Euro Chlor Risk Assessment for the Marine Environment
OSPARCOM Region - North Sea

1,4-Dichlorobenzene

February 1999

Euro Chlor
representing the chlor-alkali industry

EURO CHLOR RISK ASSESSMENT FOR THE MARINE ENVIRONMENT

1,4-DICHLOROBENZENE

OSPARCOM Region - North Sea

EXECUTIVE SUMMARY

Euro Chlor has voluntarily agreed to carry out risk assessment of 25 chemicals related to the chlorine industry, specifically for the marine environment and according to the methodology laid down in the EU Risk Assessment Regulation (1488/94) and the Guidance Documents of the EU Existing Substances Regulation (793/93).

The study consists of the collection and evaluation of data on effects and environmental concentrations. Basically, the effect data are derived from laboratory toxicity tests and exposure data from analytical monitoring programs. Finally the risk is indicated by comparing the "predicted environmental concentrations" (PEC) with the "predicted no effect concentrations" (PNEC), expressed as a hazard quotient for the marine aquatic environment.

To determine the PNEC value, three different trophic levels are considered: aquatic plants, invertebrates and fish.

In the case of 1,4-dichlorobenzene, 17 data for fish, 9 data for invertebrates and 7 data for algae have been evaluated according to the environmental quality criteria recommended by the European authorities. Both acute and chronic toxicity studies have been taken into account and the appropriate assessment factors have been used to define a final PNEC value of 20 µg/l.

The recent monitoring data available indicate that the concentration in coastal waters and estuaries is below the determination limit of 0.1 µg/l used in the monitoring programs. A worst case value in river water is found as lower than 0.45 µg/l. Using these values, the calculated PEC/PNEC ratio give a safety margin of about 40 to 200 between the predicted no effect concentration and the exposure concentration. Dilution within the sea will, of course, increase these safety margins.

Moreover, as the available data on persistence of 1,4-dichlorobenzene indicate a good biodegradation potential and no significant bioaccumulation potential in marine organisms, it can be concluded that the present use of 1,4-dichlorobenzene does not represent a risk to the aquatic environment.

1. INTRODUCTION: PRINCIPLES AND PURPOSES OF EURO CHLOR RISK ASSESSMENT

Within the EU a programme is being carried out to assess the environmental and human health risks for "existing chemicals", which also include chlorinated chemicals. In due course the most important chlorinated chemicals that are presently in the market will be dealt with in this formal programme. In this activity Euro Chlor members are cooperating with member state rapporteurs. These risk assessment activities include human health risks as well as a broad range of environmental scenarios.

Additionally Euro Chlor has voluntarily agreed to carry out limited risk assessments for 25 prioritised chemicals related to the chlorine industry. These compounds are on lists of concern of European Nations participating in the North Sea Conference. The purpose of this activity is to explore if chlorinated chemicals presently pose a risk to the marine environment especially for the North Sea situation. This will indicate the eventual necessity for further refinement of the risk assessments and eventually for additional risk reduction programmes.

These risk assessments are carried out specifically for the marine environment according to principles given in *Appendix 1*. The EU methodology is followed as laid down in the EU risk assessment Regulation (1488/94) and the Guidance Documents of the EU Existing Substances Regulation (793/93).

The exercise consists of the collection and evaluation of data on effects and environmental concentrations. Basically, the effect data are derived from laboratory toxicity tests and exposure data from analytical monitoring programs.
Where necessary the exposure data are backed up with calculated concentrations based on emission models.

Finally, in the absence of secondary poisoning, the risk is indicated by comparing the "predicted environmental concentrations" (PEC) with the "predicted no effect concentrations" (PNEC), expressed as a hazard quotient for the marine aquatic environment.

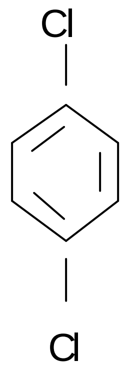
2. DATA SOURCE

The data used in this risk assessment activity are primarily derived from the data given in the HEDSET/IUCLID (February 1996) for this compound. Where necessary additional sources have been used.

3. COMPOUND IDENTIFICATION

3.1. Description

CAS number	:	106-46-7
EINECS number	:	203-400-5
EEC number	:	
IUPAC name	:	1,4-Dichlorobenzene
Synonyms	:	Benzene, 1,4-dichloro paradichlorobenzene p-dichlorobenzene pDCB
Structural formula	:	



3.2. EU labelling

According to Annex I of Directive 93/72/EEC (1.9.93 - 19th TPA), 1,4-dichlorobenzene is classified as : harmful by oral route (Xn, R22), irritant for the skin and eyes (R36/38).

4. PHYSICO-CHEMICAL PROPERTIES

Table 1 gives the major physical and chemical properties of 1,4-dichlorobenzene which were adopted for the purpose of this risk assessment.

Table 1 : physical and chemical properties of 1,4-dichlorobenzene

Property	Value
Molecular weight	147.0 g
Melting/freezing point	53°C
Boiling point	173°C
Density	1.25 g/cm^3 at 20°C
Vapour pressure	1.7 hPa at 20°C
Water solubility	70 mg/l at 20°C, 90.6 mg/l at 25°C
logKow	3.4 (measured)
logKoc	2.6 (calculated)
Henry's law constant	3.7 x 10^2 Pa m^3/mole

5. COMPARTMENT OF CONCERN BY MACKAY LEVEL I MODEL

The risk assessment presented here focuses on the aquatic marine environment, with special attention for the North sea conditions where appropriate. Although this risk assessment only focuses on one compartment, it should be borne in mind that all environmental compartments are inter-related.

An indication of the partitioning tendency of a compound can be defined using Mackay level I calculation obtained through the ENVCLASS software distributed by the "Nordic Council of Ministers". This model describes the ultimate distribution of the compound in the environment (Mackay & Patterson, 1990 - Pedersen *et al.*, 1994).

The results are valuable particularly in describing the potency of a compound to partition between water, air or sediment. Practically, it is an indicator of the potential compartments of concern.
The results of such a calculation for 1,4-dichlorobenzene are given in Table 2.

Table 2 : Partition of 1,4-dichlorobenzene into different environmental compartments according to Mackay level I calculation (Mackay & Patterson, 1990)

Compartment	%
Air	98.9
Water	0.79
Soil	0.15
Sediment	0.14

(See *Appendix 2* for details of calculation)

Due to the very low probability of partitioning to sediment, the risk assessment will focus on the water phase.

6. PRODUCTION, USES, EMISSIONS

6.1. Production and sales

1,4-dichlorobenzene is produced by chlorination of benzene in the presence of a catalyst. 1,2-dichlorobenzene is obtained simultaneously. Crystallisation combined with distillation is used to obtain the isomers separation.

1,4-dichlorobenzene is produced in Europe by 3 companies in 3 locations: Bayer AG (Germany), Elf Atochem (France), EniChem (Italy).

The total production in the European Union was estimated for 1994 to be 25,500 tonnes (CEFIC Euro Chlor, 1995). 1,4-dichlorobenzene is exported outside Europe. CEFIC exports estimation for 1994 is about 14,800 tonnes. 1,4-dichlorobenzene is also imported in the European Union. Imports were estimated to be 10,000 tonnes in 1994. However, an overall consumption in the EU is estimated as up to 15,000 tonnes per year in 1994 (EU, draft risk assessment, 1998).

6.2. Uses

1,4-dichlorobenzene is used in mainly 3 applications:

- 50% is used as raw material in synthesis of pesticides, resins, and dyestuffs
- 22% as toilet blocks deodorant
- 28% as moth repellent

6.3. Emissions

The main routes by which 1,4-dichlorobenzene enters the environment during manufacture, processing and usage are the hydrosphere and atmosphere.

1,4-dichlorobenzene mainly enters the air compartment from its use as toilet blocks deodorant and moth repellent. It can also come to the hydrosphere through its use as toilet blocks deodorant. Based on a total consumption of 15,000 tonnes/year, total air and water emissions in the EU were estimated as 7258.2 t/y and 427 t/y respectively for both production and uses (EU, draft risk assessment, 1998).

Emissions to water represented 1.9 t/y and air emissions 39 t/y in 1995 as based on a survey from about 78 sites from the European industry producing or using 1,4-dichlorobenzene (Euro Chlor, 1996). These values represent 87% reduction in water emissions as compared to the releases from 1985. Air emissions seem to have increased by about 48%, probably as a result of better estimation.

7. EFFECT ASSESSMENT

As a first approach, only the three following trophic levels are considered: aquatic plants, invertebrates and fish.

The evaluation of the data was conducted according to the environmental quality criteria recommended by the European authorities (Commission regulation 1488/94/EEC). The evaluation criteria are given in *Appendix 1*.

Documented data from all available sources, including company data and data from open literature were collected and can be found in the HEDSET data sheet for 1,4-dichlorobenzene, including their references (update version of 9/2/96). Some more references from other databases were added.

A summary of all data is given in *Appendix 3*. In total 17 data for fish, 9 data for aquatic invertebrates and 7 data for algae are given. For the respective taxonomic groups, 7, 3 and 1 data were considered valid for risk assessment purposes, 5, 2 and 4 should be considered with care and 5, 4 and 2 data respectively were judged as not valid for risk assessment.

Beforehand, a general remark is applicable to the evaluation of the ecotoxicity data for fish and invertebrates. It is necessary to distinguish the acute (LC50/EC50) studies from chronic (NOEC/LOEC) studies. In the tables presented in *Appendix 3*, the data are ranked based on class (fish, invertebrates, algae), criterion (LC50/EC50, NOEC/LOEC), environment (fresh water, saltwater) and validity (1,2,3,4) as requested by the EU risk assessment process (TGD, 1996).

The different trophic levels are reviewed hereafter. As only a few data refers to marine species, and that it shows no significant difference in sensitivity with respect to fresh water species, we will consider that the PNEC derived from the present set of data is valid for marine as well as for fresh water ecosystems. Due to its low solubility and significantly high vapour pressure 1,4-dichlorobenzene should be tested in closed system to avoid loss of volatilisation.

7.1. Fish

Only one acute toxicity study is reported for marine fish. This study has been carried out on *Cyprinodon variegatus* and reports an LC50-96h = 7.4 mg/l, based on nominal concentrations. In spite of this and the fact that it was a static design, this data can be used to some extent, being in agreement with fresh water fish results whose all available results are in a very narrow range : 2 mg/l < LC50-96h < 4 mg/l. If only best data are taken into account (on *Brachydanio rerio, Pimephales promelas* and *Jordanella floridae*), the lowest acute toxicity value of 2 mg/l can be retained (Smith *et al*, 1991). Although a lower LC50 is available on *Oncorhynchus mykiss* (1.18 mg/l) this value is considered of less validity due to the methodology used (low number of fish (Calamari *et al*., 1983).

There are four chronic study reports available on four different species. Again, results are consistent. With *Oncorhynchus mykiss*, no effect has been observed up to the highest tested concentration : NOEC > 0.122 mg/l (Calamari *et al.*, 1982). With *Pimephales promelas*, the NOEC is 0.57 mg/l, (LOEC = 1 mg/l ; MATC = 0.76 mg/l) (Carlson & Kosian, 1987). The lowest NOEC value is obtained with *Jordanella floridae* as 0.20 mg/l (Smith *et al.*, 1991).

7.2. Invertebrates

Four data are available for acute toxicity on *Daphnia magna* and three are usable ; as for fish, the results are in a narrow range ; the lowest valid data is EC50-48h for *Daphnia magna* : 0.7 mg/l (Canton, 1985).

Three data for marine water arthropods have been found but only one of them can be used for risk assessment although results should be considered with care. Abernethy *et al.* (1986) found a 24h-LC50 of 14 mg/l for *Artemia salina* under a static test with partial control of volatility.

In addition, there is one convenient value for chronic toxicity towards *Daphnia magna* with a NOEC = 0.22 mg/l (LOEC = 0.4 mg/l) (Calamari *et al*, 1982).

7.3. Algae

The same test protocol is used for deriving acute and chronic figures. The former correspond to EC50 end point, the latter to NOEC which is equivalent to an EC0 to EC10 end point. For an acute value, an EC50-96h = 1.6 mg/l for *Selenastrum capricornutum* can be used. It can be noted that this result is one order of magnitude lower than the other species studied.

In the same study (Calamari, 1982), the EC0-96h = 0.57 mg/l for *Selenastrum capricornutum* will be used as a chronic NOEC

7.4. PNEC for freshwater and marine environments

The underlined values above are used for PNEC calculation. As long term NOEC are available for all three trophic levels, an assessment factor of 10 can be applied to the lowest figure : 0.20 mg/l.

Therefore the final PNEC which is calculated for this risk assessment is 20 µg/l.

The draft for surface waters quality objectives of the European Union for substances on list I of Directive 76/464 indicates a value of 10 µg/l (CSTE, 1994) for all isomers of dichlorobenzenes.

Table 3
Summary of relevant ecotoxicity data for the PNEC derivation for 1,4-Dichlorobenzene

Available valid data	Assigned assessment factor	Lowest toxicity values
At least 1 short-term LC50 from each trophic level	1000 **PNEC = 0.7 µg/l**	– *Jordanella floridae,* LC50 - 96 h = 2 mg/l (Smith *et al.*, 1991) – *Daphnia magna,* EC50 - 48 h = 0.7 mg/l (Canton, 1985) – *Selenastrum capricornutum*, EC50 - 96 h = 1.6 mg/l (Calamari *et al.*, 1982))
3 long-term NOEC from species of 3 trophic levels	10 **PNEC = 20 µg/l**	– *Jordanella floridae,* NOEC - 10 d = 0.2 mg/l (Smith *et al.*, 1991) – *Daphnia magna,* NOEC - 28 d = 0.22 mg/l (Calamari *et al.*, 1982) – *Selenastrum capricornutum*, EC0 96 h = 0.57 mg/l (Calamari *et al.*, 1982)

7.5. Bioaccumulation

Bioconcentration factors have been determined on fish. Veith *et al* (1979) reported BCF for bluegill sunfish of 60 and for rainbow trout of 210. Investigations made by Smith *et al* (1990), Carlson *et al* (1987), Barrows *et al* (1980) gave a range of BCF for fish from 60 to 296. The half life for the elimination from the organism after transfer to a 1,4-dichlorobenzene free medium is less than 24 hours. BCF of 100 for algae is given by Freitag *et al* (1985) and for *Chlorella fusca* a BCF of 90 is given by the MITI (1985) list.

Mean BCF values of 370 to 720 were experimentally determined for rainbow trout exposed up to 119 days to 1,4-dichlorobenzene (Oliver & Niimi, 1983).

During a 60-day exposure of 1,4-dichlorobenzene to rainbow trout (from egg to alevin), BCF's were generally in the 100 to 250 range, although a BCF of 1400 was observed at the hatching stage (Calamari *et al*., 1982).

Oliver (1987) gives for the sediment biota Tubifex a BCF of 60 in a 79 days test. 1,4-dichlorobenzene is classified as having no or low bioaccumulation in the MITI list.

7.6 Persistence in water

The value of the Henry's Constant 357 Pa m^3/mole indicates that 1,4-dichlorobenzene is readily volatile from water and that the half life in water will be short and expressed in hours in running waters.

1,4-dichlorobenzene is not expected to undergo significant hydrolysis in environmental waters (Callahan *et al*., 1979).

1,4-dichlorobenzene absorbs almost no UV radiation above 300 nm in either methanol or hexane solvent (Jori *et al*., 1982; Sadtler, 1988) so that direct photolysis is not expected to be important in the environmental disappearance of the compound. Although the possibility of sensitized photolysis has been suggested, photolysis experiments from rivers flowing into the Great Lakes were found to have no accelerating effect on photodegradation (Jori *et al*., 1982).

In a model river 1 m depth with a current of 1m/s and wind velocity of 3 m/s at 20°C, Lyman (1982) calculated a half life of 4.3 hours. Using SRC's EPIWIN, with similar parameters lead to a half-life of of 3.8 hrs. In a lake situation (1 m deep, 0.05 m/sec water current and 0.5 m/sec wind velocity) a half-life of 117.4 hrs is calculated.

In marine mesocosm Wakeham *et al* (1983) observed a half life of 18 days at 8-16°C. Half lives ranging from 1.1 to 25 days were found by direct measurements in different sampling locations (EPA, 1985).

Evaporation from the hydrosphere to the atmosphere is an important environmental transport mechanism.

7.7. Persistence in air

In the atmosphere 1,4-dichlorobenzene is degraded by OH radicals with rate constants from 3.2 to 5.2 10^{-13} cm^3/molecule.sec. (Klopffer *et al*., 1986; Wahner and Zetsch, 1983; Arnts *et al*., 1989). Taking the average of these values (4.1 10^{-13} cm^3/molecule.sec) and assuming a mean OH concentration of 10^6 molecules/cm^3, this corresponds to an atmospheric half life of 20 days. A value of 26.7 days is obtained with SRC's EPIWIN software.

With an average atmospheric hydroxyl radical concentration of 8.10^5 molecules/cm^3, the half-life for indirect photooxidation reaction is estimated to be 31 days (Atkinson, 1985). McKay *et al.* (1985) indicated a rate constant in air of 9.63 10^{-3}/h for 1,4-dichlorobenzene photo-oxidation which corresponds to a half-life of 3 days.

The atmospheric half lives preclude any significant transport to the stratosphere. Hence, 1,4-dichlorobenzene will not contribute to ozone depletion.

7.8. Degradation in biological systems

1,4-dichlorobenzene is reported to be readily biodegradable. 80% degradation in 28 days (Topping, 1987) (closed bottle test). Strains of bacteria isolated from soil water, or sewage sludge samples are capable of using 1,4-dichlorobenzene as a sole carbon and energy source.

Using a static-culture screening procedure (5 or 10 mg/l test compound, a 7-day static incubation followed by 3 weekly subcultures and a settled domestic wastewater as microbial inoculum), 1,4-dichlorobenzene was biodegraded 37-55%, 54-61%, 29-34% and 0-16% after the original culture, first, second and third subculture respectively (Tabak *et al*., 1981).

1,4-dichlorobenzene was found to be degradation resistant using the Japanese MITI test (Kitano, 1978).

1,4-dichlorobenzene has BOD's of 65, 77 and 77% of the ThOD over 5-, 10- and 20-day periods, respectively (Bailey, 1983).

According to an OECD continuous test, an elimination rate of 97.1 ± 2.3% is obtained after 15 days adaptation time. 31% of elimination was attributed to biological degradation (BUA Stoff dossier, Dec. 1994). Kirk *et al* (1989) performed biodegradation tests in anaerobic conditions on a 710 µg/l 1,4-dichlorobenzene solution using biomass with addition of 50 mg/l of sodium acetate and 25 mg/l of sodium propionate.

The 1,4-dichlorobenzene elimination was reported as follows:

Time (days)	Percent elimination 1,4-dichlorobenzene
2	12%
4	20%
8	30%
16	65%
32	80%

In conclusion, 1,4-dichlorobenzene can be considered as readily biodegradable although under some conditions degradation may be reduced.
Bioremediation of soils is possible with simple biostimulation. According to Peck *et al* (1995) evidence was obtained that approximately 90% of the dichlorobenzenes (ortho and para) was removed by biodegradation in the tests made on a pharmaceutical manufacturing site in 1994.

7.9. Conclusion

It can be deduced from the above information that 1,4-dichlorobenzene (para-dichlorobenzene) is not a toxic, persistent, and liable to bioaccumulate substance as mentioned by the Oslo and Paris Conventions for the Prevention of Marine Pollution (OSPARCOM) according to the criteria currently under discussion and especially those defined by UN-ECE, Euro Chlor and CEFIC.

8. EXPOSURE ASSESSMENT

The exposure assessment is essentially based on exposure data from analytical monitoring programs. 1,4-dichlorobenzene has been measured in a number of water systems. These levels in surface waters (river water and marine waters) are detailed in *Appendix 4*. References of the available monitoring data can be found in HEDSET Data Sheet for 1,4-dichlorobenzene (updated version of 7/96). Additional sources have been also used. All the references are given in *Appendix 7.*

As it is generally not specified if the location of sampling is close to a source of emission (production or processing), it is assumed that the lower levels correspond more to a background "regional" concentrations than the higher contamined areas which could be considered as worst cases or “local” concentrations.

8.1. Marine waters and estuaries

Typical recent monitoring data for 1,4-dichlorobenzene in coastal waters and estuaries from Germany, the Netherlands, France and United Kingdom which are part of the OSPARCOM region are illustrated in the North Sea map in *Appendix 5*. Typical values are generally lower than 0.1 µg/l and a worst case identified as < 0.2 µg/l.

8.2. River waters

Surface water from several rivers in Germany (Rhine and Elbe has been analysed between 1990 and 1993). The range of concentrations (when levels above analytical quantification limit have been observed i.e. in 40% of reported data) is between 0.01 and 0.1 µg/l. A reasonable worst case is measured in the Elbe (< 0.45 µg/l) relatively far away from the sea.
Surface waters from the Netherlands (Rhine, Meuse) all showed recent concentrations (1990) lower than 0.1 µg/l.

Surface water from the river Seine (France) has been analyzed in 1995 in locations situated at 100 km of the sea or nearest. The concentrations were all under the detection limit of 0.2 µg/l.

9. RISK ASSESSMENT CONCLUSION

In the risk characterisation of 1,4-dichlorobenzene for the aquatic organisms, the PNEC is compared to the PEC. A PNEC of 20 µg/l was obtained for the aquatic species exposed to 1,4-dichlorobenzene.

In coastal waters and estuaries, recent data showed typical values lower than 0.1 µg/l (detection limit). A worse case of lower than 0.2 µg/l has been found. For river waters a typical level of 0.1 µg/l was found with a worst case concentration of 0.45 µg/l.

These monitoring data allow to calculate the following PEC/PNEC ratios

Table 4: Calculation of PEC/PNEC ratios for 1,4-dichlorobenzene

Type of water	PEC	PEC/PNEC
Coastal waters/estuaries		
• worst case	< 0.2	< 0.010
• typical	< 0.1 µg/l	< 0.005
River waters		
• worst case	0.45 µg/l	0.023
• typical	0.1 µg/l	0.005

These calculated ratios **which do not take into account any dilution factor within the sea,** correspond to a safety margin of 40 to 200 between the aquatic effect and the exposure concentration so that the present use of 1,4-dichlorobenzene should not represent a risk to the aquatic environment. The above monitoring data satisfy the draft Water Quality Objective (CSTE, 1994) set at 10 µg/l for surface waters. In addition, 1,4-dichlorobenzene has a low potential of bioaccumulation in the biosphere and is readily biodegradable.

10. REFERENCES

10.1. General References

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10.2. References for ecotoxicity data: *see Appendix 6*

Those references are used in *Appendix 3.*

10.3 References for exposure data: *see Appendix 7*

Those references are used in *Appendix 4.*

APPENDIX 1

Environmental quality criteria for assessment of ecotoxicity data

The principal quality criteria for acceptance of data are that the test procedure should be well described (with reference to an official guideline) and that the toxicant concentrations must be measured with an adequate analytical method.

Four cases can be distinguished and are summarized in the following table (according to criteria defined in IUCLID system).

Table : Quality criteria for acceptance of ecotoxicity data

Case	Detailed description of the test	Accordance with scientific guidelines	Measured concentration	Conclusion: reliability level
I	+	+	+	**[1]** : valid without restriction
II	±	±	±	**[2]** : valid with restrictions; to be considered with care
III	insufficient or -	-	-	**[3]** : invalid
IV	the information to give an adequate opinion is not available			**[4]** : not assignable

The selected validated data LC50, EC50 or NOEC are divided by an assessment factor to determine a PNEC (Predicted No Effect Concentration) for the aquatic environment.

This assessment factor takes into account the confidence with which a PNEC can be derived from the available data: interspecies- and interlaboratory variabilities, extrapolation from acute to chronic effects,...

Assessment factors will decrease as the available data are more relevant and refer to various trophic levels.

APPENDIX 2

Ultimate distribution in the environment according to Mackay level 1 model (details of calculation)

ugacity Level I calculation

Chemical: 1,4 dichlorobenzene

Temperature (C)	20
Molecular weight (g/mol)	147
Vapor pressure (Pa)	170
Solubility (g/m3)	70
Solubility (mol/m3)	0.48
Henry's law constant (PA.m3/mol)	357
Log octanol water part. coefficient	3.37
Octanol water part. coefficient	2344.23
Organic C-water part. coefficient	961.13
Air-water partition coefficient	0.15
Soil-water partition coefficient	28.83
Sediment-water partition coefficient	57.67
Amount of chemical (moles)	1
Fugacity (Pa)	.40186037E-6
Total VZ products	2488426.48

Phase properties and compositions:

Phase	: Air	Water	Soil	Sediment
Volume (m3) :	.6000E+10	.70000E+7	.45000E+5	.21000E+5
Density(kgm3):	.12056317E+2	.10000E+4	.15000E+4	.15000E+4
Frn org carb.:	.00000E+0	.00000E+0	.20000000E-1	.40000000E-1
Z mol/m3.Pa :	.41029864E-3	.28011204E-2	.80767547E-1	.16153509E+0
VZ mol/Pa :	.24617918E+7	.19607843E+5	.36345396E+4	.33922369E+4
Fugacity :	.40186037E-6	.40186037E-6	.40186037E-6	.40186037E-6
Conc mol/m3 :	.16488276E-9	.11256593E-8	.32457276E-7	.64914553E-7
Conc g/m3 :	.24237766E-7	.16547191E-6	.47712197E-5	.95424394E-5
Conc ug/g :	.20103788E-5	.16547191E-6	.31808131E-5	.63616262E-5
Amount mol :	.98929660E+0	.78796152E-2	.14605774E-2	.13632056E-2
Amount % :	98.93	0.79	0.15	0.14

APPENDIX 3

SUMMARY TABLE OF ECOTOXICITY DATA ON 1,4 DICHLOROBENZENE

1. FISH

Species	Duration d (days) - h (hours)	Type of study	Criterion (LC50/EC50 NOEC)	Concentration (mg/l)	Validity	Comments	Reference
ACUTE STUDIES							
1. FRESHWATER							
Brachydanio rerio	96 h	A,F-T	LC50	2.1	1		Roederer (1990)
Jordanella floridae	96 h	A,F-T	LC50	2.05	1		Smith *et al.* (1991)
Pimephales promelas	96h	A,F-T	LC50	4.2	1		Carlson & Kosian (1987)
Brachydanio rerio	24h	A,S,C	LC50	4.25	2	difference final/initial conc. < 10%	Calamari *et al* (1983)
Oncorhynchus mykiss	24h	A,S,C	LC50	1.18	2	difference final/initial conc. < 10%	Calamari *et al* (1983)
Jordanella floridae	96 h	A,S,S	LC50	4.5	2		Smith *et al.* (1991)
Brachydanio rerio	14 d	A,F-T	NOEC	0.44	2	endpoints: weight or behaviour	Roederer (1990)
Poecilia reticulata	14 d	N,SS,C	LC50	4	3	few details	Canton (1985)
Pimephales promelas	96h	N,S,O	LC50	30	3	95% confidence interval 18-50 mg/l ; no details on procedure	Curtis & Ward (1981)
Lepomis macrochirus	96h	N,S,O?	LC50	4.3	3	not specified co-solvent, precipitate observed, very few experimental details	Buccafusco *et al* (1981)
Pimephales promelas	96 h	N,S	LC50	3.6	3	endpoints: fry, juveniles, subadults	Mayes (1983)
2. MARINE FISH							
Cyprinodon variegatus	96 h	N,S	LC50	7.4	2		Heitmueller *et al.* (1981)

APPENDIX 3

SUMMARY TABLE OF ECOTOXICITY DATA ON 1,4 DICHLOROBENZENE

1. FISH

Species	Duration d (days) - h (hours)	Type of study	Criterion (LC50/EC50 NOEC)	Concentration (mg/l)	Validity	Comments	Reference
CHRONIC STUDIES							
1. FRESHWATER							
Jordanella floridae	28 d 10 d	A,F-T,C A,F-T,C	NOEC NOEC	> 0.35 0.20-0.23	1	endpoint at 28 d: survival & growth of 1 week old fish endpoint at 10 d: hatching and survival	Smith *et al* (1991)
Oncorhynchus mykiss	60 d	A,F-T	NOEC	> 0.122	1	embryo-larvae	Calamari *et al* (1982)
Pimephales promelas	33 d	A,F-T	NOEC	0.57	1	± 10% of nominal	Carlson & Kosian (1987)
Brachydanio rerio	28d	A,SS,C	NOEC	1.0	3	NOEC growth ; poor recovery of substance in analytical samples at renewal periods ; use of DMSO (in Dutch)	Adema & de Ruiter (1987)
2. SALTWATER (NO DATA AVAILABLE)							

APPENDIX 3

SUMMARY TABLE OF ECOTOXICITY DATA ON 1,4 DICHLOROBENZENE

2. INVERTEBRATES

Species	Duration d (days) - h (hours)	Type of study	Criterion (LC50/EC50 NOEC)	Concentration (mg/l)	Validity	Comments & remarks	Reference
ACUTE STUDIES							
1. FRESHWATER							
Daphnia magna	48 h	A,S,C	EC50	0.7	1		Canton (1985)
Daphnia magna	24 h	A,S,C	EC50	1.6	1		Calamari et al (1982)
Daphnia magna	24 h	N,S,C	EC50	3.2	2		Kuehn et al (1989)
Daphnia magna	48h	N,S,O?	LC50 NOEC	11 0.68	3	not specified co-solvent, very few experimental details)	LeBlanc (1980)
1. SALTWATER							
Artemia salina	24h	N,S,C	LC50	14	2	no headspace	Abernethy et al (1986)
Palaemonetes pugio	96h	N,S,O	LC50	60	3	95% conf. interval 36-100 mg/l ; no details on procedure	Curtis & Ward (1981)
Mysidopsis bahia	96h		EC50	1.99	4		US EPA (1978)
CHRONIC STUDIES							
1. FRESHWATER							
Daphnia magna	28 d	A,SS	NOEC	0.22	1		Calamari et al (1982)
Daphnia magna	21 d	N,SS,C	NOEC	0.3	3	non standard endpoint: time of first offspring	Kuehn et al (1989)
2. SALTWATER (NO DATA AVAILABLE)							

APPENDIX 3

SUMMARY TABLE OF ECOTOXICITY DATA ON 1,4 DICHLOROBENZENE

3. AQUATIC PLANTS

Species	Duration d (days) h (hours)	Type of study	Criterion (LC50/EC50 NOEC)	Concentration (mg/l)	Validity	Comments	Reference
1. FRESHWATER							
Selenastrum capricornutum	96 h	A,S,C	EC50 EC0	1.6 0.57	1	fluorimetric determination; endpoint: growth rate	Calamari *et al* (1982)
Scenedesmus pannonicus	72 h	A,S	EC50	31	2	few details	Canton (1985)
Scenedesmus subspicatus	48 h	S,C	EC50 EC10	28 13	2	endpoint: biomass	Kuehn & Pattard (1990)
Scenedesmus subspicatus	48 h	S,C	EC50 EC10	38 16	2	endpoint: growth rate	Kuehn & Pattard (1990)
Cyclotella meneghiniana	48 h	A,S	EC50	34.3	2	endpoint: DNA increase	Figueroa & Simmons (1991)
Ankistrodesmus falcatus	4 h	A,S	EC50	20	3	14C-carbonate uptake	Wong *et al* (1984)
2. SALTWATER							
Skeletonema costatum	96 h		EC50	59.1	4		US EPA (1978)

APPENDIX 3

LIST OF ABBREVIATIONS USED IN TABLES

A	=	analysis
C	=	closed system or controlled evaporation
h	=	hour(s)
d	=	day(s)
MATC	=	maximum acceptable toxicant concentration
N	=	nominal concentration
S	=	static
SS	=	semistatic
F-T	=	flow-through

Validity column:
1 = valid without restriction
2 = valid with restrictions : to be considered with care
3 = invalid
4 = not assignable

APPENDIX 4

ENVIRONMENTAL MONITORING LEVELS OF 1,4-DICHLOROBENZENE IN NATURAL SURFACE WATERS

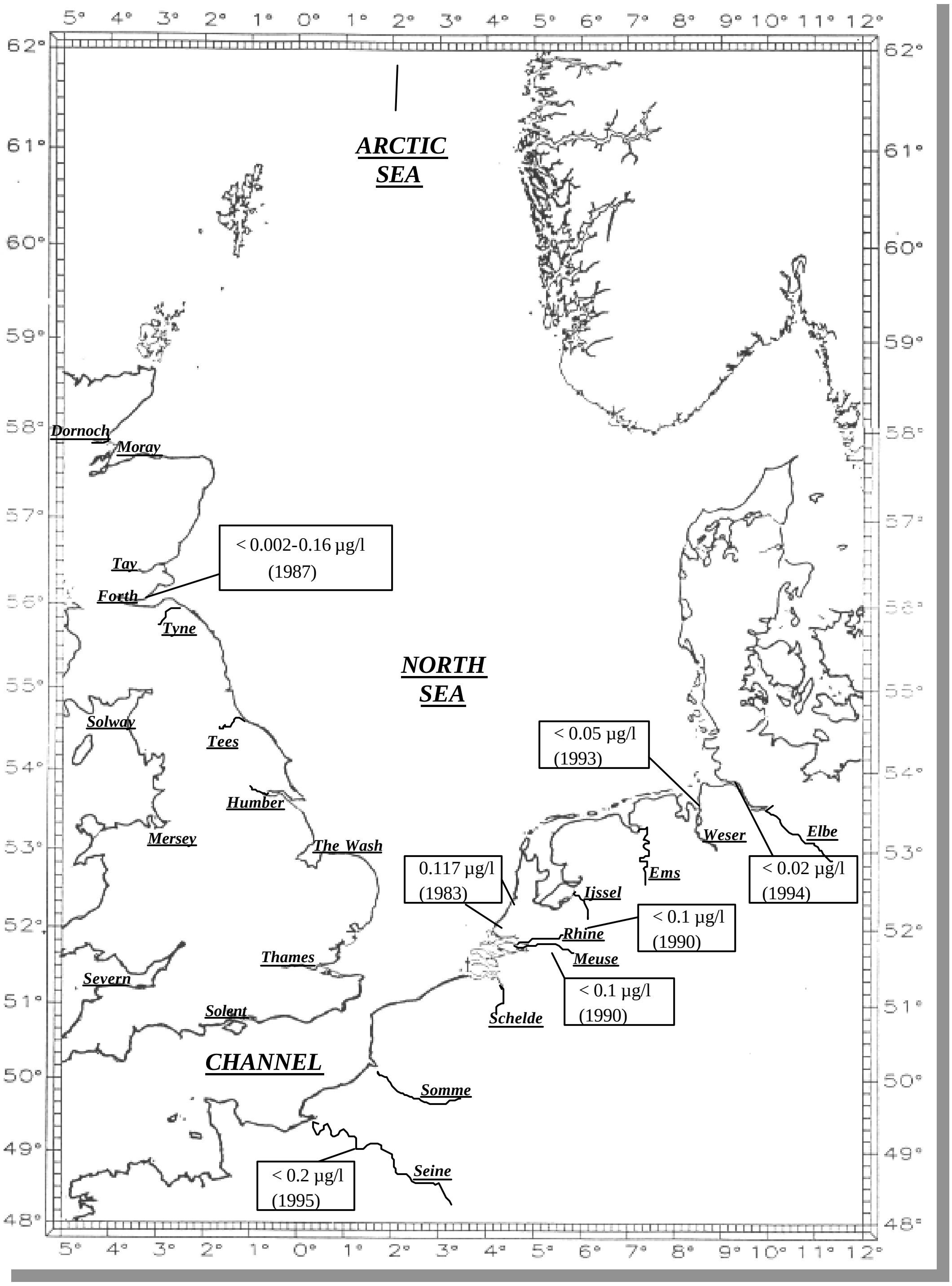
Area	Year of measurement	Average or median concentration (µg/l)	Reference
1. Coastal waters and estuaries			
• Weser estuary (D)	1993-1994	< 0.05	ARGE Weser, 1995 EU COMMPS, 1998
• Elbe estuary (D)	1994	< 0.02	EU COMMPS, 1998
• Coastal waters (NL)	1983	0.117	van de Meent *et al.*, 1986
• Seine estuary (F)	1995	< 0.2	Agence de Bassin, 1995
• Forth estuary (UK)	1987	< 0.002-0.16	Rogers, 1989
2. Fresh waters			
• Elbe (Magdebourg) (D)	1993	< 0.45	IKSE, 1994
• Rhine (various loc.) (D)	1990	0.01-0.1(a)	IKSR, 1993
• Meuse (Eysden) (NL)	1990	< 0.1	RIZA, 1991
• Rhine (Lobith) (NL)	1990	< 0.1	RIZA, 1991
• Rhine (NL)	1983	0.3	van de Meent *et al.*, 1986
• Seine river (F)	1995	< 0.2	Agence de Bassin, 1995

(a) All dichlorobenzenes

The symbol < indicates that the value is under the detection limit of the analytical method

APPENDIX 5

NORTH SEA MONITORING DATA ON 1,4-DICHLOROBENZENE



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