt}$ for the consumption of root crops.

5.5.3 Selection of MPC_{soil}

The lowest value of the routes included is the $MPC_{human,\ soil}$. Therefore, the MPC_{soil} for tetrachlorobenzenes is 2.6 $\mu g/kg_{dwt}$.

5.5.4 Derivation of NC_{soil}

The NC is set a factor of 100 below the MPC. Therefore, the NC_{soil} is 2.6 $\mu g/kg_{dwt}$ / 100 = 2.6×10^{-2} $\mu g/kg_{dwt}$.

5.5.5 Derivation of $SRC_{eco,\ soil}$

Since only acute values for the toxicity of 1,2,3,4-tetrachlorobenzene in soil are available, the $SRC_{eco,\ soil}$ is derived by comparing the geometric mean of the $L(E)C_{50}$ values with an assessment factor of 10 with the result of the equilibrium partitioning method (Van Vlaardingen and Verbruggen, 2007). For 1,2,3,4-tetrachlorobenzene, the geometric mean of the $L(E)C_{50}$ values is 254 mg/kg_{dwt}. Using an assessment factor of 10, the $SRC_{eco,\ soil}$ is 254 mg/kg_{dwt} / 10 = 2.5×10^4 $\mu g/kg_{dwt}$.
The $SRC_{eco,\ soil}$ derived using the equilibrium partitioning method is 2.9×10^4 $\mu g/kg_{dwt}$. Therefore, the $SRC_{eco,\ soil}$ is set to 2.5×10^4 $\mu g/kg_{dwt}$.

5.6 Derivation of ERLs for groundwater

5.6.1 Derivation of MPC_{gw}

5.6.1.1 $MPC_{eco,\ gw}$

Since no toxicity data are available for the groundwater compartment, the $MPC_{eco,\ water}$ for surface water is taken as a substitute. Therefore, the $MPC_{eco,\ gw}$ is 0.46 $\mu g/L$.

5.6.1.2 $MPC_{human,\ gw}$

The $MPC_{dw,\ water,\ provisional}$ is used as a substitute for the $MPC_{human,\ gw}$. Therefore, the $MPC_{human,\ gw}$ is 0.74 µg/L.

5.6.2 Selection of MPC_{gw}

The lowest value of the routes included is the $MPC_{eco,\ water}$. Therefore, the MPC_{gw} is 0.46 µg/L.

5.6.3 Derivation of NC_{gw}

The NC is set a factor of 100 below the MPC. For groundwater therefore, the NC_{gw} is
0.46 µg/L / 100 = 4.6×10^{-3} µg/L.

5.6.4 Derivation of $SRC_{eco,\ gw}$

Since no toxicity data are available for the groundwater compartment, the $SRC_{eco,\ water}$ for surface water is taken as a substitute. Therefore, the $SRC_{eco,\ gw}$ is 58 µg/L.

5.7 Derivation of ERLs for air

5.7.1.1 $MPC_{eco,\ air}$

Since no data on the ecotoxicity of tetrachlorobenzenes in air are available, no $MPC_{eco,\ air}$ can be derived.

5.7.1.2 $MPC_{human,\ air}$

The $MPC_{human,\ air}$ is set at the same value as the TCA. Since no TCA for tetrachlorobenzenes is available, no $MPC_{human,\ air}$ can be derived.

5.7.2 Selection of MPC_{air}

The MPC_{air} for tetrachlorobenzenes cannot be derived.

5.8 Overview of MPCs for tetrachlorobenzenes

In Table 29, an overview of the ERLs derived for tetrachlorobenzenes is given.

Table 29. Tetrachlorobenzenes: derived NC, MPC, MAC_{eco} and SRC_{eco}

ERL	Unit	NC	MPC	MAC_{eco}	SRC_{eco}
Water	µg/L	1.6×10^{-5}	1.6×10^{-3}	0.13	58
Marine	µg/L	1.6×10^{-5}	1.6×10^{-3}	1.3×10^{-2}	58
Soil	µg/kg	2.6×10^{-2}	2.6	n.a.	2.5×10^{3}
Groundwater	µg/L	4.6×10^{-3}	0.46	n.a.	58
Air	µg/m^3	n.a.	n.d.	n.a.	n.a.
Drinking water	µg/L	n.a.	0.74	n.a.	n.a.

5.9 Comparison of derived ERLs with monitoring data

Monitoring data for the Rhine from the years 2003–2006, obtained from RIWA (Association of River Waterworks), show that at all sampling occasions and locations, the concentration of tetrachlorobenzenes in water was usually below detection limits (0.01 µg/L). However, it should be noted that monitoring data are not reported for all tetrachlorobenzenes. In 2003–2005, measured concentrations are reported for 1,2,3,4- and 1,2,4,5-tetrachlorobenzene. In 2006, only for 1,2,4,5-tetrachlorobenzene concentrations were reported.
On two occasions in 2004, a concentration of 0.05 µg 1,2,3,4-tetrachlorobenzene/L was measured, which would result in an exceedance of the MPC_{water} and potentially the MAC for tetrachlorobenzenes. In more recent monitoring reports, no tetrachlorobenzenes were measured above detection limits.

5.10 Sum limits

The small differences in toxicity of the individual tetrachlorobenzenes can result in unacceptable risks when a mixture of tetrachlorobenzenes is present at one location. In order to prevent this accumulation of toxicity, the use of a sum limit for tetrachlorobenzenes is proposed. In this approach, the sum of the concentrations of the combination of the three individual tetrachlorobenzenes should not exceed the ERLs for the grouped tetrachlorobenzenes (Table 29). It should be noted that the sum limit only applies when all three tetrachlorobenzenes are included in the analysis.

6 Conclusions

In this report, the risk limits negligible concentration (NC), maximum permissible concentration (MPC), maximum acceptable concentration for ecosystems (MAC_{eco}), and serious risk concentration for ecosystems (SRC_{eco}) are derived for monochlorobenzene, the group of three dichlorobenzenes (1,2-dichlorobenzene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene) and the group of three tetrachlorobenzenes (1,2,3,4-tetrachlorobenzene, 1,2,3,5-tetrachlorobenzene and 1,2,4,5-tetrachlorobenzene) in water, groundwater, soil and air. No risk limits were derived for water organisms via the sediment compartment because the triggers to derive such limits were not exceeded.

The ERLs that were obtained are summarised in the table below. Because of the small difference in toxicity of the individual isomers, the risk limits for di- and tetrachlorobenzenes refer to a sum limit. In this approach, the sum of the concentrations of the individual di- or tetrachlorobenzenes should not exceed the ERLs for the group. The sum limit only applies when all isomers are included in the analysis. It should further be noted that the respective chlorobenzenes may occur simultaneously, and an additive effect cannot be excluded.

Table 30. Derived NC, MPC, MAC_{eco}, and SRC_{eco} values

ERL	Unit	Substance	NC	MPC	MAC_{eco}	SRC_{eco}
Water	µg/L	monochlorobenzene	0.32	32	40	1.9×10^3
Marine	µg/L	monochlorobenzene	3.2×10^{-2}	3.2	4.0	1.9×10^3
Soil	µg/kg	monochlorobenzene	4.3	4.3×10^2	n.a.	2.6×10^4
Groundwater	µg/L	monochlorobenzene	0.32	32	n.a.	1.9×10^3
Air	µg/m^3	monochlorobenzene	n.a.	5.0×10^2	n.a	n.a.
Drinking water	µg/L	monochlorobenzene	n.a.	2.1×10^2	n.a.	n.a.
Water	µg/L	dichlorobenzenes	6.9×10^{-2}	6.9	20	6.8×10^2
Marine	µg/L	dichlorobenzenes	2.0×10^{-2}	2.0	2.0	6.8×10^2
Soil	µg/kg	dichlorobenzenes	3.1	3.1×10^2	n.a.	2.0×10^4
Groundwater	µg/L	dichlorobenzenes	0.20	20	n.a.	6.8×10^2
Air	µg/m^3	dichlorobenzenes	n.a.	n.d.	n.a.	n.a.
Drinking water	µg/L	dichlorobenzenes	n.a.	3.8×10^2	n.a.	n.a.
Water	µg/L	tetrachlorobenzenes	1.6×10^{-5}	1.6×10^{-3}	0.13	58
Marine	µg/L	tetrachlorobenzenes	1.6×10^{-5}	1.6×10^{-3}	1.3×10^{-2}	58
Soil	µg/kg	tetrachlorobenzenes	2.6×10^{-2}	2.6	n.a.	2.5×10^4
Groundwater	µg/L	tetrachlorobenzenes	4.6×10^{-3}	0.46	n.a.	58
Air	µg/m^3	tetrachlorobenzenes	n.a.	n.d.	n.a.	n.a.
Drinking water	µg/L	tetrachlorobenzenes	n.a.	0.74	n.a.	n.a.

n.d. = not derived.

n.a. = not applicable.

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Appendix 1. Information on bioconcentration

Detailed information on bioconcentration is presented in the following tables. For explanation of symbols and abbreviations, see Van Vlaardingen and Verbruggen, 2007. For information on the reliability index, see section 2.2 of the main text. In case of citations, the original reference is given behind the secondary source. If cited references could be retrieved, they were checked and included in the reference list. Otherwise, evaluation was based on the secondary source.

Legend to column headings	
A	test water analysed Y(es)/N(o)
Test type	S = static; Sc = static closed; R = renewal; F = flow through; CF = continuous flow; IF = intermittent flow system
Purity	refers to purity of active substance or content of active in formulation
Test water	am = artificial medium; dtw = dechlorinated tap water; dw = deionised/dechlorinated/distilled water; nw= natural water; rw = reconstituted water; rtw = reconstituted tap water; tw = tap water
T	temperature
Ri	Reliability index according to Klimisch *et al*. (1997); asterisk indicates citation

Table A1.1. Bioconcentration data for monochlorobenzene

Species	Species properties	Subst. purity [%]	A	Test type	Test water	pH	Hardness/ Salinity	Temp. [°C]	Exp. time	Exp. conc. [mg/L]	BCF [L/kg]	BCF type	Method	Ri	Notes	Reference
Algae																
Chlorella fusca									24h	0.05	50			4		Freitag et al., 1984
Oedogonium cardiacum									24h	0.01-0.1	4185		cosm	4	2	Lu and Metcalf, 1975
Pseudokirchneriella subcapitata									24h	10	2172			4		Casserly et al., 1983
Crustacea																
Daphnia magna									24h	0.01-0.1	2789		cosm	4	2	Lu and Metcalf, 1975
Insecta																
Culex quinquifasciatus									24h	0.01-0.1	1292		cosm	4	2	Lu and Metcalf, 1975
Mollusca																
Physa									24h	0.01-0.1	1313		cosm	4	2	Lu and Metcalf, 1975
Pisces																
Gambusia affinis									48h	0.01-0.1	645		cosm	4	2	Lu and Metcalf, 1975
Lepomis macrochirus								22	14d	0.001005	41			4	3	IUCLID, 2000: Monsanto and Bayer AG
Leuciscus idus									72h	0.05	70			3	4	Freitag et al., 1984
Leuciscus idus									72h	0.05	75			3	4	Freitag, 1987
Leuciscus idus										0.05	75			4	1	Freitag et al., 1984
Pimephales promelas	mature female			Sc	nw	>6.6	75-85	21-22	until steady state	3.6	84		kinetic	2		De Wolf and Lieder, 1998
Pimephales promelas									28d		447			4		BUA.054: ref. 31

Species	Species properties	Subst. purity [%]	A	Test type	Test water	pH	Hardness/ Salinity	Temp. [°C]	Exp. time	Exp. conc. [mg/L]	BCF [L/kg]	BCF type	Method	Ri	Notes	Reference
Cyprinus carpio	32 g, 12 cm		GC-FID	CF				25±2	56d	46	25	wwt	kinetic	2	5	METI (http://www.safe.nite.go.jp)
Cyprinus carpio	32 g, 12 cm		GC-FID	CF				25±2	56d	8.6	11	wwt	kinetic	2	5	METI (http://www.safe.nite.go.jp)
fish				F							12-450			4		Hesse et al., 1991: Kenaga, 1980 and EPA, 1984
fish											10-447			4		IUCLID, 2000: Petrasol BV

Notes
1 Unit unclear
2 Based on dry weight
3 According to ASTM guidelines
4 Exposure duration too short
5 Recalculated from original data

Table A1.2. Bioconcentration data for 1,2-dichlorobenzene

Species	Species properties	Subst. purity [%]	A	Test type	Test water	pH	Hardness/ Salinity	Temp. [°C]	Exp. time	Exp. conc. [mg/L]	BCF [L/kg]	BCF type	Method	Ri	Notes	Reference
Algae																
cyanobacteria and green algae									40h		6212			4		BUA.053: Davis et al., 1983
Pseudokirchneriella subcapitata									24h	10	19700			4		Casserly et al., 1983
Pseudokirchneriella subcapitata									24h	2	10080			3	1	Casserly et al., 1983
Crustacea																
Callinectes sapidus	0.5% lipid		GC-MS							9 ng/L	144		equi	4	2	Pereira et al., 1988
Pisces																
Cynoscion nebulosis	2.3% lipid		GC-MS							9 ng/L	142		equi	4	2	Pereira et al., 1988
Cyprinus carpio									21d	70.3 µg/L	40			4		BUA.053: Tadokoro and Tomita, 1987
Cyprinus carpio									56d	0.01	90-260			4	3	IUCLID, 2000: Bayer
Cyprinus carpio									56d	0.1	150-230			4	3	IUCLID, 2000: Bayer
Cyprinus carpio	31 g, 11 cm		GC-ECD	CF				25±2	56d	53	178	wwt	k1/k2	2	6	METI (http://www.safe.nite.go.jp)
Cyprinus carpio	31 g, 11 cm		GC-ECD	CF				25±2	56d	6.3	174	wwt	k1/k2	2	6	METI (http://www.safe.nite.go.jp)
Ictalurus furcatus	3.3% lipid		GC-MS							9 ng/L	218		equi	4	2	Pereira et al., 1988
Lepomis macrochirus	0.37-0.95 g			IF	nw	7.1	35	16	14d	0.00789	89			4*	4	Veith et al., 1980
Lepomis macrochirus	0.37-0.95 g			F	nw	6.3-7.9		16	14d	0.00789	89			2	4	Barrows et al., 1978
Micropogonias undulatus										9 ng/L	192		equi	4	2	BUA.053: Pereira et al., 1988
Oncorhynchus mykiss				F					119d	0.047 µg/L	270		equi	3	5	Oliver and Niimi, 1983
Oncorhynchus mykiss				F					105d	0.940 µg/L	560		equi	3	5	Oliver and Niimi, 1983
Pimephales promelas	0.39 g	95	GC	R	tw				8d	10.3	454	steady state	k1/k2	2	3	Sijm et al., 1993
Poecilia reticulata	3 m/o	95	GC	R	tw				8d	1.5	251	steady state	k1/k2	2	3	Sijm et al., 1993

Notes
1 Mixture with 7 other aromatic compounds
2 Field study in contaminated estuary
3 According to OECD guidelines
4 Closed system; equilibrium reached after 14 days
5 Equilibrium after 7-8 days; loading too high (18 g fish/L)
6 Recalculated from original data

Table A1.3. Bioconcentration data for 1,3-dichlorobenzene

Species	Species properties	Subst. purity [%]	A	Test type	Test water	pH	Hardness/ Salinity	Temp. [°C]	Exp. time	Exp. conc. [mg/L]	BCF [L/kg]	BCF type	Method	Ri	Notes	Reference
Pisces																
Cyprinus carpio				F					8w	0.1	57-229			4		BUA.133: MITI, 1992
Cyprinus carpio				F					8w	0.01	58-370			4		BUA.133: MITI, 1992
Cyprinus carpio				F				25	64d	0.1	57-229			4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Cyprinus carpio				F				25	64d	0.01	58-370			4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Cyprinus carpio	4.8% lipids, 32.2 g, 10.7 cm	98	GC-MS	CF				25±2	56d	83	138	wwt	k1/k2	2	5	METI (http://www.safe.nite.go.jp)
Cyprinus carpio	4.8% lipids, 32.2 g, 10.7 cm	98	GC-MS	CF				25±2	56d	8.9	195	wwt	k1/k2	2	5	METI (http://www.safe.nite.go.jp)
Lepomis macrochirus	0.37-0.95 g			F	nw	6.3-7.9		16	14d	0.107	66			2		Barrows et al., 1978
Lepomis macrochirus	0.37-0.94 g			F	nw	7.1	35	16	14d	0.107	66		k1/k2	4*		Veith, 1981
Lepomis macrochirus				F				16	14d	0.107	66		k1/k2	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Oncorhynchus mykiss				F					119d	0.000028	420			3	2	Oliver and Niimi, 1983
Oncorhynchus mykiss				F					105d	0.00069	740			3	2	Oliver and Niimi, 1983
Oncorhynchus mykiss				F				15	105d	0.00069	740		k1/k2	4*	1	IUCLID, 2000: Hoechst AG and Clariant GmbH
Oncorhynchus mykiss				F				15	119d	0.000028	420		k1/k2	4*	1	IUCLID, 2000: Hoechst AG and Clariant GmbH
Pimephales promelas											98			4		Veith, 1981
Pimephales promelas		98						25	32d		97			4		IUCLID, 2000: Hoechst AG and Clariant GmbH
Pimephales promelas									30d		98			4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Pimephales promelas	mature female, 1.45-4.71 g	98		Sc	nw	>6.6	75-85	21-22	until steady state	2.5	728	kinetic		2		De Wolf and Lieder, 1998
Poecilia reticulata	2y old; 15-20 mm; 206-283 mg; 5% lipids	>97	GC-ECD	S	tw/dw			13	48h		294	steady state	Cf/Cw	3	3,4	Opperhuizen et al., 1988
Poecilia reticulata	2y old; 15-20 mm; 206-283 mg; 5% lipids	>97	GC-ECD	S	tw/dw			19	48h		301	steady state	Cf/Cw	3	3,4	Opperhuizen et al., 1988
Poecilia reticulata	2y old; 15-20 mm; 206-283 mg; 5% lipids	>97	GC-ECD	S	tw/dw			28	48h		330	steady state	Cf/Cw	3	3,4	Opperhuizen et al., 1988
Poecilia reticulata	2y old; 15-20 mm; 206-283 mg; 5% lipids	>97	GC-ECD	S	tw/dw			33	48h		346	steady state	Cf/Cw	3	3,4	Opperhuizen et al., 1988
Poecilia reticulata		>97						33	48h	sol. limit	6918			4		IUCLID, 2000: Hoechst AG and Clariant GmbH

Notes
1 Closed system; equilibrium reached after 14 days
2 Loading too high (18 g fish/L)
3 Exposure in a mixture
4 Equilibrium was reached in a preliminary study at 48h but this does not seem to be reliable; original BCF in ref reported based on lipid contents, recalculated using 5% lipids
5 Recalculated from original data

Table A1.4. Bioconcentration data for 1,4-dichlorobenzene

Species	Species properties	Subst. purity [%]	A	Test type	Test water	pH	Hardness/ Salinity	Temp. [°C]	Exp. time	Exp. conc. [mg/L]	BCF [L/kg]	BCF type	Method	Ri	Notes	Reference
Pisces																
Cyprinus carpio		98.9	HPLC-UV	CF		7.3-7.6		25±2	35d	1.9	69	wwt	k1/k2	2	1	METI (http://www.safe.nite.go.jp)
Cyprinus carpio		98.9	HPLC-UV	CF		7.3-7.6		25±2	35d	0.18	80	wwt	k1/k2	2	1	METI (http://www.safe.nite.go.jp)
Poecilia reticulata	female, 0.62 g; 5.4% lipid weight	>97	GC	F	tw		89	21	2 d	0.116	97	steady state	Cf/Cw	2	2,3	Könemann and Van Leeuwen, 1980

Notes
1 Recalculated from original data
2 Exposure in a mixture
3 Total exposure was 19 d but BCF was calculated after 2 d of exposure. BCF recalculated from original value (1800), which was based on lipid content.

Table A1.5. Bioconcentration data for 1,2,3,4-tetrachlorobenzene.

Species	Species properties	Subst. purity [%]	A	Test type	Test water	pH	Hardness/ Salinity	Temperature [°C]	Exp. time	Exp. conc. [mg/L]	BCF [L/kg]	BCF type	Method	Ri	Notes	Reference
Pisces																
Cyprinus carpio	4.5% lipids, 26.7 g, 10.1 cm	97	GC-ECD	CF				25±1	56 d	9.0	1122	wwt	k1/k2	2	1	METI (http://www.safe.nite.go.jp)
Cyprinus carpio	4.5% lipids, 26.7 g, 10.1 cm	97	GC-ECD	CF				25±1	56 d	0.84	1159	wwt	k1/k2	2	1	METI (http://www.safe.nite.go.jp)
Poecilia reticulata	3 m/o	95	GC	R	tw				8d	0.36	2310	steady state	k1/k2	2	2	Sijm et al., 1993
Poecilia reticulata	2y old; 15-20 mm; 206-283 mg; 5% lipids	>97	GC-ECD	S	tw/dw			13	48h		2506	steady state	Cf/Cw	3	3,4	Opperhuizen et al., 1988
Poecilia reticulata	2y old; 15-20 mm; 206-283 mg; 5% lipids	>97	GC-ECD	S	tw/dw			19	48h		2748	steady state	Cf/Cw	3	3,4	Opperhuizen et al., 1988
Poecilia reticulata	2y old; 15-20 mm; 206-283 mg; 5% lipids	>97	GC-ECD	S	tw/dw			28	48h		2812	steady state	Cf/Cw	3	3,4	Opperhuizen et al., 1988
Poecilia reticulata	2y old; 15-20 mm; 206-283 mg; 5% lipids	>97	GC-ECD	S	tw/dw			33	48h		3459	steady state	Cf/Cw	3	3,4	Opperhuizen et al., 1988
Poecilia reticulata	150 mg, 18 mm	>95		Sc	tw/dw				290h	0.06	6600	whole fish	equi	3	5	Schrap and Opperhuizen, 1990

Notes
1 Recalculated from original data
2 According to OECD guidelines
3 Exposure in a mixture
4 Equilibrium was reached in a preliminary study at 48 h but this does not seem to be reliable; original BCF in ref reported based on lipid contents, recalculated using 5% lipids
5 mortality during test

Table A1.5. Bioconcentration data for 1,2,3,5-tetrachlorobenzene

Species	Species properties	Subst. purity [%]	A	Test type	Test water	pH	Hardness/ Salinity	Temp. [°C]	Exp. time	Exp. conc. [mg/L]	BCF [L/kg]	BCF type	Method	Ri	Notes	Reference
Pisces																
Lepomis macrochirus	0.37-0.95 g			F	nw	6.3-7.9		16	28d	0.00772	1800			3	1	Barrows et al., 1978
Poecilia reticulata	female, 0.62 g, lipid content 5.4%		GC	F	tw			21	7d	0.0012	3888	steady state	Cf/Cw	2	2	Könemann and Van Leeuwen, 1980

Notes
1 Equilibrium not reached after 28 days
2 Total exposure was 19 d, but BCF was calculated after 7 d of exposure. BCF recalculated from original value (72000), which was based on lipid content. Original value lipid based (72000 L/kg) was recalculated; exposure to a mixture of chlorobenzenes; actual concentration measured

Table A1.6. Bioconcentration data for 1,2,4,5-tetrachlorobenzene

Species	Species properties	Subst. purity [%]	A	Test type	Test water	pH	Hardness/ Salinity	Temp. [°C]	Exp. time	Exp. conc.. [mg/L]	BCF [L/kg]	BCF type	Method	Ri	Notes	Reference
Algae																
Selenastrum capricornutum	exponential growth phase										7700		equi	4		BUA.086: Mailhot, 1987
Pisces																
Cyprinus carpio	5.7% lipids, 24.7 g, 9.7 cm	99	GC-ECD	CF				25±1	56 d	7.2	3543	wwt	k1/k2	2	1	METI (http://www.safe.nite.go.jp)
Cyprinus carpio	5.7% lipids, 24.7 g, 9.7 cm	99	GC-ECD	CF				25±1	56 d	0.73	3128	wwt	k1/k2	2	1	METI (http://www.safe.nite.go.jp)
Cyprinus carpio	20-30 g			F				25	28d	7.24 µg/L	1122		equi	4		BUA.086: Tadokoro and Tomita, 1987
Cyprinus carpio	20-30 g			F				25	28d	7.24 µg/L	3981		equi	4		BUA.086: Tadokoro and Tomita, 1987
Jordanella floridae	4-6mo; lipid content 8.5%			F				25	28d	3.02 µg/L	4050		k1/k2	2		Smith et al., 1990
Oncorhynchus mykiss	not yet fully grown			F	nw				119d	1 ± 0.5	6200		equi	3	2	Oliver and Niimi, 1983
Oncorhynchus mykiss	not yet fully grown			F	nw				105d	21 ± 13 ng/L	15000		equi	3	2	Oliver and Niimi, 1983

Notes
1 Recalculated from original data
2 Loading too high (18 g fish/L)

Appendix 2. Detailed aquatic toxicity data

Detailed information on bioconcentration is presented in the following tables. For an explanation of the symbols and abbreviations, see Van Vlaardingen and Verbruggen, 2007. For information on the reliability index, see section 2.2 of the main text. In case of citations, the original reference is given behind the secondary source. If cited references could be retrieved, they were checked and included in the reference list. Otherwise, evaluation was based on the secondary source.

Legend to column headings	
A	test water analysed Y(es)/N(o)
Test type	S = static; Sc = static closed; R = renewal; F = flow through; CF = continuous flow; IF = intermittent flow system
Purity	refers to purity of active substance or content of active substance in formulation
Test water	am = artificial medium; dtw = dechlorinated tap water; dw = deionised/dechlorinated/distilled water; nw= natural water; rw = reconstituted water; rtw = reconstituted tap water; tw = tap water
T	temperature
Ri	Reliability index according to Klimisch et al. (1997); asterisk indicates citation

Table A2.1. Acute toxicity of monochlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Activated sludge									30min	EC50	resp. inhibition	140	4	1	IUCLID, 2000
Activated sludge									30min	EC50	resp. inhibition	2950	3	2, 40	IUCLID, 2000: Bayer AG
Activated sludge									24d	EC50		20	4	3	IUCLID, 2000: Bayer AG
Aerobicheterotrophs									15h	EC50	resp. inhibition	310	4	4	IUCLID, 2000: Bayer AG
Pseudomonas fluorescens										EC50	luminescence	118.3	4*	8	Warne et al., 1999
Pseudomonas fluorescens		Y	S	>98	am	7.1	25		20 min	EC50	luminescence	118.5	2	6	Boyd et al., 1998
Protozoa															
Tetrahymena pyriformis			Sc	>95	am	7.34	27		40h	IC50	growth inhibition	83.5	3	9	Schultz, 1999
Algae															
Ankistrodesmus falcatus		N	Sc		am	8	20		4h	EC50	photosynth.	50.3	3	10	Wong et al., 1984
Chlamydomonas angulosa	5*10^4 cells/mL	N	Sc		am	6.5	19		3h	EC50	photosynth.	57	3	11	Hutchinson et al., 1980
Clamydomonas sp.									3h	EC50		56.6	4*		IUCLID, 2000: Petrasol BV
Chlorella vulgaris	20*10^4 cells/mL	N	Sc		am	6.5	19		3h	EC50	photosynth	99	3	12	Hutchinson et al., 1980
Cyclotella sp.									48h	EC50		235.7	4	39	IUCLID, 2000: Petrasol BV
Pseudokirchneriella subcapitata									120h	EC50	cell number	280	4		IUCLID, 2000: Bayer AG
Pseudokirchneriella subcapitata		Y	Sc		am				96h	EC50	growth	12.5	2	15	Calamari et al., 1983

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Pseudokirchneriella subcapitata	5mln cells/l	Y	Sc		am		20		96h	EC50	growth inhibition	12.5	2	16	Galassi and Vighi, 1981
Pseudokirchneriella subcapitata			Sc						96h	EC50	cell number	12.5	4*		IUCLID, 2000: Bayer AG
Pseudokirchneriella subcapitata									96h	EC50		224	4		IUCLID, 2000: Petrasol BV
Pseudokirchneriella subcapitata									96h	EC50	cell growth	224	4*		US-EPA, 1980
Pseudokirchneriella subcapitata									96h	EC50	cell number	232	4		US-EPA, 1980
Scenedesmus subspicatus									48h	EC50	biomass	110	4	17	IUCLID, 2000: Bayer AG
Scenedesmus subspicatus									48h	EC50	growth rate	220	4	17	IUCLID, 2000: Bayer AG
Crustacea															
Ceriodaphnia dubia	< 12 h	N	S		nw	8.2± 0.2	25±2	90-110	48h	LC50	mortality	47	3	13	Cowgill and Milazzo, 1991
Ceriodaphnia cf. *dubia*	< 24 h	Y	S	>97		7.7	23±1	65.2	48h	EC50	immobility	5.29	2		Rose et al., 1998
Ceriodaphnia dubia	< 24 h	Y	Sc	>99.9	nw	7.6	25	45.5	24h	LC50	mortality	7.6	2	18	Marchini et al., 1993
Ceriodaphnia dubia/affinis	neonates	N	Sc		nw	8.2-9.0	20	90	48h	LC50	mortality	8.9	3	19	Hesse et al., 1991: Cowgill et al., 1985
Ceriodaphnia dubia/affinis	neonates	N	Sc		nw	8.2-8.8	24	90	48h	LC50	mortality	11.1	3	19	Hesse et al., 1991: Cowgill et al., 1985
Daphnia carinata	< 24 h	Y	S				20		48h	EC50	immobility	3.99	2		Warne et al., 1999: Khalil, 1998
Daphnia magna			Sc		nw	7			24h	EC50	immobility	16	3	20	Bazin et al., 1987
Daphnia magna	<72 h		Sc		am	7.8-8.2	20	200	24h	EC50	immobility	12	3	21	Devillers et al., 1987
Daphnia magna	<24 h	N	S		am	8.0± 0.2	20	250.2	24h	EC50	immobility	195	3	13	Bringmann and Kühn, 1982
Daphnia magna	<24 h	N	S		tw	7.6-7.7	20-22	286	24h	EC50	immobility	310	3	13	Bringmann and Kühn, 1977b
Daphnia magna		Y	Sc		am				24h	EC50	immobility	4.3	2	20, 22	Calamari et al., 1983
Daphnia magna	< 24 h	N	S		am	7.5± 0.3	21±2	115±8	24h	LC50	immobility	6.2	3	23	Wei et al., 1999
Daphnia magna	1.5 mm	N	Sc		aw	6-7			48h	EC50	immobility	0.58	3	23	Bobra et al., 1985
Daphnia magna			Sc			7			48h	LC50	immobility	0.59	4		IUCLID, 2000: Hoechst AG and Clariand GmbH
Daphnia magna	< 48 h	Y	S		am (DSW)		22±1	100	48h	LC50	immobility	26	2	24	Hermens et al., 1984
Daphnia magna			Sc						24h	LC50	mortality	16	4		IUCLID, 2000: Bayer AG
Daphnia magna			S						24h	LC50	mortality	34	3	13	IUCLID, 2000: Bayer AG
Daphnia magna			Sc						24h	LC50	mortality	140	4		IUCLID, 2000: Bayer AG
Daphnia magna			S						24h	LC50	mortality	310	4		IUCLID, 2000: Bayer AG
Daphnia magna		N	S						48h	EC50		86	3	13	US-EPA, 1980
Daphnia magna	neonates	N	Sc		aw	8	20	160	48h	LC50	mortality	12.9	3		Hesse et al., 1991: Cowgill et al., 1985
Dapnhia magna			S		nw	8	20	170	48h	LC50	mortality	12.9	4*		Gersich et al., 1986
Daphnia magna	neonates	N	Sc		aw	8	24	160	48h	LC50	mortality	17.3	3		Hutchinson et al., 1980
Daphnia magna	< 12 h	N	S		nw	8.2± 0.2	25±2	160-180	48h	LC50	mortality	31	3	13	Cowgill and Milazzo, 1991
Daphnia magna			S			8.2	25		48h	LC50	mortality	31	4*		IUCLID, 2000: Bayer AG
Daphnia magna		N	S		nw	7.7-8.3	19.8-20.9	157±4	48h	LC50	mortality	13.9	3	13	Gersich et al., 1986
Daphnia magna			S			8.2	25		48h	LC50	mortality	47	4		IUCLID, 2000: Bayer AG
Daphnia magna									48h	LC50	mortality	19.9	4	25	IUCLID, 2000: Monsanto and Bayer AG
Daphnia magna									48h	LC50	mortality	0.59	4	26	IUCLID, 2000: Petrasol BV
Daphnia magna									48h	LC50	mortality	5.8	4	27	IUCLID, 2000: Petrasol BV
Daphnia magna	< 24 h	N	Sc	-	rw	6.7-8.1	22±1	72±6	48h	LC50	mortality	86	3	28	LeBlanc, 1980
Daphnia magna									48h	LC50	mortality	5.8	4	29	Zhao et al., 1993
Daphnia magna	4-6 days	N	Sc	>97%	dw		23±2		48h	LC50	mortality	0.58	3		Abernethy et al., 1986

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Daphnia pulex	<24 h	N	S	ag	am		20	293.6	96h	LC50	mortality	32.2	3	13	Ikemoto et al., 1992
Pisces															
Carassius auratus	3.8-6.4 cm, 1-2 g	N	S		nw diluted	7.5	25	soft water	96h	LC50	mortality	51.62	3	13, 29	Pickering and Henderson, 1966
Carassius auratus			S			7	12.8	300	24h	LC50	mortality	5	4	30	BUA.054: Wood, 1953
Cyprinus carpio	5 g, 5 cm	N	R				20±1		48h	LC50	mortality	19	3		Zhao et al., 1993
Danio rerio		Y	Sc		am	7.4	23	310	48h	LC50	mortality	10.5	2	31	Calamari et al., 1983.
Danio rerio	3 +/- 0.5 cm		S				22		96h	LC50	mortality	91	4	32	BUA.054: Rompps Chemie-Lexikon, 1979
Danio rerio			S						96h	LC50	mortality	91	4*		IUCLID, 2000 Bayer AG
Lepomis macrochirus	juv. 3.65±0.72 cm, 0.90±0.22 g	Y	S	reagent grade	dtw		22±1	30.2	96h	LC50	mortality	4.5	2	28, 33	Bailey et al., 1985
Lepomis macrochirus		Y	S						96h	LC50	mortality	4.5	4*		IUCLID, 2000: Bayer AG
Lepomis macrochirus	juv. 3.65±0.72 cm, 0.90±0.22 g	Y	F	reagent grade	dtw		22±1	30.2	96h	LC50	mortality	7.4	2	28, 33	Bailey et al., 1985
Lepomis macrochirus		Y	F						96h	LC50	mortality	7.4	4*	28	IUCLID, 2000 Bayer AG
Lepomis macrochirus	0.31-1.2 g	N	S	>80%	rw	6.5-7.9	21-23	31-48	96h	LC50	mortality	16	3	23	Buccafusco et al., 1981
Lepomis macrochirus		N	S						96h	LC50	mortality	15.9	4*	13	US-EPA, 1980
Lepomis macrochirus	3.8-6.4 cm, 1-2 g	N	S		nw diluted	7.5	25	~20	96h	LC50	mortality	24	3	13, 29	Pickering and Henderson, 1966
Lepomis macrochirus									96h	LC50	mortality	19.95	4	28	BUA.054: Janardan et al., 1984
Lepomis macrochirus	juveniles		S		nw	6.7-7.8	22	28-33	96h	LC50	mortality	6	3	28	Buccafusco et al., 1981
Lepomis macrochirus			S			7	12.8	300	24h	LC50	mortality	5	3	30	BUA.054: Wood, 1953
Leuciscus idus			S						96h	LC50	mortality	42.2	4		IUCLID, 2000: Bayer AG
Leuciscus idus melanotus		N	S	-	tw	7--8	20±1	255	48h	LC50	mortality	24	3	13, 34	Juhnke and Lüdemann, 1978
Oncorhynchus mykiss		Y	Sc		am	7.4	15	310	48h	LC50	mortality	4.1	2	31	Calamari et al., 1983
Oncorhynchus mykiss			Sc						48h	LC50	mortality	4.1	4*		IUCLID, 2000: Bayer AG
Oncorhynchus mykiss	200-400 g	Y	F		nw		15		96h	LC50	mortality	4.7	2		Dalich et al., 1982
Oncorhynchus mykiss		Y	F						96h	LC50		4.7	4*		McCarty et al., 1985
Oncorhynchus mykiss	4.6-6.4 cm		F		am	7.6-8.2	15		96h	LC50	mortality	7.47	2		Hodson et al., 1984
Oncorhynchus mykiss			F						96h	LC50	mortality	7.46	4*		IUCLID, 2000: Petrasol BV
Oryzias latipes									48h	LC50	mortality	17	4	35	IUCLID, 2000: Bayer AG
Oryzias latipes	0.2 g	N	S	ag	am		20	293.6	24h	LC50	mortality	55.1	3	13	Ikemoto et al., 1992
Perca flavescens			S			7	12.8	300	24h	LC50	mortality	5	3	30	BUA.054: Wood, 1953
Pimephales promelas	30-34 d	N	F		rw		25	43.3-48.5	96h	LC50	mortality	19	2		Hall et al., 1989
Pimephales promelas										LC50	mortality	27	4	8, 36	Nendza and Russom, 1991
Pimephales promelas	3.8-6.4 cm, 1-2 g	N	S		nw diluted	7.5	25	soft water	96h	LC50	mortality	29.12	3	13, 29	Pickering and Henderson, 1966
Pimephales promelas	3.8-6.4 cm, 1-2 g	N	S		nw diluted	7.5	25	hard water	96h	LC50	mortality	33.93	3	13, 29	Pickering and Henderson, 1966
Pimephales promelas									96h	LC50	mortality	19	4	8	Zhao et al., 1993
Pimephales promelas	28-36 d	Y	F		nw		25±1		96h	LC50	mortality	16.9	2		Fathead minnow database, US- EPA, 2008
Pimephales promelas	fry	N	Sc	rg	rw	7.6-8.3		96-125	96h	LC50	mortality	22.3	4*		Hesse et al., 1991: Mayes et al., 1983
Pimephales promelas			F						96h	LC50	mortality	22.2	4		IUCLID, 2000a: Petrasol BV
Pimephales promelas	30-34 d		Sc				22		96h	LC50	mortality	35.4	2		Pickering and Henderson, 1966
Pimephales promelas	60-100 d		Sc				22		96h	LC50	mortality	22.2	3		Pickering and Henderson, 1966
Pimephales promelas			F						96h	LC50	mortality	19.12	4		IUCLID, 2000: Bayer AG
Pimephales promelas									48h	LC50	mortality	26	4		IUCLID, 2000: Bayer AG

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Pimephales promelas	larvae	Y	F	>99.9	nw	7.6	25	45.5	24h	LC50	mortality	7.7	2	37	Marchini et al., 1993
Pimephales promelas	30-34 days old	N	F		nw		25	43.3-48.5	96h	LC50	mortality	19.1	2		Hall et al., 1984
Poecilia reticulata	6 m old, 1.9-2.5 cm, 0.1-0.2 g	N	S		nw diluted	7.5	25	~20	96h	LC50	mortality	44	3	13, 29	Pickering and Henderson, 1966
Poecilia reticulata									7-14d	LC50	mortality	19	4	8	Zhao et al., 1993
Poecilia reticulata	2-3 m/o		S						24h	LC50	mortality	5.63	4		Benoit-Guyod et al., 1984
Poecilia reticulata	2-3 m/o		Rc					25	14d	LC50	mortality	19.1	4		IUCLID, 2000: Bayer AG
Poecilia reticulata		Y	F						96h	LC50		23	4	8	McCarty et al., 1985
Salmo sp.		Y	S						96h	LC50	mortality	10.4	4		IUCLID, 2000: Monsanto and Bayer AG
Salmo trutta			S			7	12.8	300	24h	LC50	mortality	5	3	13, 38	BUA.054: Wood, 1953

Notes

1	According to OECD guideline 209
2	According to ISO 8192
3	ETAD fermentation tube method
4	Prolonged incubation compared to ISO 8192
5	Determined by graphic interpolation
6	Not stated whether open or closed
7	Similar to ISO/DIS 9509
8	Cited in reference
9	Methods in Schultz 1997
10	Light intensity 5000 lux, stocks in acetone (>0.1% total conc), recalculated from log EC50 in mM
11	Light intensity 400 foot candles; 12h light:dark
12	Light intensity 400 foot candles; 12h light:dark
13	Open system, no analysis of concentrations
14	Light intensity 4500 lux; loss of compound was less than 10% of initial value
15	EPA algal assay
16	EPA AAPBT test
17	According to modified DIN 37412 T.9 method
18	Analysis at beginning and end of test, value estimated by interpolation
19	Test according to ASTM
20	AFNOR test
21	AFNOR test with modifications
22	AFNOR test; loss of compound was less than 15% of initial value
23	Test solution constituted with saturated compound
24	Test according to NEN 6501; results based on measured concentrations.
25	According to OECD guideline 202
26	Recalculated from 5.2 µmol/L
27	Recalculated from 51.6 µmol/L
28	EPA method
29	Open system, no analysis of concentrations; Tlm is used as LC50
30	No information exposure concentrations; a concentration of 5 mg/L was classified as 'non-toxic'. Aerated, open systems
31	IRSA test; loss of compound was less than 10% of initial value
32	According to UBA, 1984
33	Based on average measured concentration; EPA method
34	Open system, no analysis of concentrations; test according to Mann, 1976
35	According to Japanese Industrial Standard method.
36	Cited in reference, source EPA, according to ASTM guideline
37	Concentration measured twice during test, EPA method, value estimated by interpolation

38 Open system, no analysis of concentrations; according to OECD guideline 203; based on nominal concentrations
39 Species unclear
40 Exceeds water solubility

Table A2.2. Chronic toxicity of monochlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Pseudomonas putida		N	Sc		am	7.0	25	81.2	16h	NOEC	growth	17	3	1	Bringmann and Kühn, 1976, 1977a, 1979
Cyanobacteria															
Microcystis aeruginosa		N	Sc		am	7.0	27	55	8d	NOEC	growth	120	3	1, 2	Bringmann and Kühn, 1976, 1978a,b
Protozoa															
Chilomonas paramaecium		N	Sc		am	6.9	20	74.6	48h	NOEC	growth	>195	3	1	Bringmann et al., 1980
Entosiphon sulcatum	Stein	N	Sc		am	6.9	25	75.1	72h	NOEC	growth	>390	3	1	Bringmann and Kühn, 1979, 1980b
Uronema parduczi	Chatton-Lwoff	N	Sc		am	6.9	25	75.1	20h	NOEC	growth	>392	3	1	Bringmann and Kühn, 1980a
Algae															
Scenedesmus quadricauda		N	Sc		am	7.0	27	55	8d	NOEC	growth	>390	3	1, 2	Bringmann and Kühn, 1977a, 1978ab, 1979
Scenedesmus subspicatus									48h	EC10	biomass	38	4	3	IUCLID: Bayer AG
Scenedesmus subspicatus									48h	EC10	growth rate	50	4	3	IUCLID: Bayer AG
Pseudokirchneriella subcapitata		Y	Sc		am				96h	NOEC	growth	6.8	2	4	Calamari et al., 1983
Crustacea															
Ceriodaphnia dubia	< 12 h	N	R		nw	8.2±0.2	25±2	90-110	10d	NOEC	mortality	3.89	3	5	Cowgill and Milazzo, 1991
Ceriodaphnia dubia	< 12 h	N	R		nw	8.2±0.2	25±2	90-110	10d	NOEC	reproduction	12	3	5	Cowgill and Milazzo, 1991
Daphnia magna	< 24 h	Y	S		am		19±1		16d	NOEC	reproduction	0.32	2		Hermens et al., 1984
Daphnia magna	< 24 h	Y	S		am		19±1		16d	NOEC	growth	0.32	4*		De Wolf et al., 1988
Daphnia magna	< 24 h	Y	S		am		19±1		16d	NOEC	reproduction	1	4*		De Wolf et al., 1988
Daphnia magna	< 24 h	Y	S		am		19±1		16d	NOEC	growth	0.32	4*		Hermens et al., 1985a
Daphnia magna			R						16d	NOEC	growth	0.32	4*		IUCLID, 2000: Bayer AG
Daphnia magna	< 12 h	N	R		nw	8.2±0.2	25±2	160-180	10d	NOEC	mortality	<1.4	3	5	Cowgill and Milazzo, 1991
Daphnia magna	< 24 h	Y	S		am		19±1		16d	NOEC	mortality	1	2		Hermens et al., 1984
Daphnia magna	< 12 h	N	R		nw	8.2±0.2	25±2	160-180	10d	NOEC	reproduction	6.5	3	5	Cowgill and Milazzo, 1991
Daphnia magna			Sc						21d	NOEC	reproduction	2.5	4		IUCLID, 2000: Bayer AG
Daphnia magna									9d	NOEC	reproduction	11	4		IUCLID, 2000: Petrasol
Daphnia magna									14d	NOEC	reproduction	2.5	4*		IUCLID, 2000: Petrasol
Amphibia															
Ambystoma gracile	embryo-larva		F					100	9.5d	LC10	mortality	0.872	2	6	Black et al., 1982
Pisces															
Danio rerio	<1d old --> fry	Y	R	>99	rw	7.4-8.4		210	28d	NOEC	growth	4.8	2		Hesse et al., 1991: Van Leeuwen et al., 1990
Danio rerio	<1d old --> fry	Y	R	>99	rw	7.4-8.4		210	28d	NOEC	mortality	8.5	2		Hesse et al., 1991: Van Leeuwen et al., 1990
Danio rerio									28d	NOEC	reproduction	8.5	4*		IUCLID, 2000: Petrasol
Danio rerio									28d	NOEC		10.3	4		IUCLID, 2000: Petrasol
Oncorhynchus mykiss	(sub)adult	Y	CF		nw				30d	NOEC	mortality	2.9	2	7	Hesse et al., 1991: Dalich et al., 1982

Notes
1 Toxicity threshold is used as a NOEC
2 Light intensity 2800 lm
3 According to modified DIN 38412 T.9 method
4 EPA algal assay
5 Renewal every other day
6 LC50 = 1.15 mg/L; LC50 after 5.5d exposure = 1.65 mg/L
7 Reported value is the average of the nominal NOEC and the lowest analysed concentration during the test

Table A2.3. Acute toxicity of monochlorobenzene to marine organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Vibrio fischeri									10min	EC50	bioluminescense	20	4	1	Bazin et al., 1987
Vibrio fischeri									10min	EC50	bioluminescense	18	2	1	BUA.054: Ferard et al., 1983
Vibrio fischeri			S		am	5-9			15min	EC50	bioluminescense	20	4		Kaiser and Palabrica, 1991: Bazin et al., 1987
Vibrio fischeri			S		am	5-9			15min	EC50	bioluminescense	14.8	4		Kaiser and Palabrica, 1991: Hermens et al., 1985
Vibrio fischeri									15min	EC50	bioluminescense	14.8	4*	1	Hermens et al., 1985b
Vibrio fischeri									15min	EC50	bioluminescense	11.5	2	1	Ribo and Kaiser, 1983
Vibrio fischeri			S		am	5-8	15		15min	EC50	bioluminescense	11.5	4*	2	Kaiser and Ribo, 1988: Ribo and Kaiser, 1983
Vibrio fischeri		Y	S		am		15		15min	EC50	bioluminescense	15	2		Hermens et al., 1985
Vibrio fischeri		N	S				20		15min	EC50	bioluminescense	16	2		Zhao et al., 1993
Vibrio fischeri			S		am	5-9			30m	EC50	bioluminescense	11.3	4		Kaiser and Palabrica, 1991: Ribo and Kaiser, 1983
Vibrio fischeri									30min	EC50	bioluminescense	11.3	4*	1	Ribo and Kaiser, 1983
Vibrio fischeri									30min	EC50	bioluminescense	11.26	4*	1	IUCLID: Bayer AG
Vibrio fischeri			S		am	5-8	15		30min	EC50	bioluminescense	11.3	4*	2	Kaiser and Ribo, 1988: Ribo and Kaiser, 1983
Vibrio fischeri									30min	EC50	bioluminescense	11	4	2	Sixt et al., 1995
Vibrio fischeri									30min	EC50	bioluminescense	11.25	4	2	Warne et al., 1999
Vibrio fischeri		N	Sc			6.5-7.5	15		5min	EC50	bioluminescense	9.4	2		Blum and Speece, 1991
Vibrio fischeri									5min	EC50	bioluminescense	14.6	2	1	BUA.054: Ferard et al., 1983
Vibrio fischeri									5min	EC50	bioluminescense	9.4	2	1	Ribo et al., 1983
Vibrio fischeri									5min	EC50	bioluminescense	9.4	4*	1	IUCLID: Bayer AG
Vibrio fischeri			S		am	5-8	15		5min	EC50	bioluminescense	9.36	4*	2	Kaiser and Ribo, 1988: Ribo and Kaiser, 1983
Vibrio fischeri									5min	EC50	bioluminescense	20	4	1	IUCLID: Bayer AG
Algae															
Chlorella marine		N	Sc				20		72h	EC50	growth rate	20.2	3	4	Ma et al., 1997
Nannochloropsis oculata		N	Sc				20		72h	EC50	growth rate	26.2	3	4	Ma et al., 1997
Phaeodactylum tricornutum		N	Sc				20		72h	EC50	growth rate	19.6	3	4	Ma et al., 1997
Platymonas subcordiformis		N	Sc				20		72h	EC50	growth rate	30.2	3	4	Ma et al., 1997
Pyramidomonas sp.		N	Sc				20		72h	EC50	growth rate	37.2	3	4	Ma et al., 1997
Skeletonema costatum									96h	EC50	growth rate	341	4		US-EPA, 1980
Skeletonema costatum			Sc						120h	EC50	cell number	203	3		Cowgill et al., 1989
Crustacea															
Artemia spp									24h	LC50	mortality	41	4*	2	Zhao et al., 1993
Artemia salina			Sc		nw	7.7-8.1	10.5-22	29.2-30.7	48h	LC50	mortality	40.6	3		Wells et al., 1982
Americamysis bahia			S						96h	LC50	mortality	16.4	4		US-EPA, 1980
Pisces															
Cyprinodon variegatus	8-15 mm, 14-28 d	N	S	>80%	nw	-	25-31	10-31	96h	LC50	mortality	10	3	3	Heitmuller et al., 1981
Cyprinodon variegatus			S					31	96h	LC50	mortality	10	4*	5	IUCLID, 2000: Bayer AG
Cyprinodon variegatus		N	S						96h	LC50	mortality	10.5	3	3	US-EPA, 1980
Platichthys flesus	56.2 g	Y	CF	97-99	rw		6	5	96h	LC50	mortality	6.6	2	6	Furay and Smith, 1995
Solea solea	45 g	Y	CF	97-99	rw		6	22	96h	LC50	mortality	5.8	2	6	Furay and Smith, 1995

Notes
1 Microtox test
2 Cited in reference
3 Open system, no analysis of concentrations
4 Culturing described by Otsuki et al., 1987, 12h light, nominal concentrations
5 EPA-method
6 OECD, fish collected in Thames, aeration, 12h light, recovery >80%, recalculated from µM

Table A2.4. Chronic toxicity of monochlorobenzene to marine organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Algae															
Skeletonema costatum			Sc						5d	NOEC	cell volume, cell number	100	4		US-EPA, 1980
Crustacea															
Portunus pelagicus	First instar	N	S				26		NR	EC10	growth	0.25	3	1	Mortimer and Connell, 1995
Portunus pelagicus	Sixth instar	N	S				26		NR	EC10	growth	0.25	3	1	Mortimer and Connell, 1995

Notes
1 Open system, no analysis of concentrations

Table A2.5. Acute toxicity of 1,2-dichlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Pseudomonas fluorescens		Y	S	>98	am	7.1	25		20 min	EC50	luminescence	21.6	2	2	Boyd et al., 1998
Pseudomonas fluorescens										EC50	luminescence	21.6	4*	1	Warne et al., 1999
Protozoa															
Tetrahymena pyriformis			Sc	>95	am	7.35	27		40h	IC50	growth inhibition	1471	3	3, 25	Schultz, 1999
Tetrahymena pyriformis			S				30		24h	EC50	cell proliferation	51	4	2	Yoshioka et al., 1985
Algae															
Ankistrodesmus falcatus		N	Sc		am	8	20		4h	EC50	photosynth.	20.8	3	4	Wong et al., 1984
Chlorella vulgaris									6h	EC50	growth	38	4	26	BUA.053: Kramer and Trumper, 1986
Pseudokirchneriella subcapitata		Y			am		20±1		3h	EC50	photosynth.	10	2	5	Calamari et al., 1983
Pseudokirchneriella subcapitata		Y	Sc	ag	am				96h	EC50	growth	2.2	4*	6	Calamari et al., 1983
Pseudokirchneriella subcapitata										EC50		91.6	4	7	LeBlanc, 1984
Pseudokirchneriella subcapitata									96h	EC50	cell growth	98	4		US-EPA, 1980
Pseudokirchneriella subcapitata	5 mln cells/L	Y	Sc		am		20		96h	EC50	growth inhibition	2.2	2	8	Galassi and Vighi, 1981
Scenedesmus pannonicus		Y	Sc	99.9	rw				24h	EC50		17	2		Canton et al., 1985
Selenastrum subspicatus	8681 SAG	N	Sc		am	8.1-9.6	24±1	55	48h	EC50	growth rate	13.5	3	10	Kühn and Pattard, 1990
Scenedesmus subspicatus									48h	EC50	growth rate	13.5	4*	9	IUCLID, 2000: Bayer AG
Scenedesmus subspicatus									48h	EC50	biomass	14	4	9	IUCLID, 2000: Bayer AG
Crustacea															
Daphnia magna	<24 h	N	S		tw	7.6-7.7	20-22	286	24h	EC50	immobility	68	3	11	Bringmann and Kühn, 1977b
Daphnia magna	<24 h, IRCHA	N	S		am	8.0±0.2	20	250.2	24h	EC50	immobility	45	3	11	Bringmann and Kühn, 1982
Daphnia magna		Y	Sc		am				24h	EC50	immobility	0.78	2	12	Calamari et al., 1983
Daphnia magna	< 24 h	N	S		am	7.5±0.3	21±2	115±8	24h	LC50	immobility	3.4	3	11	Wei et al., 1999
Daphnia magna	1.5 mm	N	Sc		aw	6-7			48h	EC50	immobility	2.35	3	13	Bobra et al., 1985
Daphnia magna	< 48 h	Y	S		am		22±1	100	48h	LC50	immobility	3.8	2	14	Hermens et al., 1984
Daphnia magna		Y	Sc	99.9	rw				48h	EC50	immobility	0.74	2		Canton et al., 1985
Daphnia magna	<24 h, IRCHA	N	S	-	am	8.0±0.2	25±1	250	24h	EC50	mortality	1.7	3	11	Kühn et al., 1989
Daphnia magna									24h	EC50		1.7	4*	16	IUCLID, 2000: Bayer AG
Daphnia magna		Y	Sc	99.9	rw				48h	LC50	mortality	2.2	2		Canton et al., 1985
Daphnia magna	< 24 h	N	Sc	-	rw	6.7-8.1	22±1	72±6	48h	LC50	mortality	2.4	3		LeBlanc, 1980
Daphnia magna		Y	R	> 98	rw		20		48h	LC50	mortality	0.13	2		Pawlisz and Peters, 1995
Daphnia magna									48h	LC50	mortality	2.3	4	7	Zhao et al., 1993
Daphnia magna			S						48h	EC50		2.44	4	18	US-EPA, 1980

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Daphnia pulex	<24 h	N	S	ag	am		20	293.6	96h	LC50	mortality	8.27	3	11	Ikemoto et al., 1992
Insecta															
Aedes sticticus	adults						25		48h	LC50	mortality	>40	4		BUA.053: Nishiuchi, 1981
Chironomidae	larvae								2h	LC52	mortality	3.9	4		BUA.053: Fellton, 1940
Chironomidae	larvae								68h	LC100	mortality	7.8	4		BUA.053: Fellton, 1940
Cloeon	nymphs								48h	LC50	mortality	48	4		BUA.053: Nishiuchi and Asano, 1979
Cloeon dipeterum	larvae						25		48h	LC50	mortality	26	4		BUA.053: Nishiuchi, 1981
Orthetrum albistylum speciosum	larvae						25		48h	LC50	mortality	>40	4		BUA.053: Nishiuchi, 1981
Sympetrum frequens	larvae						25		48h	LC50	mortality	>40	4		BUA.053: Nishiuchi, 1981
Micronecta sedula	larvae						25		48h	LC50	mortality	>40	4		BUA.053: Nishiuchi, 1981
Sigara substriata	larvae								48h	LC50	mortality	>40	4		BUA.053: Nishiuchi, 1981
Tanytarsus dissimilis	3-4 instart, 2-3.5 mm	Y	S			7.6	20	47	24h	LC50	mortality	20.9	2		Call et al., 1983
Tanytarsus dissimilis	3-4 instar	Y	S			7.6	20	47	48h	LC50	mortality	12	2		Call et al., 1983
Tanytarsus dissimilis	larvae								96h	LC50	mortality	11.8	4		US-EPA, 1980
Pisces															
Cyprinus carpio	5 g, 5 cm	N	R				20±1		48h	LC50	mortality	9.5	3	11	Zhao et al., 1993
Danio rerio		Y	Sc		am	7.4	23	320	48h	LC50	mortality	6.8	2	19	Calamari et al., 1983
Danio rerio			F						48h	LC50	mortality	10	2		Slooff, 1979
Danio rerio		Y	F						96h	LC50	mortality	5.2	2	20	IUCLID, 2000: Bayer AG
Lepomis macrochirus	0.32-1.2 g	N	S	>80%	rw	6.5-7.9	21-23	32-48	96h	LC50	mortality	5.6	3	11	Buccafusco et al., 1981
Lepomis macrochirus			S						96h	LC50	mortality	5.6	4*		US-EPA, 1980
Lepomis macrochirus	33-75 mm	N	S	-	nw	7.6-7.9	23	55	96h	LC50	mortality	27	3	11	Dawson et al., 1975/77
Lepomis macrochirus	33-75 mm	N	S	-	nw	7.6-7.9	23	55	96h	LC50	mortality	29	3	11, 21	Dawson et al., 1975/77
Lepomis macrochirus			S				22		96h	LC50	mortality	5.6	4*		IUCLID, 2000: Bayer AG
Leuciscus idus									48h	LC50	mortality	29	4*		IUCLID, 2000: Bayer AG
Leuciscus idus melanotus		N	S	-	tw	7--8	20±1	255	48h	LC50	mortality	29	3	11, 22	Juhnke and Lüdemann, 1978
Leuciscus idus melanotus		N	S	-	tw	7--8	20±1	255	48h	LC50	mortality	20	3	11, 22	Juhnke and Lüdemann, 1978
Oncorhynchus mykiss	4.3 g	Y	F			6.8-7.5	11.6-12.7	51-56.8	96h	LC50	mortality	1.61	2		Ahmad et al., 1984
Oncorhynchus mykiss	5.6 cm, 2.69 g	Y	F			7.5	12	57	96h	LC50	mortality	1.58	2		Call et al., 1983
Oncorhynchus mykiss	5.6 cm, 2.69 g	Y	F			7.5	12	57	6 d	LC50	mortality	1.54	2		Call et al., 1983
Oncorhynchus mykiss		Y	Sc		am	7.4	15	320	48h	LC50	mortality	2.3	2	19	Calamari et al., 1983
Oncorhynchus mykiss									96h	LC50	mortality	1.1	4		BUA.053: Ribo and Kaiser, 1983
Oncorhynchus mykiss			F						96h	LC50	mortality	1.67	4		US-EPA, 1980
Oncorhynchus mykiss			F						96h	LC50	mortality	1.58	4*		US-EPA, 1980
Oncorhynchus mykiss			F						96h	LC50	mortality	1.58	4*		IUCLID, 2000: Bayer AG
Oncorhynchus mykiss			Sc				15		48h	LC50	mortality	2.3	4		IUCLID, 2000: Bayer AG
Oncorhynchus mykiss		Y	F						96h	LC50		1.6	4	7	McCarty et al., 1985
Oryzias latipes	3 cm; 0.3g	Y	R						48h	LC50	mortality	9.9	2		Yoshioka et al., 1986
Oryzias latipes									48h	LC50	mortality	10	4*	23	IUCLID, 2000: Bayer AG
Oryzias latipes	0.2 g	N	S	ag	am		20	293.6	24h	LC50	mortality	34.5	3	11	Ikemoto et al., 1992
Pimephales promelas			F						96h	LC50	mortality	17	4	7	Blum and Speece, 1991
Pimephales promelas	28-36 d	Y	F		nw		25±1		96h	LC50	mortality	9.47	2		Fathead minnow database, US-EPA, 2008
Pimephales promelas									96h	LC50	mortality	5.9	4	7	Zhao et al., 1993
Pimephales promelas	30-35 d	N	F		rw		25	43.3-48.5	96h	LC50	mortality	5.8	4		Hall et al., 1989
Pimephales promelas										LC50	mortality	9.5	4	7	Nendza and Russom, 1991
Pimephales promelas		N	S				22		96h	LC50	mortality	57	3	18	Curtis et al., 1979
Pimephales promelas									96h	LC50	mortality	5.8	4		BUA.053: Könemann, 1979
Pimephales promelas									96h	LC50	mortality	9.5	4	7	Mekenyan and Veith, 1993
Pimephales promelas			S				22		96h	LC50	mortality	57	4*		IUCLID, 2000: Bayer AG

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Pimephales promelas									96h	LC50	mortality	5.8	4*		IUCLID, 2000: Bayer AG
Pimephales promelas	3 months, 3,6 cm	Y	R	95					96h	LC50	mortality	6	2	20	Sijm et al., 1993
Pimephales promelas	30-35 days old	N	F		nw		25	43.3-48.5	96h	LC50	mortality	5.85	2		Hall et al., 1984
Poecilia reticulata	3 months, 2,6 cm	Y	R	95					96h	LC50	mortality	4.8	2	20	Sijm et al., 1993
Poecilia reticulata	2-3 months old	N	R		am		22	25	14 d	LC50	mortality	5.85	2	24	Könemann, 1981
Poecilia reticulata									7-14d	LC50	mortality	5.9	4*	7	Zhao et al., 1993
Trout (not specified)									48h	LC50	mortality	6	4		BUA.053: Durig, 1976

Notes

1 Cited in reference, unit unclear
2 Not stated whether system is open or closed
3 Methods in Schultz, 1997
4 Light intensity 5000 lux, stocks in acetone (>0.1% total conc), recalculated from log EC50 in mM
5 Light intensity 4500 lx; loss of compound was less than 10% of initial value
6 EPA algal assay
7 Cited in reference
8 EPA AAPBT test
9 Probably Selenastrum subspicatus; DIN 38412
10 fluorescent light with 17.0 W/m2; initial cell density: 1e4 cells/L
11 Open system, no analysis of concentrations
12 AFNOR test; loss of compound was less than 15% of initial value; closed system
13 Test solution constituted with saturated compound
14 Test according to NEN 6501.
15 Photoperiod 9:15 light:dark with fluorescent light
16 According to DIN 38412
17 n = 23 with 7 different populations
18 Open system, results based on nominal concentrations
19 IRSA test; loss of compound was less than 10% of initial value
20 According to OECD guideline 203
21 LC50 recalculated using nonlinear regression
22 Test according to Mann, 2076; aerated systems
23 According to Japanese Industrial Standard method
24 Covered with glass, acute tests with 96 hours exposure time are preferred
25 Exceeds water solubility
26 Short exposure duration

Table A2.6. Chronic toxicity of 1,2-dichlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Aeromonos hydrophila										NOEC	growth	150	3	1, 12	BUA.053: Schubert, 1979
Bacillus subtilis										NOEC	growth	150	3	12	BUA.053: Schubert, 1979
Pseudomonas cepacia										NOEC	growth	150	3	1, 12	BUA.053: Schubert, 1979
Pseudomonas fluorescens									24h	NOEC		250	3	2, 12	IUCLID, 2000: Bayer AG
Pseudomonas putida		N	Sc		am	7.0	25	81.2	16h	NOEC	growth	15	3	3	Bringmann and Kühn, 1976
Cyanobacteria															
Microcystis aeruginosa		N	Sc		am	7.0	27	55	8d	NOEC	growth	53	3	2, 3	Bringmann, 1975
Protozoa															
Chilomonas paramaecium		N	Sc		am	6.9	20	74.6	48h	NOEC	growth	>60	3	3, 5	Bringmann et al., 1980
Entosiphon sulcatum	Stein	N	Sc		am	6.9	25	75.1	72h	NOEC	growth	>64	3	3, 5	Bringmann, 1978, Bringmann and Kühn, 1979, 1980b
Uronema parduczi	Chatton-Lwoff	N	Sc		am	6.9	25	75.1	20h	NOEC	growth	80	3	3, 5	Bringmann and Kühn, 1980a
Algae															
Pseudokirchneriella subcapitata	PRINTZ								96h	NOEC	growth	0.88	4		BUA.053: Calamari et al., 1983
Pseudokirchneriella subcapitata	PRINTZ								96h	NOEC	growth	< 0.9	4		BUA.053: Galassi and Vighi, 1981
Pseudokirchneriella subcapitata		Y	Sc		am		20±1		3h	NOEC	photosynth.	< 0.4	2		Calamari et al., 1983
Pseudokirchneriella subcapitata									96h	NOEC	cell growth	<12.9	4		US-EPA, 1980
Pseudokirchneriella subcapitata	10E4 cells/ml	N	S		am		22		120h	LOEC	growth	80	3	6	Millington et al., 1988
Pseudokirchneriella subcapitata	10E4 cells/ml	N	S		am		22		120h	LOEC	growth	80	3	6	Millington et al., 1988
Pseudokirchneriella subcapitata	10E4 cells/ml	N	S		am		22		120h	LOEC	growth	80	3	6	Millington et al., 1988
Scenedesmus quadricauda		N	Sc		am	7.0	27	55	8d	NOEC	growth	>100	3	3, 4, 12	Bringmann and Kühn, 1977a
Scenedesmus subspicatus									48h	EC10	biomass	3	4	7	IUCLID, 2000: Bayer AG
Scenedesmus subspicatus			Sc						48h	EC10	growth rate	7.8	3	7	Kuhn and Pattard, 1990
Scenedesmus subspicatus	10E4 cells/ml	N	S		am		22		120h	LOEC	growth	50	3	6	Millington et al., 1988
Scenedesmus subspicatus	10E4 cells/ml	N	S		am		22		120h	LOEC	growth	100	3	6	Millington et al., 1988
Scenedesmus subspicatus	10E4 cells/ml	N	S		am		22		120h	LOEC	growth	100	3	6	Millington et al., 1988
Crustacea															
Daphnia magna	<24 h, IRCHA	N	R	-	am	8.0±0.2	25±1	250	21d	NOEC	reproduction, mortality	0.63	3	8	Kühn et al., 1989
Daphnia magna			R						21d	NOEC	reproduction, mortality	0.63	4*	7	IUCLID, 2000: Bayer AG
Daphnia magna		Y	R		tw	6.6-7.6		16	21d	NOEC	reproduction, mortality	0.505	2	9	Hesse et al., 1991: Kühn et al., 1989
Pisces															
Oncorhynchus mykiss			F						119d	NOEC	mortality	>0.047	3	10	Oliver and Niimi, 1983
Oncorhynchus mykiss			F						105d	NOEC	mortality	>0.94	3	10	Oliver and Niimi, 1983
Pimephales promelas	larvae									NOEC	mortality	2	4		US-EPA, 1980

Notes
1 Growth stimulation
2 German standard methods
3 Toxicity threshold is used as a NOEC
4 Light intensity 2800 lm
5 1.5*10^4 cells/ml
6 Open system, no analysis of concentrations; every 24h cell count, acetone as solvent max. 100 µl/l, BBM medium
7 According to DIN 38412
8 photoperiod 9:15 light:dark with fluorescent light
9 Reported value is the average of the nominal NOEC and the lowest analysed concentration during the test
10 Experiment to determine BCF; one concentration; no deaths occurred; loading 18 g fish/L.
11 Data originates from US EPA, 1980
12 Exceeds water solubility

Table A2.7. Acute toxicity of 1,2-dichlorobenzene to marine organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Vibrio fischeri									30min	EC50	bioluminescense	6	2	1, 3	Sixt et al., 1995
Vibrio fischeri		N	Sc			6.5-7.5	15		5min	EC50	bioluminescense	2.7	2	3	Blum and Speece, 1991
Vibrio fischeri		N	S				20		15min	EC50	bioluminescense	6.1	2	3	Zhao et al., 1993
Vibrio fischeri			S		am	5-8	15		5min	EC50	bioluminescense	10.2	2	1, 3	Kaiser and Ribo, 1988: McFeters et al., 1985
Vibrio fischeri			S		am	5-8	15		5min	EC50	bioluminescense	2.74	2	1, 3	Kaiser and Ribo, 1988: Ribo and Kaiser, 1983
Vibrio fischeri			S		am	5-8	15		15min	EC50	bioluminescense	3.14	2	1, 3	Kaiser and Ribo, 1988: Ribo and Kaiser, 1983
Vibrio fischeri			S		am	5-8	15		30min	EC50	bioluminescense	4.04	4*	1, 3	Kaiser and Ribo, 1988: Ribo and Kaiser, 1983
Vibrio fischeri									5min	EC50	bioluminescense	2.7	4*	3	IUCLID: Bayer AG
Vibrio fischeri									30min	EC50	bioluminescense	5.99	2	1, 3	Warne et al., 1999
Vibrio fischeri			S		am	5<pH<9			30m	EC50	bioluminescense	5.99	4*	3	Kaiser and Palabrica, 1991
Vibrio fischeri			S		am	5<pH<9			30m	EC50	bioluminescense	4.05	4*	3	Kaiser and Palabrica, 1991: Ribo and Kaiser, 1983
Vibrio fischeri			S		am	5<pH<9			15m	EC50	bioluminescense	4.24	4	3	Kaiser and Palabrica, 1991: Bazin et al., 1987
Vibrio fischeri			S		am	5<pH<9			5m	EC50	bioluminescense	10.2	4*	3	Kaiser and Palabrica, 1991: McFeters et al., 1983
Algae															
Skeletonema costatum										EC50		44.2	4	1	LeBlanc, 1984
Skeletonema costatum									96h	EC50	growth rate	44.1	4		BUA.053: US-EPA, 1980
Skeletonema costatum									96h	EC50	growth rate	44.1	4*		WHO, 1991: orig ref US-EPA, 1980
Pyramidomonas sp.		N	Sc				20		72h	EC50	growth rate	17.9	3	4	Ma et al., 1997
Platymonas subcordiformis		N	Sc				20		72h	EC50	growth rate	16.9	3	4	Ma et al., 1997
Nonnochloropsis oculata		N	Sc				20		72h	EC50	growth rate	13.1	3	4	Ma et al., 1997
Chlorella marine		N	Sc				20		72h	EC50	growth rate	16.2	3	4	Ma et al., 1997
Phaeodactylum tricornutum		N	Sc				20		72h	EC50	growth rate	12.8	3	4	Ma et al., 1997
Crustacea															
Artemia spp									24h	LC50	mortality	15	4*	1	Zhao et al., 1993
Artemia spp	larvae	N	Sc	>97%			20±1		24h	LC50	mortality	15	3		Abernethy et al., 1986
Americamysis bahia										LC50		1.97	4*	1	LeBlanc, 1984
Americamysis bahia			S						96h	LC50	mortality	1.97	4		US-EPA, 1980
Palaemonetes pugio			S				22		96h	LC50	mortality	9.4	4		BUA.053: Curtis et al., 1979
Palaemonetes pugio		Y	S		am	8.3-8.7	22	25	96h	LC50	mortality	10	3	8,9	BUA.053: Curtis and Ward, 1981
Palaemonetes pugio			S				22		96h	LC50	mortality	10	3*		IUCLID, 2000: Bayer AG
Echinodermata															
Paracentrotus lividus	embryo	N	S	>99	nw	8.2-8.4		37.6-37.8	48h	NOEC	development	0.147	3	2	Pagano et al.,1988
Paracentrotus lividus	embryo	N	S	>99	nw	8.2-8.4		37.6-37.8	48h	LOEC	genotoxicity	0.147	3	2	Pagano et al.,1988
Paracentrotus lividus	sperm	N	S	>99	nw	8.2-8.4		37.6-37.8		LOEC	fertilisation success	1.47	3	2	Pagano et al.,1988
Paracentrotus lividus	sperm	N	S	>99	nw	8.2-8.4		37.6-37.8		LOEC	development	1.47	3	2	Pagano et al.,1988
Pisces															
Cyprinodon variegatus	8-15 mm, 14-28 d	N	S	>80%	nw	-	25-31	10-31	96h	LC50	mortality	9.7	3	2	Heitmuller et al., 1981
Cyprinodon variegatus			S						96h	LC50	mortality	9.7	4*		IUCLID, 2000: Bayer AG
Menidia beryllina	40-100 mm	N	S	-	rw	-	20	-	96h	LC50	mortality	7.3	3	2	Dawson et al., 1975/77
Menidia beryllina	40-100 mm	N	S	-	rw	-	20	-	96h	LC50	mortality	9.2	3	2, 5	Dawson et al., 1975/77
Menidia beryllina	40-100 mm	N	S	-	rw	-	20	-	96h	LC10	mortality	8.5	3	2, 6	Dawson et al., 1975/77
Platichthys flesus	56.2	Y	CF	97-99	rw		6	5	96h	LC50	mortality	4.6	2	7	Furay and Smith, 1995
Solea solea	45	Y	CF	97-99	rw		6	22	96h	LC50	mortality	4.2	2	7	Furay and Smith, 1995

Notes
1 Cited in reference
2 Open system, no analysis of concentrations

3 Microtox test
4 Culturing described by Otsuki et al., 1987, 12h light, nominal concentrations
5 LC50 recalculated with nonlinear regression
6 LC10 calculated from original data
7 OECD, fish collected in Thames, aeration, 12h light/dark, recovery >80%, recalculated from uM
8 Not stated whether open or closed
9 Analysed but results not reported and endpoint based on nominal value

Table A2.8. Chronic toxicity of 1,2-dichlorobenzene to marine organisms

Species	Species properties	A	Test type	Substance purity [%]	Test water	pH	Temp. [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Algae															
Monochrysis lutheri							20.5		10d	NOEC	growth	7.6	3	1	Ukeles, 1962
Dunaliella euchlora							20.5		10d	NOEC	growth	7.6	3	1	Ukeles, 1962
Chlorella sp.							20.5		10d	NOEC	growth	7.6	3	1	Ukeles, 1962
Protococcus sp.							20.5		10d	NOEC	growth	7.6	3	1	Ukeles, 1962
Phacodactylum tricornutum									10d	NOEC	growth	7.6	3	1	Ukeles, 1962
Skeletonema costatum									96h	NOEC	cell growth and Chl-a content	<12.8	4		US-EPA, 1980
Mollusca															
Mercenaria mercenaria	eggs	N	R		nw		24		48h	NOEC	eggs developing	5	3		Davis and Hidu, 1969
Mercenaria mercenaria	2 d old larvae	N	R		nw		24		10d	NOEC	survival	>1000	3	2	Davis and Hidu, 1969

Notes
1 Formulation containing 130 mg 1,2-dichlorobenzene/L
2 Exceeds water solubility

Table A2.9. Acute toxicity of 1,3-dichlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
aerobic bacteria, adapted										EC100		≥ 20	4		IUCLID, 2000: Hoechst AG and Clariant GmbH
Pseudomonas fluorescens		Y	S	>98	am	7.1	25		20m	EC50	luminescence	34.6	2	4	Boyd et al., 1998
Pseudomonas fluorescens										EC50	luminescence	34.6	4*	3	Warne et al., 1999
Protozoa															
Tetrahymenis pyriformis									24h	EC50		130	4	4	Yoshioka et al., 1985
Tetrahymenis pyriformis							30		24h	EC50		130	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Algae															
Algae (unspecified)				99.4					96h	EC50	growth rate	31	4		IUCLID, 2000: Hoechst AG and Clariant GmbH
Ankistrodesmus falcatus		N	Sc		am	8	20		4h	EC50	photosynth.	22.8	3	5	Wong et al., 1984
Chlorella vulgaris		N							6h	EC50	growth	35-38	4	6	IUCLID, 2000: Hoechst AG
Pseudokirchneriella subcapitata									96h	EC50		179	3	23	BUA.008: US-EPA, 1978
Pseudokirchneriella subcapitata									96h	EC50		149	3	23	BUA.008: US-EPA, 1978
Pseudokirchneriella subcapitata			S						96h	EC50	growth rate	149	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Scenedesmus pannonicus		Y	Sc	99.4	rw				24h	EC50		31	2		Canton et al., 1985
Scenedesmus subspicatus	8681 SAG	N	Sc	-	am	8.1-9.6	24±1	55	48h	EC50	growth rate	30	3	8	Kühn and Pattard, 1990
Crustacea															
Daphnia magna	<24h, IRCHA	N	S	-	am	8.0±0.2	25±1	250	24h	EC50	mortality	7	3	7, 9	Kühn et al, 1989

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Daphnia magna									24h	EC50		7	4*	18	IUCLID, 2000: Hoechst AG and Clariant GmbH
Daphnia magna	< 24 h	Y	Sc	95-99%	nw	7.0-7.5	20±1	44.7 (43.5-47.5)	48h	EC50	immobility	6	3	11	Richter et al., 1983
Daphnia magna			Sc		nw	7			24h	EC50	immobility	6	3	10	Bazin et al., 1987
Daphnia magna		N							24h	EC50		6	4*	10	IUCLID, 2000: Hoechst AG and Clariant GmbH
Daphnia magna	< 24 h	N	S		am	7.5±0.3	21±2	115±8	24h	LC50	immobility	5.7	3	7	Wei et al 1999
Daphnia magna		Y	Sc	99.9	rw				48h	EC50	immobility	1.2	2		Canton et al., 1985
Daphnia magna		Y		99.4					24h	EC50		1.2	4*	13	IUCLID, 2000: Hoechst AG and Clariant GmbH
Daphnia magna	< 24 h	Y	Sc	95-99%	nw	7.1-7.7	20±1	44.7 (43.5-47.5)	48h	EC50	immobility	4.2	2	12	Richter et al., 1983
Daphnia magna		Y							48h	EC50		4.2	4*	14	IUCLID, 2000: Hoechst AG and Clariant GmbH
Daphnia magna		Y	Sc	99.9	rw				48h	LC50	mortality	6.8	2		Hesse et al., 1991: Canton et al., 1985
Daphnia magna		Y		99.4					24h	LC50	mortality	6.8	4*	13	IUCLID, 2000: Hoechst AG and Clariant GmbH
Daphnia magna	< 24 h	Y	Sc	95-99%	nw	7.1-7.7	20±1	44.7 (43.5-47.5)	48h	LC50	mortality	7.4	2	16	Richter et al., 1983
Daphnia magna		Y							48h	LC50	mortality	7.4	4*	14	IUCLID, 2000: Hoechst AG and Clariant GmbH
Daphnia magna	< 24 h	N	Sc	-	rw	6.7-8.1	22±1	72±6	48h	LC50	mortality	28	3		LeBlanc, 1980
Daphnia magna		N							48h	LC50	mortality	28	4*	15	IUCLID, 2000: Hoechst AG and Clariant GmbH
Daphnia magna	< 24 h	Y	Sc	95-99%	nw	7.0-7.5	20±1	44.7	48h	LC50	mortality	7.2	3	11	Richter et al., 1983
Daphnia magna									48h	LC50	mortality	4.9	4	17	Zhao et al., 1993
Daphnia magna									24h	EC50		6.3-12.6	4		BUA.008: Hoechst, 1979
Daphnia pulex	<24 h	N	S	ag	am		20	293.6	96h	LC50	mortality	8.08	3	7	Ikemoto et al., 1992
Insecta															
Chironomus riparius	4th-instar	Y	R	>95	nw		19 ± 0.5		96h	NOEC	behaviour	0.0368	2		van der Zandt et al., 1994
Chironmus riparius	4th instar		R						96h	NOEC	behaviour/ movement	0.0367	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Pisces															
Cyprinus carpio	5 g, 5 cm	N	R				20±1		48h	LC50	mortality	8.7	3		Zhao et al., 1993
Danio rerio		N	S						48h	LC50	mortality	3.15-6.3	4	19	IUCLID, 2000: Hoechst AG and Clariant GmbH
Lepomis macrochirus	0.32-1.2 g	N	Sc	>80%	rw	6.5-7.9	21-23	32-48	96h	LC50	mortality	5	3	20	Buccafusco et al., 1981; also stated in BUA.008
Lepomis macrochirus									96h	LC50	mortality	5.02	4*		BUA.008: US-EPA, 1978
Lepomis macrochirus			S						96h	LC50	mortality	5	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Lepomis macrochirus			S						96h	LC50	mortality	5.02	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Leuciscus idus									96h	LC50	mortality	13.9	4		BUA.008: Hoechst, 1980
Leuciscus idus melanotus			S						96h	LC50	mortality	13.9	4*	13	IUCLID, 2000: Hoechst AG and Clariant GmbH
Leuciscus idus									48h	LC50	mortality	3.1-6.3	4		BUA.008: Hoechst, 1979
Leuciscus idus melanotus			S						48h	LC50	mortality	3.1-6.3	4*	18	IUCLID, 2000: Hoechst AG and Clariant GmbH
Oryzias latipes									48h	LC50	mortality	9	4		BUA.133: MITI, 1992
Oryzias latipes		Y	R						48h	LC50	mortality	9	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Oryzias latipes	0.2 g	N	S	ag	am		20	293.6	24h	LC50	mortality	31.4	3	7	Ikemoto et al., 1992
Paramisgurnus dabrayanus			S						48h	LC50	mortality	5.97	4		IUCLID, 2000: Hoechst AG and Clariant GmbH
Phoxinus sp.										LC50	mortality	7.37	4		IUCLID, 2000: Hoechst AG and Clariant GmbH
Pimephales promelas			F						96h	LC50	mortality	9.5	4	17	Blum and Speece, 1991
Pimephales promelas									96h	LC50	mortality	7.4	4	17	Zhao et al., 1993
Pimephales promelas	30-35 d	N	F		rw		25	43.3-48.5	96h	LC50	mortality	14	2		Hall et al., 1989
Pimephales promelas										LC50	mortality	8	4	17	Nendza and Russom, 1991
Pimephales promelas	28-36 d	Y	F		nw		25±1		96h	LC50	mortality	8.03	2		Fathead minnow database, US-EPA, 2008
Pimephales promelas		Y	F	98					96h	LC50	mortality	8.03	4*	21	IUCLID, 2000: Hoechst AG
Pimephales promelas	30 d, 0.12 g	Y	F		nw	7.5	25±1	45.5	96h	LC50	mortality	7.8	2		Veith et al., 1983
Pimephales promelas	30 d, 0.1-6-0.160 g	Y	F	98	nw	7.3-7.6	25	44-46	96h	LC50	mortality	7.8	4*		Carlson and Kosian, 1987
Pimephales promelas			F						96h	LC50	mortality	7.8	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Pimephales promelas		Y	F						96h	LC50	mortality	7.79	4*		WHO 1991: US-EPA,1980

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Pimephales promelas										LC50	mortality	8.1	4	17	Mekenyan and Veith, 1993
Pimephales promelas		Y	S		rw	7.2-7.9	22	40-48	96h	LC50	mortality	12.7	3	4,	BUA.008: Curtis and Ward, 1981
Pimephales promelas			F						96h	LC50	mortality	7.36	4	15	IUCLID, 2000: Hoechst AG and Clariant GmbH
Pimephales promelas			S	98					96h	LC50	mortality	7.7	4	21	IUCLID, 2000: Hoechst AG and Clariant GmbH
Pimephales promelas	juvenile 28-34 d	Y	CF	high	nw	7.6	25	44	96h	LC50	mortality	9.12	2		Broderius and Kahl, 1985
Pimephales promelas	28-34 d		F	99					96h	LC50	mortality	9.12	4*	14	IUCLID, 2000: Hoechst AG and Clariant GmbH
Pimephales promelas	30-35 days old	N	F		nw		25	43.3-48.5	96h	LC50	mortality	7.37	2		Hall et al., 1984
Pimephales promelas		Y	F						96h	LC50	mortality	7.79	4*	17	McCarty et al., 1985
Poecilia reticulata									7-14 d	LC50	mortality	7.4	4	17	Zhao et al., 1993
Poecilia reticulata	2-3 months old	N	R		am		22	25	14 d	LC50	mortality	7.4	2	22	Könemann, 1981
Poecilia reticulata			R				22		14 d	LC50	mortality	7.37	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH

Notes

1 Concentration exceeds water solubility
2 Microtox test
3 Cited in reference, unit unclear
4 Not stated whether system is open or closed
5 Light intensity 5000 lux, stocks in acetone (>0.1% total conc), recalculated from log EC50 in mM
6 Measured is extinction at 680 nm; method according to Wachstumstest of Boehm et al., 1972
7 Open system, no analysis of concentrations
8 Fluorescent light with 17.0 W/m2; initial cell density: 1e4 cells/L
9 Photoperiod 9:15 light:dark with fluorescent light
10 According to AFNOR methods
11 Animals were fed 20 mg/L dw trout chow and yeast during test; based on mean concentrations; 16:8h light::dark at 344 lm; binomial
12 Based on mean concentrations; 16:8h light:dark at 344 lm; binomial
13 According to OECD guidelines
14 According to ASTM standard test
15 According to US EPA guidelines
16 Based on mean concentrations; 16:8h light:dark at 344 lm; probit analysis
17 Cited in reference
18 According to DIN 38412
19 According to AFNOR T90 303
20 Undissolved chemical present at highest concentrations
21 According to APHA standard methods
22 Covered with glass
23 Exceeds water solubility
24 Concentrations measured, results not reported and endpoint based on nominal value

Table A2.10. Chronic toxicity of 1,3-dichlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Anaerobic bacteria from a domestic STP		N							40h	NOEC		40	4	1	IUCLID, 2000: Hoechst AG and Clariant GmbH
Anaerobic microorganisms							37		193h	NOEC	gas production	50	4	2	IUCLID, 2000: Hoechst AG and Clariant GmbH
Algae															
Pseudokirchneriella subcapitata									96h	NOEC		41.8	4		BUA.008: US-EPA, 1978
Pseudokirchneriella subcapitata			S						96h	NOEC		41.8	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Scenedesmus subspicatus			Sc						48h	EC10	growth rate	12.5	3		Kühn and Pattard, 1990
Crustacea															
Daphnia magna	<24 h, IRCHA	N	R	-	am	8.0±0.2	25±1	250	21d	NOEC	reproduction	0.8	4	3	Kühn et al., 1989
Daphnia magna	<24 h, IRCHA	Y	R	-	am	8.0±0.2	25±1	250	21d	NOEC	reproduction	0.5	4	3	Kühn et al., 1989
Daphnia magna	< 24 h	Y	R	95-99%	nw	6.6-7.9	20±1	44.7 (43.5-47.5)	28d	NOEC	reproduction	0.69	2	4	Richter et al., 1983
Daphnia magna		Y	CF	98	nw	6.9-7.4		42	28d	NOEC	reproduction	0.69	4*		Hesse et al., 1991: Call et al., 1989
Daphnia magna		Y							21d	NOEC	reproduction rate	0.69	4	7	IUCLID, 2000: Hoechst AG and Clariant GmbH
Daphnia magna	< 24 h	Y	R	95-99%	nw	6.6-7.9	20±1	44.7 (43.5-47.5)	28d	EC10	growth	1.3	2	4	Richter et al., 1983
Daphnia magna		Y	Rc		tw	6.6-7.6		16	21d	NOEC	reproduction	0.65	2	5	Hesse et al., 1991: Kühn et al., 1989
Daphnia magna	< 24 h		R		tw		19		16d	NOEC	growth	0.3	4	6	Deneer et al., 1988
Daphnia magna			R						21d	NOEC	reproduction rate	0.54	4		IUCLID, 2000: Hoechst AG and Clariant GmbH
Pisces															
Oncorhynchus mykiss		Y	F			7.4	25.0	45	32d	NOEC	mortality	0.555	2		Ahmad et al., 1984
Oncorhynchus mykiss		Y	F			7.4	25.0	45	32d	NOEC	growth	0.555	2		Ahmad et al., 1984
Pimephales promelas	4-12 h embryo	Y	F		nw	7.3-7.6	25	44-46	32d	NOEC	mortality	1	2		Carlson and Kosian, 1987
Pimephales promelas										NOEL		1.51	4		US-EPA, 1980
Pimephales promelas	embryo to early juvenile	Y	F	98					31-33d	NOEC	mortality, development	1	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH
Pimephales promelas	ELS	Y	F									1.51	4*	8	McCarty et al., 1985

Notes
1 ETAD fermentation tube method
2 EC15 = ca. 100 mg/L
3 Photoperiod 9:15 light:dark with fluorescent light
4 Based on mean concentrations; 16:8 h light:dark at 344 lm; Dunnett; control mortality <30%
5 Reported value is the average of the nominal NOEC and the lowest analysed concentration during the test
6 NEN 6502, 6501; EC10=0.95 mg/L
7 ASTM guidelines; LOEC = 1.5 mg/L; same as Richter et al.
8 Cited in reference

Table A2.11. Acute toxicity of 1,3-dichlorobenzene to marine organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Vibrio fischeri									5m	EC50	luminescence	2.9	4		IUCLID, 2000: Hoechst AG and Clariant GmbH
Vibrio fischeri									30min	EC50	bioluminescense	5.1	4	1	Sixt et al., 1995
Vibrio fischeri		N	S			6.5-7.5	15		5min	EC50	bioluminescense	3.1	2		Blum and Speece, 1991
Vibrio fischeri		N	S				20		15min	EC50	bioluminescense	8.5	2		Zhao et al., 1993
Vibrio fischeri		N	Sc		am		15		15min	EC50	bioluminescense	3.29	2		Hermens et al., 1985b
Vibrio fischeri			S		am	5-8	15		5min	EC50	bioluminescense	3.07	4	1	Kaiser and Ribo, 1988: McFeters et al., 1985
Vibrio fischeri			S		am	5-8	15		15min	EC50	bioluminescense	4.14	4	1	Kaiser and Ribo, 1988: McFeters et al., 1985
Vibrio fischeri			S		am	5-8	15		30min	EC50	bioluminescense	5.1	4	1	Kaiser and Ribo, 1988: McFeters et al., 1985
Vibrio fischeri									10min	EC50	bioluminescense	4.2	4	3	Bazin et al., 1987
Vibrio fischeri									30min	EC50	bioluminescense	5.1	4	1	Warne et al., 1999
Vibrio fischeri			S		am	5<pH<9			30min	EC50	bioluminescense	5.1	4*		Kaiser and Palabrica, 1991
Vibrio fischeri			S		am	5<pH<9			30min	EC50	bioluminescense	5.1	4*		Kaiser and Palabrica, 1991: Ribo and Kaiser, 1983
Vibrio fischeri			S		am	5<pH<9			15min	EC50	bioluminescense	3.29	4*		Kaiser and Palabrica, 1991: Hermens et al., 1985
Vibrio fischeri			S		am	5<pH<9			30min	EC50	bioluminescense	71.6	4		Kaiser and Palabrica, 1991: R. Speece, 1987
Vibrio fischeri									30min	EC50	bioluminescense	5.1	4		BUA.008: Ribo and Kaiser, 1983
Vibrio fischeri									5min	EC50	bioluminescence	3.3	4		BUA.008: Kamlet et al., 1986
Algae															
Skeletonema costatum									96h	EC50		52.8	4		BUA.008: US-EPA, 1978
Skeletonema costatum									96h	EC50		49.6	4		BUA.008: US-EPA, 1978
Crustacea															
Artemia spp									24h	LC50	mortality	11	4	1	Zhao et al., 1993
Americamysis bahia									96h	LC50	mortality	2.85	4	4	BUA.008: US-EPA, 1978
Americamysis bahia			S						96h	LC50	mortality	2.85	4*	4	IUCLID, 2000: Hoechst AG and Clariant GmbH
Pisces															
Cyprinodon variegatus	8-15 mm	N	S	>80%	nw	-	25-31	10-31	96h	LC50	mortality	7.8	3	2	Heitmuller et al., 1981
Cyprinodon variegatus									96h	LC50	mortality	7.8	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH

Notes
1 Cited in reference
2 Open system, no analysis of concentrations
3 Microtox test
4 NOEC < 1.3mg/L

Table A2.12. Chronic toxicity of 1,3-dichlorobenzene to marine organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Algae															
Skeletonema costatum									96h	NOEC		7.3	4		BUA.008: US-EPA, 1978
Skeletonema costatum			S						96h	NOEC		7.3	4*		IUCLID, 2000: Hoechst AG and Clariant GmbH

Table A2.13. Acute toxicity of 1,4-dichlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Methanogenic sewage sludge	900 mg/L		Sc			7	35		48h	EC50	gas production	86	2		EU-RAR: Blum and Speece, 1991
Nitrosomonas spec.	450 mg/L		Sc			6.5-8	25		12h	EC50	NH4-uptake	86	2		EU-RAR: Blum and Speece, 1991
Sewage sludge	200 mg/L		Sc			7	35		12h	EC50	O2-uptake	330	2		EU-RAR: Blum and Speece, 1991
Algae															
Cyclotella meneghiniana		Y							48h	EC50	growth	34.3	2	1	EU-RAR: Figueroa and Simmons, 1991
Pseudokirchneriella subcapitata		Y	Sc						96h	EC50	growth	1.6	2	1	EU-RAR: Calamari et al., 1983
Scenedesmus subspicatus		N	S						48h	EC50	proliferation inhibition	38	2		EU-RAR: Kühn and Pattard, 1990
Secenedesmus pannonicus		Y	S						72h	EC50	growth	31	2		EU-RAR: Canton et al., 1985
Crustacea															
Daphnia magna		Y	S						24h	EC50	immobilisation	1.6	2		EU-RAR; Calamari et al., 1982
Daphnia magna		N	S						24h	EC50	immobilisation	3.2			EU-RAR: Kühn et al., 1989
Daphnia magna		Y	S						48h	EC50	immobilisation	0.7	2		EU-RAR: Canton et al., 1985
Daphnia magna		Y	S						48h	LC50	mortality	2.2	2		EU-RAR: Canton et al., 1985
Pisces															
Danio rerio		Y	FT						96h	LC50	mortality	2.1	2		EU-RAR: Röderer, 1990
Jordanella floridae		Y	S						96h	LC50	mortality	4.5	2		EU-RAR: Smith et al., 1991
Jordanella floridae		Y	FT						96h	LC50	mortality	2.1	2		EU-RAR: Smith et al., 1991
Oncorhynchus mykiss		Y	FT						96h	LC50	mortality	1.12	2		EU-RAR: Call et al., 1983
Pimephales promelas	larvae	N	Sc						96h	LC50	mortality	3.6	2		EU-RAR: Mayes et al., 1983
Pimephales promelas	juvenile	N	Sc						96h	LC50	mortality	14.2	2		EU-RAR: Mayes et al., 1983
Pimephales promelas	adult	N	Sc						96h	LC50	mortality	11.7	2		EU-RAR: Mayes et al., 1983
Pimephales promelas	30 d old	Y	FT						96h	LC50	mortality	4.2	2		EU-RAR: Carlson and Kosian, 1987

Notes
1 Analysis at test start.

Table A2.14. Chronic toxicity of 1,4-dichlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Algae															
Scenedesmus subspicatus		N	S						48h	EC10	proliferation inhibition	16	2		EU-RAR: Kühn and Pattard, 1990
Crustacea															
Daphnia magna		N	R						21d	NOEC	hatching	0.4		1	EU-RAR: Kühn et al., 1989
Daphnia magna		Y	R						28d	NOEC	fertility	0.22	2		EU-RAR: Calamari et al., 1982
Pisces															
Danio rerio		Y	FT						14d	NOEC	mortality, weight, behaviour	0.44	2		EU-RAR: Röderer, 1990
Jordanella floridae	embryo	Y	FT						16d	NOEC	hatching, survival	0.2	2		EU-RAR: Smith et al., 1991
Oncorhynchus mykiss	embryo	Y	FT						60d	NOEC		> 0.1	2	2	EU-RAR: Calamari et al., 1983
Pimephales promelas	embryo	Y	FT						28d	NOEC	hatching, survival	0.57	2		EU-RAR: Carlson and Kosian, 1987

Notes
1 Test concentration decreased from 0.5 to 0.3 mg/L between renewals. 0.4 mg/L is the mean concentration.
2 No effects at any tested concentration

Table A2.15. Acute toxicity of 1,4-dichlorobenzene to marine organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Pisces															
Cyprinodon variegatus		N	S						96h	LC50	mortality	7.4	2		EU-RAR; Heitmüller et al., 1981

Table A2.16. Chronic toxicity of 1,4-dichlorobenzene to marine organisms

No data on the chronic toxicity of 1,4-dichlorobenzene to marine organisms were available in the EU-RAR.

Table A2.17. Acute toxicity of 1,2,3,4-tetrachlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Pseudomonas fluorescens										EC50	luminescence	11.8	4	1	Warne et al., 1999
Pseudomonas fluorescens		Y	S	>98	am	7.1	25		20 min	EC50	luminescence	12.1	2	2	Boyd et al., 1998
Algae															
Ankistrodesmus falcatus		N	Sc		am	8	20		4h	EC50	growth	4.1	3	3	Wong et al., 1984
Crustacea															
Ceriodaphnia cf. *dubia*	< 24 h	Y	S	>97%		7.7	23±1	65.2	48h	EC50	immobility	0.13	2		Rose et al., 1998
Daphnia carinata	< 24 h	Y	S				20±1		48h	EC50	immobility	0.51	2		Warne et al., 1999: Khalil, 1998
Daphnia magna	< 48 h	Y	S		am		22±1	100	48h	LC50	immobility	0.54	2	4	Hermens et al., 1984
Daphnia magna	<48 h	Y	S		am		22	100	48h	EC50	reproduction	0.09	2	5	De Wolf et al., 1988
Daphnia pulex	<24 h	N	S	ag	am		20	293.6	96h	LC50	mortality	0.18	3	6	Ikemoto et al., 1992
Pisces															
Jordanella floridae		Y	F						96h	LC50		2.01	2		McCarty et al., 1985
Oryzias latipes	0.2 g	N	S	ag	am		20	293.6	24h	LC50	mortality	1.93	3	6	Ikemoto et al., 1992
Pimephales promelas	30-35 d	N	F		rw		25	43.3-48.5	96h	LC50	mortality	0.8	2		Hall et al., 1989
Pimephales promelas	30 d, 0.12 g	Y	F		nw	7.5	25±1	45.5	96h	LC50	mortality	1.1	2		Veith et al., 1983
Pimephales promelas	30 d	Y	F			7.3-7.6	25	44-46	96h	LC50	mortality	1.1	4*		Carlson and Kosian, 1987
Pimephales promelas									96h	LC50	mortality	1.1	4*		Mekenyan and Veith, 1993
Pimephales promelas		Y	F						96h	LC50	mortality	1.07	4*		US-EPA, 1980
Pimephales promelas	30-35 days old	N	F		nw		25	43.3-48.5	96h	LC50	mortality	0.8	4*		Hall et al., 1984
Pimephales promelas		Y	F						96h	LC50		1.08	4		McCarty et al., 1985
Poecilia reticulata	1yr, male, 10-14mm	Y	CF	98	tw, dw		20		96h	LC50	mortality	0.4	2		van Hoogen and Opperhuizen, 1988

Notes
1 Cited in reference; unit unclear
2 Not stated whether system is open or closed
3 Light intensity 5000 lux, stocks in acetone (>0.1% total conc.), recalculated from log EC50 in mM
4 Test according to NEN 6501, 6502
5 Test conditions according to Hermens et al., 1984, recalculated from log(µl/l)
6 Open system, no analysis of concentrations

Table A2.18. Chronic toxicity of 1,2,3,4-tetrachlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Crustacea															
Daphnia magna	<24 h	Y	R		am		19±1		16d	NOEC	reproduction	0.01	2		Hermens et al., 1984
Daphnia magna	<24 h	Y	R		am		19±1		16d	NOEC	mortality	0.1	2		Hermens et al., 1984
Daphnia magna	<24 h	Y	R		am		19±1		16d	NOEC	growth	0.055	2		Hermens et al., 1985a
Daphnia magna	<24 h	Y	R		am		19±1		16d	NOEC	reproduction	0.055	2		De Wolf et al., 1988
Daphnia magna	<24 h	Y	R		am		19±1		16d	NOEC	growth	0.055	2		De Wolf et al., 1988
Insecta															
Chironomus riparius	3rd instar	N	S	>99%	aw	8.2±0.2	21±2	210	48h	LC10	mortality	0.62	3	1	Roghair et al., 1994
Chironomus riparius	eggs to 2nd instar	Y	R	99%	am	8.2	18 ± 1	209	28d	NOEC	growth	0.0518	2		Leslie et al., 2004
Pisces															
Danio rerio	<1d old --> fry	Y	R	99	rw	7.4-8.4		210	28d	NOEC	growth	0.1	2		Hesse et al., 1991: Van Leeuwen et al., 1990
Danio rerio	<1d old --> fry	Y	R	99	rw	7.4-8.4		210	28d	NOEC	mortality	0.31	2		Hesse et al., 1991: Van Leeuwen et al., 1990
Oncorhynchus mykiss		Y	F			7.4	25.0	45	32d	NOEC	mortality	0.245	2		Ahmad et al., 1984
Pimephales promelas	4-12 h embryos	Y	F			7.3-7.6	25	44-46	32d	NOEC	mortality	0.25	2		Carlson and Kosian, 1987
Pimephales promelas												0.318	4	3	US-EPA, 1980
Pimephales promelas	early life stages	Y	F									0.32	4	4	McCarty et al., 1985
Pimephales promelas	early life stages	Y	F									0.71	4	4	McCarty et al., 1985

Notes
1 Open system, no analysis of concentrations; recalculated
2 Recalculated few data in lower concentration range
3 Endpoint undetermined
4 Cited in reference

Table A2.19. Acute toxicity of 1,2,3,4-tetrachlorobenzene to marine organisms

Species	Species properties	A	Test type	Subst. purity	Test water	pH	Temp. [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Vibrio fischeri									30min	EC50	bioluminescense	4	4	1	Sixt et al., 1995
Vibrio fischeri		N	Sc			6.5-7.5	15		5min	EC50	bioluminescense	2.3	2		Blum and Speece, 1991
Vibrio fischeri		N	Sc		am		15		15min	EC50	bioluminescense	1.9	2		Hermens et al., 1985b
Vibrio fischeri									30min	EC50	bioluminescense	4.02	4*	1	Warne et al., 1999
Vibrio fischeri			S		am	5<pH<9			30min	EC50	bioluminescense	4.02	4		Kaiser and Palabrica, 1991: Ribo and Kaiser, 1983
Vibrio fischeri			S		am	5<pH<9			15min	EC50	bioluminescense	1.88	4		Hermens et al., 1985b
Algae															
Pyramidomonas sp.		N	Sc				20		72h	EC50	growth rate	3.55	3	2	Ma et al., 1997
Platymonas subcordiformis		N	Sc				20		72h	EC50	growth rate	3.4	3	2	Ma et al., 1997
Nannochloropsis oculata		N	Sc				20		72h	EC50	growth rate	2.92	3	2	Ma et al., 1997
Chlorella marine		N	Sc				20		72h	EC50	growth rate	2.24	3	2	Ma et al.,1997
Phaeodactylum tricornutum		N	Sc				20		72h	EC50	growth rate	1.88	3	2	Ma et al., 1997

Notes
1 Cited in reference
2 Culturing described by Otsuki et al., 1987, 12h light, nominal concentrations

Table A2.20. Chronic toxicity of 1,2,3,4-tetrachlorobenzene to marine organisms

Species	Species properties	A	Test type	Substance purity [%]	Test water	pH	Temp [°C]	Salinity [‰]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Echinodermata															
Portunus pelagicus	1st instar	N	S				26		NR	EC10	growth	0.035	3	1	Mortimer and Connell, 1995

Notes
1 Open system, no analysis of concentrations

Table A2.21. Acute toxicity of 1,2,3,5-tetrachlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Algae															
Ankistrodesmus falcatus		N	Sc		am	8	20		4h	EC50	photosynth.	3	3	1	Wong et al., 1984
Chlamydomonas angulosa		N	Sc		am	6.5	19		3h	EC50	photosynth.	1.6	3	2	Hutchinson et al., 1980
Chlorella vulgaris		N	Sc		am	6.5	19		3h	EC50	photosynth.	2.5	3	3	Hutchinson et al., 1980
Pseudokirchneriella subcapitata									96h	EC50	cell numbers	17.7	3	7	US-EPA, 1980
Crustacea															
Daphnia magna	4-6 days	N	Sc	>97%	dw		23±2		48h	LC50	mortality	0.86	4*		Abernethy et al., 1986
Daphnia magna	< 24 h	N	Sc	-	rw	7.4-9.4	22±1	173±13	48h	LC50	mortality	9.7	3		LeBlanc, 1980
Daphnia magna	1.5 mm	N	Sc		aw	6-7			48h	EC50	immobility	0.86	3	4	Bobra et al., 1985
Daphnia magna		N	S						48h	EC50		50.2	3	5, 7	US-EPA, 1980
Pisces															
Lepomis macrochirus	0.32-1.2 g	N	S	>80%	rw	6.5-7.9	21-23	32-48	96h	LC50	mortality	6.4	3	4, 5, 7	Buccafusco et al., 1981
Lepomis macrochirus		N	S						96h	LC50	mortality	6.42	4*	5, 7	US-EPA, 1980
Poecilia reticulata	2-3 m/o	N	R		am		22	25	14d	LC50	mortality	3.7	2	6	Könemann, 1981

Notes
1 Light intensity 5000 lux, recalculated from log EC50 in mM
2 Light intensity 400 foot candles; 12h light:dark; 5*10^4 cells/mL
3 Light intensity 400 foot candles; 12h light:dark; 20*10^4 cells/mL
4 Test solution constituted with saturated compound
5 Open system, no analysis of concentrations
6 Covered with glass
7 Exceeds water solubility

Table A2.22. Chronic toxicity of 1,2,3,5-tetrachlorobenzene to freshwater organisms

No data were available on the chronic toxicity of 1,2,3,5-tetrachlorobenzene to freshwater organisms.

Table A2.23. Acute toxicity of 1,2,3,5-tetrachlorobenzene to marine organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Vibrio fischeri									30 min	EC50	bioluminescense	2.5	4	1	Sixt et al., 1995
Vibrio fischeri		N	Sc			6.5-7.5	15		5 min	EC50	bioluminescense	3.3	2		Blum and Speece, 1991
Vibrio fischeri			S		am	5<pH<9			30 min	EC50	bioluminescense	2.48	4		Kaiser and Palabrica, 1991
Vibrio fischeri									30 min	EC50	bioluminescense	2.48	4*	1	Warne et al., 1999
Algae															
Skeletonema costatum									96 h	EC50	cell growth	0.7	4		US-EPA, 1980
Skeletonema costatum									96 h	EC50	cell growth	0.7	4*		US-EPA, 1980
Crustacea															
Mysidopsis bahia			S						96 h	LC50	mortality	0.34	4		US-EPA, 1980
Mysidopsis bahia		N	S						96 h	LC50	mortality	0.34	3	2	US-EPA, 1980
Pisces															
Cyprinodon variegatus	8-15 mm, 14-28 d	N	S	>80%	nw	-	25-31	10-31	96 h	LC50	mortality	3.7	3	2	Heitmuller et al., 1981
Cyprinodon variegatus		N	S						96 h	LC50	mortality	3.7	4*	2	US-EPA, 1980

Notes
1 Cited in reference
2 Open system, no analysis of concentrations

Table A2.24. Chronic toxicity of 1,2,3,5-tetrachlorobenzene to marine organisms

No data were available on the chronic toxicity of 1,2,3,5-tetrachlorobenzene to marine organisms.

Table A2.25. Acute toxicity of 1,2,4,5-tetrachlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Pseudomonas fluorescens										EC50	luminescence	1.27	4	1	Warne et al., 1999
Pseudomonas fluorescens		Y	S	>98	am	7.1	25		20 min	EC50	luminescence	2.16	2	2	Boyd et al., 1998
Protozoa															
Tetrahymena pyriformis							30		24h	LC50	mortality	20	3	3, 14	Yoshioka, 1985
Tetrahymena pyriformis			S	>95	am	7.35	27		40h	IC50	growth inhibition	100	3	4, 14	Schultz, 1999
Algae															
Ankistrodesmus falcatus		N	Sc		am	8	20		4h	EC50	growth rate	4.9	3	5, 14	Wong et al., 1984
Pseudokirchneriella subcapitata									96h	EC50	growth rate	52.9	3	14	US-EPA, 1980: US-EPA, 1978
Pseudokirchneriella subcapitata									96h	EC50	growth rate	46.8	3	14	US-EPA, 1980
Crustacea															
Daphnia magna	<24 h	N	Sc	-	rw	7.4-9.4	22±1	173±13	48h	LC50	mortality	>530	3	6, 14	LeBlanc, 1980
Daphnia magna	<24 h	N	Sc	-	rw	7.4-9.4	22±1	173±13	48h	NOEC	mortality	320	3	6, 14	LeBlanc, 1980
Pisces															
Cyprinus carpio	5 g, 5 cm	N	R				20±1		48h	LC50	mortality	2.8	3	7, 10	Zhao et al., 1993
Jordanella floridae	2-4 month	N	R		nw	6.95±0.35	25±1	48±2.13	96h	LC50	mortality	2.08	3	8, 9	Smith et al., 1991
Jordanella floridae	2-4 mo	Y	F		nw	6.95±0.35	25±1	48±2.13	96h	LC50	mortality	2.15	3	9	Smith et al., 1991
Lepomis macrochirus	0.32-1.2 g	N	S	>80%	rw	6.5-7.9	21-23	32-48	96h	LC50	mortality	1.6	3	9, 10	Buccafusco et al., 1981
Lepomis macrochirus		N	S						96h	LC50	mortality	1.55	3	10	US-EPA, 1980
Leuciscus idus melanotus		N	S	-	tw	7--8	20±1	255	48h	LC50	mortality	30	3	10, 11, 14	Juhnke and Lüdemann, 1978
Leuciscus idus melanotus		N	S	-	tw	7--8	20±1	255	48h	LC0	mortality	10	3	10, 11, 14	Juhnke and Lüdemann, 1978
Pimephales promelas	30-35 d	N	F		rw		25	43.3-48.5	96h	LC50	mortality	0.3	2		Hall et al., 1989
Pimephales promelas									96h	LC50	mortality	0.3	4	12	Zhao et al., 1993
Poecilia reticulata	2-3 m/o	N	R		am		22	25	14 d	LC50	mortality	1.4	2	13	Könemann, 1981

Notes
1 Cited in reference, unit unclear
2 Not stated whether system is open or closed
3 Concentration exceeds water solubility; estimated value
4 Methods in Schultz, 1997
5 Light intensity 5000 lux, stocks in acetone (>0.1% total conc), recalculated from log EC50 in mM
6 According to US EPA, 1975
7 Extrapolated value
8 Renewal every 24h
9 According to US EPA; precipitate present
10 Open system, no analysis of concentrations
11 Test according to Mann, 1976
12 Cited in reference
13 Covered with glass
14 Exceeds water solubility

Table A2.26. Chronic toxicity of 1,2,4,5-tetrachlorobenzene to freshwater organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Hardness $CaCO_3$ [mg/L]	Exp time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Pisces															
Jordanella floridae	eggs, < 24 h old	Y	F		nw	6.95±0.35	25±1	48±2.13	4-6d	NOEC	hatchability	>0.238	2		Smith et al., 1991
Jordanella floridae	2 weeks	Y	F		nw	6.95±0.35	25±1	48±2.13	10d	NOEC	mortality	>0.238	2		Smith et al., 1991
Jordanella floridae	1 week	Y	F		nw	6.95±0.35	25±1	48±2.13	28d	NOEC	growth	0.067	2		Smith et al., 1991
Jordanella floridae	early life stages	Y	F						28d		fry growth, survival	0.084	2		McCarty et al., 1985
Oncorhynchus mykiss	egg		R			7.2	10	50	96h	NOEC	mortality	10	3	1	Van Leeuwen et al., 1985
Oncorhynchus mykiss	egg		R			7.2	10	50	96h	NOEC	mortality	10	3	1	Van Leeuwen et al., 1985
Oncorhynchus mykiss	14 d		R			7.2	10	50	96h	NOEC	mortality	10	3	1	Van Leeuwen et al., 1985
Oncorhynchus mykiss	28 d		R			7.2	10	50	96h	NOEC	mortality	10	3	1	Van Leeuwen et al., 1985
Oncorhynchus mykiss	42 d		R			7.2	10	50	96h	NOEC	mortality	10	3	1	Van Leeuwen et al., 1985
Oncorhynchus mykiss	young larva		R			7.2	10	50	96h	NOEC	mortality	1.2	2		Van Leeuwen et al., 1985
Salvenius fontinalis	early life stages	Y	F						28d		fry growth, survival	≤ 0.24	2		McCarty et al., 1985

Notes
1 Exceeds water solubility

Table A2.27. Acute toxicity of 1,2,4,5-tetrachlorobenzene to marine organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Bacteria															
Vibrio fischeri		N	Sc			6.5-7.5	15		5min	EC50	bioluminescense	10	3	4	Blum and Speece, 1991
Vibrio fischeri									30min	EC50	bioluminescense	4.5	4	1, 4	Sixt et al., 1995
Vibrio fischeri		N	S				20		15min	EC50	bioluminescense	0.67	2		Zhao et al., 1993
Vibrio fischeri							15		30min	EC50	bioluminescense	4.51	3	4	Ribo and Kaiser, 1983
Vibrio fischeri									30min	EC50	bioluminescense	4.51	4*	1, 4	Warne et al., 1999
Vibrio fischeri			S		am	5<pH<9			30min	EC50	bioluminescense	4.51	4*	4	Kaiser and Palabrica, 1991
Algae															
Skeletonema costatum									96h	EC50	growth	52.9	3	4	US-EPA, 1978
Skeletonema costatum									96	EC50	cell growth	7.3	3	4	US-EPA, 1980
Crustacea															
Americamysis bahia		N	S						96h	LC50	mortality	1.48	4		US-EPA, 1980
Pisces															
Cyprinodon variegatus	8-15 mm, 14-28 d	N	S	>80%	nw	-	25-31	10-31	96h	LC50	mortality	0.8	3	2	Heitmuller et al., 1981
Cyprinodon variegatus	<20 d old	Y	CF		nw	7.3-8.3	30	12-28	96h	LC50	mortality	0.33	2		Ward et al., 1981
Cyprinodon variegatus		N	S						96h	LC50	mortality	0.84	3	2	US-EPA, 1980

Notes
1 Cited in reference
2 Open system, no analysis of concentrations; extrapolated value
3 Up to 5% methanol as dissolvant
4 Exceeds water solubility

Table A2.28. Chronic toxicity of 1,2,4,5-tetrachlorobenzene to marine organisms

Species	Species properties	A	Test type	Subst. purity [%]	Test water	pH	Temp. [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [mg/L]	Ri	Notes	Reference
Pisces															
Cyprinodon variegatus	<1d old --> 28 d post-hatching	Y	CF		nw (filtered)	7.3-8.3	30	12-28	>28d	NOEC	mortality	0.18	2		Ward et al., 1981
Cyprinodon variegatus	<1d old --> 28 d post-hatching	Y	CF		nw (filtered)	7.3-8.3	30	12-28	>28d	NOEC	hatchability	>0.52	3	1	Ward et al., 1981
Cyprinodon variegatus												0.129	4		US-EPA, 1980

Notes
1 Value exceeds LC_{50}

Appendix 3. Detailed soil toxicity data

Table A3.1. Toxicity of monochlorobenzene to soil organisms

Species	Species properties	Soil type	A	Subst. purity [%]	pH	o.m. [%]	Clay [%]	T [°C]	Exp. time	Criterion	Test endpoint	Result test soil [mg/kgd.w.]	Result stand. soil [mg/kgd.w.]	Ri	Notes	Reference
Bacteria																
unspecified		sandy loam	Y			0.7		25	8-10h	IC50	O2 consumption	330	1714	4	2	Arulgnanendran and Nirmakhandan, 1998
polytox, mixed microbial culture of 12 strains		sandy loam	Y			0.7		25	8-10h	IC50	O2 consumption	35576	508229	4	2	Arulgnanendran and Nirmakhandan, 1998
Annelida																
Eisenia andrei	adult	sand	Y	>98	4.8	3.7	1.4	23	14d	LC50		240	649	2	1	Van Gestel et al., 1991
Eisenia andrei	adult	OECD artificial	Y	>98	5.9	8.1	8.1	23	14d	LC50		446	551	2	1	Van Gestel et al., 1991
Lumbricus rubellus	adult	sandy	Y	>98	4.8	3.7	1.4	15	14d	LC50		547	1478	2	1	Van Gestel et al., 1991
Lumbricus rubellus	adult	OECD artificial	Y	>98	5.9	8.1	8.1	15	14d	LC50		1107	1367	2	1	Van Gestel et al., 1991

Notes
1 Data corrected for recovery
2 Exposure duration too short

A3.2. Toxicity of 1,2-dichlorobenzene to soil organisms

Species	Species properties	Soil type	A	Subst. purity [%]	pH	o.m. [%]	Clay [%]	T [°C]	Exp. time	Criterion	Test endpoint	Result test soil [mg/kgd.w.]	Result stand. soil [mg/kgd.w.]	Ri	Notes	Reference
Bacteria																
unspecified		sandy loam	Y			0.7		25	8-10 h	IC50	O2 consumption	120	1714	4	3	Arulgnanendran and Nirmakhandan, 1998
polytox, mixed microbial culture of 12 strains		sandy loam	Y			0.7		25	8-10 h	IC50	O2 consumption	282587	4036957	4	3	Arulgnanendran and Nirmakhandan, 1998
mixed soil culture		clay-loam	N		7.4				14 d	LOEC	viable bacterial numbers	10		4	1	Meharg et al., 1998
Pseudomonas sp.		clay-loam	Y	>99	7.4	7.5	30		49 d	NOEC	colony development	≥ 3200	≥ 4256	4	2,3	Thompson et al., 1999a
mixed soil culture		clay-loam	Y	>99	7.4	7.5	30		7 d	NOEC	viable bacterial numbers	1300	1733	4	2,3	Thompson et al., 1999a
mixed soil culture		clay-loam	Y	>99	7.4	7.5	30		14 d	NOEC	viable bacterial numbers	1300	1733	4	2,3	Thompson et al., 1999a
mixed soil culture		clay-loam	Y	>99	7.4	7.5	30		49 d	NOEC	viable bacterial numbers	1300	1733	4	2,3	Thompson et al., 1999a
mixed soil culture		clay-loam	Y	>99	7.4	7.5	30		22 w	LOEC	viable bacterial numbers	100	133	4	2,3	Thompson et al., 1999b
mixed soil culture		clay-loam	Y	>99	7.4	7.5	30		22 w	LOEC	bacterial taxa composition	100	133	4	2,3	Thompson et al., 1999b
Fungi																
mixed soil culture		clay-loam	N		7.4				14 d	NOEC	viable fungal hyphal lengths	10		4	1	Meharg et al. 1998
mixed soil culture		clay-loam	Y	>99	7.4	7.5	30		7 d	LOEC	viable fungal hyphal lengths	65	87	4	2,3	Thompson et al., 1999a
mixed soil culture		clay-loam	Y	>99	7.4	7.5	30		14 d	LOEC	viable fungal hyphal lengths	65	87	4	2,3	Thompson et al., 1999a
mixed soil culture		clay-loam	Y	>99	7.4	7.5	30		49 d	LOEC	viable fungal hyphal lengths	65	87	4	2,3	Thompson et al., 1999a
mixed soil culture		clay-loam	Y	>99	7.4	7.5	30		22 w	LOEC	viable fungal hyphal lengths	100	133	4	2,3	Thompson et al., 1999b

Notes
1 O.m. content of soil not given, recalculation to standard soil not possible
2 Endpoint expressed as nominal; total recovery of extractable radioactivity in concurrent system 42-78% of nominal at the end of the experiment; actual exposure not known
3 Exposure duration too short

A3.3. Toxicity of 1,3-dichlorobenzene to soil organisms

Species	Species properties	Soil type	A	Subst. purity [%]	pH	o.m. [%]	Clay [%]	T [°C]	Exp. time	Criterion	Test endpoint	Result test soil [mg/kgd.w.]	Result stand. soil [mg/kgd.w.]	Ri	Notes	Reference
Bacteria																
unspecified		sandy loam	Y			0.7		25	8-10h	IC50	O2 consumption	140	2000	4	1	Arulgnanendran and Nirmakhandan, 1998
polytox, mixed microbial culture of 12 strains		sandy loam	Y			0.7		25	8-10h	IC50	O2 consumption	417977	5971100	4	1	Arulgnanendran and Nirmakhandan, 1998

Notes
1 Exposure duration too short

A3.4. Toxicity of 1,2,3,4-tetrachlorobenzene to soil organisms

Species	Species properties	Soil type	A	Subst. purity [%]	pH	o.m. [%]	Clay [%]	T [°C]	Exp. time	Criterion	Test endpoint	Result test soil [mg/kgd.w.]	Result stand. soil [mg/kgd.w.]	Ri	Notes	Reference
Eisenia andrei	adult	sandy	Y	>98	4.8	3.7	1.4	23	14d	LC50		75	203	2	1	van Gestel et al., 1991
Eisenia andrei	adult	OECD artificial	Y	>98	5.9	8.1	8.1	23	14d	LC50		223	275	2	1	van Gestel et al., 1991
Lumbricus rubellus	adult	sandy	Y	>98	4.8	3.7	1.4	15	14d	LC50		112	303	2	1	van Gestel et al., 1991
Lumbricus rubellus	adult	OECD artificial	Y	>98	5.9	8.1	8.1	15	14d	LC50		201	248	2	1	van Gestel et al., 1991

Notes
1 Data corrected for recovery

A3.5. Toxicity of 1,2,3,5-tetrachlorobenzene to soil organisms

No data were available on the toxicity of 1,2,3,5-tetrachlorobenzene to soil organisms.

A3.6. Toxicity of 1,2,4,5-tetrachlorobenzene to soil organisms

No data were available on the toxicity of 1,2,4,5-tetrachlorobenzene to soil organisms.

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