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

Trichloroethylene

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EURO CHLOR RISK ASSESSMENT FOR THE MARINE ENVIRONMENT

TRICHLOROETHYLENE

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). This was done as a parallel exercise with the on-going European Risk Assessment the scope of which being broader and covering all compartments.

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: primary producers (aquatic plants), primary consumers (invertebrates) and secondary consumers (fishes).
In the case of trichloroethylene (TRI) 20 data for fish, 30 data for invertebrates and 13 data for algae have been evaluated according to the 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 150µg/l.

All the monitoring data available indicate a progressive decrease of the trichloroethylene concentration in surface waters since 1983 up to now. Most of the available monitoring data apply to rivers and estuary waters and were used to calculate PEC's.The most recent data (1991-1995) support a typical PEC of 0.1 µg TRI/l water and a worst case PEC of 3.5 µg TRI/l water. The calculated PEC/PNEC ratios give a safety margin of 40 to 1500 between the probable no effect concentration and the exposure concentration. Dilution within the sea of course increase those safety margins.

Moreover, as the available data on persistence of trichloroethylene indicate a half-life in water of a few hours or days and as the bioaccumulation in marine organisms can be considered negligible, it can be concluded that the present use of trichloroethylene 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 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 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 SOURCES

The data used in this risk assessment activity are primarily derived from the data given in the HEDSET (updated version of 8/95) for this compound. Where necessary additional sources have been used. For interested parties the HEDSET is available at Euro Chlor. The references of the HEDSET and additional sources are given in chapter 10.

3. COMPOUND IDENTIFICATION

3.1 Description

CAS number	:	79-01-6
EINECS number	:	201-167-4
EEC number	:	602-027-00-9

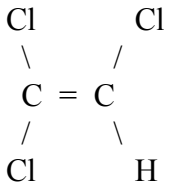
IUPAC name : Trichloroethylene

Trichloroethylene is commonly abbreviated to TRI. Other synonyms which are used include:

- trichloroethene
- 1,1,2-trichloroethylene
- ethinyl trichloride
- acetylene trichloride
- ethene, 1,1,2-trichloro

Trichloroethylene has the following formula:

C_2HCl_3



3.2 EU labelling

According to Annex I of Directive 93/72/EEC (1.9.93 - 19th TPA), trichloroethylene is classified as carcinogenic, category 3 : Xn, R40 (possible risks of irreversible effects).

Environmental labelling was decided for trichloroethylene in Annex 1 of Directive 96/54/EC (30.10.96-22th TPA) and it should be classified according the EU criteria as “dangerous for the environment” : R 52/53 (harmful for aquatic organisms and may cause long-term adverse effects in the aquatic environment).

4. PHYSICO-CHEMICAL PROPERTIES

Table 1 gives the major chemical and physical properties of the compound which were adopted for the purpose of this risk assessment.

Table 1 : Physical and chemical properties of trichloroethylene

Property	**Value**
Molecular weight	131,5
Aspect	Colourless liquid
Melting point	- 84,8°C
Boiling point	86,7°C
Decomposition temperature	120°C
Density	1,4649 g/cm^3
Vapour pressure	86hPa at 20°C
log octanol-water partition coefficient, log Kow	2.29 (measured)
log Koc (5 % OC)	2,1 (calculated)
Water solubility	1100 mg/l
Henry's Law constant	1,03 x 10^3 Pa.m^3 -mole -1

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 et al., 1990; Pedersen et al., 1994).

It should be recognized, however, that this model takes no account of transfer rates between compartments, the compartment into which the chemical is discharged, or any removal processes within compartments. Hence it is not designed to predict environmental concentrations for the purpose of risk assessment.

The results of such a calculation for Trichloroethylene are given in Table 2.

Table 2 : Results of a Mackay level I calculation for trichloroethylene

Compartment	**%**
Air	99,72
Water	0,28
Soil	0,0042
Sediment	0,0040

(See *Appendix 2*) for details of calculations)

6. USE, APPLICATIONS

6.1 Production and consumption

Trichloroethylene is mainly produced jointly with tetrachloroethylene (PER), by the so called "TRI/PER process" which is based on the chlorination or oxychlorination of various raw materials. The major raw material is presently the light fractions of the residues of the vinyl chloride monomer manufacture. Trichloroethylene is also obtained by dehydrochlorination of tetrachloroethane. In 1995, the consumption of trichloroethylene in the European Union was about 110,000 tonnes including 10,000 tonnes imported from the USA or Eastern European countries. The consumption of trichloroethylene as a feedstock for CFC substitutes (HCFCs and HFCs) was in the range of 20,000 tonnes for the same year and an increase of this production is expected for the next years. Trichloroethylene is also exported from European Union at an estimated level of 20,000 tonnes.

6.2 Main Uses

According to the European Chlorinated Solvent Association (ECSA), the major use of trichloroethylene (more than 80 %) is for vapour degreasing and cleaning of metal parts. The introduction of more efficient and closed degreasing equipment has significantly reduced the consumption of TRI during the last decade, and consequently the emissions in the environment and in the workplace. Trichloroethylene is used as a replacement for 1,1,1-trichloroethane (a substance which was phased out in the developed world under the Montreal Protocol at the end of 1995), in vapour degreasing systems. It is not, however, generally recommended or used as a replacement in emissive applications such as cold cleaning.

Trichloroethylene is also used in adhesives and for synthesis in the chemical industry (HFCs for example) and as solvent for various products. When used as a solvent, TRI is subject to extensive recycling through collecting organisations set up by the producers.

6.3 Applicable regulations

In the EU the trichloroethylene emissions in water are governed by the EC Directive 90/415 of July 27, 1990 which requires the following emission limits:

- For production of trichloroethylene by the TRI-PER process, a monthly limit for emissions in water of 2.5 g/ton of combined capacity of TRI and PER is applicable as per 1.1.1995. The maximum concentration of TRI in the water effluent is 0.5 mg/l.
- The same emission limit applies for the tetrachloroethane dehydrochlorination process, by taking into account an equivalent "TRI/PER" capacity producing 1 TRI and 2 PER.
- For the use of TRI in metal degreasing, a monthly average emission limit of

0.1mg of TRI per liter of water effluent is required and applicable as per 1.1.1993, when the annual consumption of TRI by the unit exceeds 30 kg.

7. EFFECT ASSESSMENT

As a first approach, this chapter only considers the following three trophic levels: primary producers (aquatic plants), primary consumers (invertebrates) and secondary consumers (fish). The effects on other organisms are only discussed when indicated.

The evaluation of the data was conducted according to the 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 the open literature were collected and incorporated into the HEDSET for trichloroethylene, including their references (updated version of 8/8/95). A summary of all data is given in *Appendix 3*. In total 20 different data for fish, 30 different data for aquatic invertebrates and 13 different data for algae have been evaluated.

Respectively 2, 1 and 1 data were considered valid for risk assessment purposes. For each of these taxonomic categories 4, 2 and 1 should be considered with care, and 14, 27 and 11 data respectively were judged as not valid for risk assessment.

A lot of references have been discarded because the test procedures were not adapted to the properties of this chemical. Its high volatility leads to a rapid decrease of concentrations in water (around 75 % in 24h). Therefore static tests, with no analytical monitoring, could not be accepted.

In order to follow the methodology proposed in the EU Risk Assessment Regulation (1488/94) it is necessary to distinguish the acute studies, usually characterized by LC50/EC50, from chronic studies (NOEC/EC10). In the tables presented in *Appendix 3*, the data are ranked based on class (fishes, invertebrates, algae), criterion (LC50/EC50, NOEC/EC10), environment (freshwater, saltwater) and validity (1, 2, 3, 4).

The different trophic levels are reviewed hereafter. The reference numbers are those listed in the Table of *Appendix 3* and given in *Appendix 6*.

7.1. Marine fish

Three acute toxicity studies are reported for marine fish. Two of them can be used in the context of the present risk assessment with some restrictions (Ward, G.S. et al 1986 and Pearsons, C.R. et al. 1975). One study has been done with *Cyprinodon variegatus* and reports an LC50-96h = 52 mg/l, based on an average of initial and final measured concentrations. Analysis carried out showed that concentrations of

TCE decreased by more than 75% during the first 24h and were less than 3% of initial concentrations after 96h. EC50-96h using initial concentration = 99 mg/l. The other one has been done with *Limanda limanda* (dab). No analysis of test chemical concentration was made but a flow-through protocol was used. An LC50-96h = 16 mg/l was obtained and will be used for deriving a PNEC.

7.2. Freshwater fish

Among the 17 data reported, 3 were not assignable as for validity criteria. The 14 assignable data reported for toxicity to freshwater fish, three were discarded being secondary data , (Yoshioka, Y. et al. 1986 - Juhnke and Luedemann 1978 - Loeckle, D.M. 1983), three others lacking experimental details (Sloof, W. 1983 and Sloof, W. 1979), two others due to inappropriate test design (Buccafusco, R.J. et al. 1981 and Hermens, J. et al 1985), and one which reports an LC0-60d of 5µl/l (7.3. mg/l) but is poorly described (Loeckle, D.M. 1983). Three data could be used with care, giving LC50-96h of 40.7 - 44 and 63.1 mg/l, the 2 first on *Pimephales promelas* (Veith, G.D., et al. 1983 and Alexander, H.C., 1978) and the third on *Jordanella floridae* (Smith, A.D. et al. 1991). In the latter, 2 acute toxicity tests have been carried out: one according to a static design (LC50-96h = 63.1 mg/l) the other according to a flow-through protocol (LC50 -96h = 28.3 mg/l), measured values, showing the advantage of such a protocol for a volatile substance.

This latter value is most adequate for risk assessment and will be used as an acute value for PNEC derivation. The same report describes results obtained in a chronic study (early-life stages, 28 days): NOEC = 5.8 mg/l (MATC = 11 mg/l).

7.3. Marine invertebrates

Two reports have been found (Ward, G.S. et al. 1986 and Pearsons, C.R. et al. 1975) which can be used with some restrictions . The EC50-96h = 14 mg/l on *Mysisdopsis bahia* will beretained.

7.4. Freshwater invertebrates

As for fish, most data were not considered for risk assessment, due to inappropriate test designs. For instance, in the reference describing a EC50-48h = 2.2 mg/l, immobilisation in control vessels reveals problems with daphnids health, whether in the reference reporting a EC50-48h = 7.8 mg/l, there are greatest uncertainties with solutions preparation and therefore with concentrations. Indeed the best report (Hermens, J. et al. 1984) gives an EC50-48h = 20.8 mg/l on *Daphnia magnia*. There are no convenient values for chronic toxicity towards invertebrates for fresh water organisms as well as for marine ones.

7.5. Marine algae

The same test protocol is used for deriving acute and chronic figures. The former correspond to EC50 end point, the latter to NOEC or EC10 end point. For an acute value, an EC50-96h = 95 mg/l for *Skeletonema costatum* can be used (Ward, G.S. et al. 1986).No chronic data have been found.

7.6. Freshwater algae

One valid acute test identified an EC50-72h at 36.5 mg/l for *Chlamydomonas reinhardtii* (Brack, W. and Rottler, H. 1994). A NOEC of 12.3 µg/l is found in the same species. Other acute or chronic data are not judged reliable.

7.7. PNEC for marine environment

Apart from the above reported data on single species studies, a multispecies study (fresh water microcosm), including 3 trophic levels (decomposers, phytoplankton and zooplankton), has been carried out with exposure to 2 different levels of trichloroethylene (mean measured concentrations: 1.5 and 7.5 mg/l) during 11 weeks (Lay, J.P. et al. 1991). It was shown that no significant effect on algae could be observed at the low level. At the high level, theprimary production per cell decreased, with no effect on cell density. For zooplankton, the low concentration did not show any effect, while a decreased reproduction rate of *Daphnia pulex* and *Cyclops sp.* was observed at 7.5 mg/l. For decomposers, an increase of bacteria concentration (2 cocci strains) is observed, along with formation of traces of trichloroacetic acid.

From this study, it can be concluded that the chronic NOEC for a simple ecosystem is around 1.5 mg/l. The high end of the aquatic food web (fish) is absent from this study but, as it has been shown in single species laboratory studies that fish are not more sensitive than invertebrates, it is still reasonably conservative to select an assessment factor of 10, giving a PNEC aquatic organisms = 0.150 mg/l. This value can also be used for seawater organisms as there is no reasons to foresee a difference in sensitivity with respect to fresh water organisms. A summary of the valid data selected for the derivation of PNEC values at different level is given in Table 3. This table exemplifies the PNEC values derived from acute, chronic and ecosystem studies. It is generally considered that the latter are closer to real world than the former. Therefore the better value should be in the lower end of the table.

As far as the North Sea is concerned, acute effect studies are not relevant because of the absence of local sources. **The final PNEC which is calculated for this risk assessment of trichloroethylene is 150 µg/l.**

7.8. Bioaccumulation

Bioaccumulation of trichloroethylene in aquatic species is unlikely in view of its physical and chemical properties. A bioconcentration factor of 17 has been measured for bluegill sunfish (Barrows et al.) and of 39 for rainbow trout (Veith et al.).

7.9 Persistence

As indicated by the Henry's law constant, trichloroethylene entering aquatic systems will be transferred to the atmosphere through volatilization. A half life of 3.4 hours can be calculated from this constant for a water depth of 1m. In the atmosphere, indirect photolysis (reaction with OH radicals) occurs rapidly with a half life between 5 and 8 days. No effect of trichloroethylene can be expected on stratospheric ozone depletion and global warming. Trichloroethylene has a negligible tropospheric ozone creation potential in the atmosphere.

7.10 Conclusion

It can be deduced from the above information that trichloroethylene is not a "persistent, toxic 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.

Table 3 : Summary of ecotoxicity data selected for the PNEC derivation, with the appropriate assessment factors for trichloroethylene

Available valid data	Assessment factor	Comments
At least 1 short-term LC50 from each trophic level (fish, daphnia, algae)	1000 PNEC = 14 µg/l	*Limanda limanda* LC50-96h = 16 mg/l (Pearsons, C.R. et al. 1975) *Mysidopsis bahia* EC50-96h = 14 mg/l *(Ward, G.S. et al. 1986)* *Chlamydomonas reinhardtii* EC50-72h = 36.5mg/l (Brack, W. and Rottler, H. 1994)
2 long-term NOEC from species of 2 trophic levels (fish and/or daphnia and/or algae)	50 PNEC = 116 µg/l	*Jordanella floridae* ELS-28d NOEC = 5.8 mg/l (Smith, A.D. et al. 1991) *Chlamydomonas reinhardtii* NOEC-72h = 12.3 µg/l (Brack, W. and Rottler, H. 1994)
Field studies	case by case here 10 PNEC = 150 µg/l	Fresh water microcosm NOEC =1.5 mg/l (Lay, J.P. et al. 1991)

8. EXPOSURE ASSESSMENT

The exposure assessment is essentially based on exposure data from analytical monitoring programs. Trichloroethylene 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 Trichloroethylene (updated version of 8/95). 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 to background "regional" concentrations and the higher to contamined areas, or "local" concentrations, considered as worst cases.

8.1 Marine waters

In coastal waters and estuaries, observed concentrations are in a range from 0.001 µg/l up to 3.5 µg/l. Typical recent monitoring data for TRI in coastal waters and estuaries which are part of the OSPARCOM region are given hereafter and illustrated on the North Sea map in *Appendix 5*.

Weser estuary (D)	0.002-0.007 µg/l	1993
Rhine estuary (NL)	0.0013-0.074 µg/l	1993
Rhine D/NL Border	< 0.05 µg/l	1993
Rhine D/NL Border	0.30 µg/	1990
Maas B/NL Border	< 1 µg/l	1991
Schelde B/NL Border	0.51 µg/l	1993
Meuse B/NL Border	0.50 µg/l	1992
Maas estuary	< 0.28 µg/l	1992
Tees estuary	< 0.030-0.704 µg/l	1993
UK river estuaries	< 0.03-3.5 µg/l	1993
Seine river and estuaries	< 1 µg/l	1995
North Sea (open sea)	< 0.005 µg/l	1983-84
Baltic Sea	0.002 µg/l	1988

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

8.2 River waters

Background levels of trichloroethylene in typical river in non industrialized area are in general lower than 0.1 µg/l. In the Rhine river water, in the Ruhr area, up to 1 µg/l is measured (see *Appendix 4*).

8.3 Other monitoring data

Recent data on TRI levels measured in aquatic organisms are not available. As already stated (see 7.8) we can consider that bioaccumulation is negligible in marine organisms. In 1989-1990 trichloroethylene was not detected in Scandinavian sediments at a detection limit of 10 µg/kg (see Tema Nord 1994 in *Appendix 7*).

9. RISK ASSESSMENT CONCLUSION

In the risk characterization of trichloroethylene for the aquatic organims, the PNEC is compared to the PEC. A PEC of 150 µg/l was obtained for the aquatic species exposed to trichloroethylene. In coastal waters and estuaries, trichloroethylene is observed up to 3.5 µg/l (worst case) but the concentration of the river waters support a typical value of less than 0.1 µg/l.

In non-industrialized areas a typical river water concentration below 0.1 µg/l was derived from the measured levels; a worst case was also identified in our industrialized zone with measured levels up to 1 µg/l.

These monitoring values allow to calculate the ratios PEC/PNEC which are summarised in Table 4.

Table 4 : Calculation of PEC/PNEC ratios for trichloroethylene :

Type of water	PEC level	PEC/PNEC
Coastal waters/estuaries		
• worst case	3.5 µg/l	0.023
• typical water	0.1 µg/l	0.00067
River waters :		
• worst case	1 µg/l	0.0067
• typical water	0.1 µg/l	0.00067

These calculated ratios, which do not take into account any dilution factor within the sea, correspond to a safety margin of 40 to 1500 between the aquatic effect and the exposure concentration so that the present use of trichloroethylene should not represent a risk to the aquatic environment. In addition the above monitoring data satisfy the European water quality objective (Directive 90/415/EEC) which is set at 10 µg/l for continental surface water as well as for marine water. This objective is clearly reached even in the worst case reported hereabove. In addition, as stated in section 7.8, there is no sign of bioaccumulation in the biosphere.

10. REFERENCES

10.1 General references

Barrows M.E., Petrocelli, S.R., Macek, K.J., Carroll, J.J. (1978): Bioconcentration and elimiation of selected water pollutants by bluegill sunfish (Lepomis macrochirus) in dynamics, exposure and hazard assessment of toxic chemicals; R. Hague Ed.; Ann Arbor, Science 379-392, Ann Aarbor Michigan (1978)

BUA Stoffbericht (1995) - Trichloroethen

Mackay, D. Patterson, S. (1990); Fugacity models; in Karcher, W. Devillers, J. (Eds); Pratica applications of quantitative structure-activity relations in environmental chemistry and toxicology 433-460

Pedersen, F., Tyle, H., Niemelä, J.R., Guttmann, B. Lander, L., Wedebrand, A. (1994); Environmental Hazard Classification-Data collection and interpretation guide; TemaNord 1994;589

Veith et al. (1979) - Journal of the Fisheries Research Board of Canada 36,1040-1048

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

Those references are used in *Appendix 3*.

10.3. References for monitoring data : see *Appendix 7*.

Those references are used in *Appendix 4*.

APPENDIX 1

11/06/97
TRI

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, etc.

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 I model
(details of calculation)

Fugacity Level I calculation

Chemical: Trichloroethylene

Temperature (C)	20
Molecular weight (g/mol)	131.50
Vapor pressure (Pa)	8600
Solubility (g/m3)	1100
Solubility (mol/m3)	8.37
Henry's law constant (PA.m3/mol)	1028.09
Log octanol water part. coefficient	2.29
Octanol water part. coefficient	194.98
Organic C-water part. coefficient	79.94
Air-water partition coefficient	0.42
Soil-water partition coefficient	2.40
Sediment-water partition coefficient	4.80
Amount of chemical (moles)	1
Fugacity (Pa)	.40505450E-6
Total VZ products	2468803.55

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	.97267662E-3	.23327789E-2	.46655579E-2
VZ mol/Pa	.24617918E+7	.68087364E+4	.10497505E+3	.97976716E+2
Fugacity	.40505450E-6	.40505450E-6	.40505450E-6	.40505450E-6
Conc mol/m3	.16619331E-9	.39398705E-9	.94490263E-9	.18898052E-8
Conc g/m3	.21854420E-7	.51809297E-7	.12425469E-6	.24850939E-6
Conc ug/g	.18126944E-5	.51809297E-7	.82836464E-7	.16567292E-6
Amount mol	.99715988E+0	.27579093E-2	.42520618E-4	.39685910E-4
Amount %	99.72	0.28	.42520618E-2	.39685910E-2

SUMMARY TABLE OF ECOTOXICITY DATA ON TRICHLOROETHYLENE

1./a FISH

Species	Duration d (days) - h (hours)	Type of study	Criterium (LC50/EC50 NOEC/LOEC)	Concentration (mg/l)	Validity	Comments & remarks	Reference
EC50/LC50 STUDIES							
1. FRESHWATER							
Oryzias latipes	48 h	N S	LC50	79	3		Yoshioka et al,1986
Oryzias latipes	48 h	N S	LC50	270	3		Sloof et al,1983
Leuciscus melanotus (Golden Orfe)	48 h	N SO	LC0 LC50	102 136	3		Junhke & Luedemann, 1978
Lepomis macrochirus (Bluegill sunfish)	96 h	N S	LC50	44.7	3		Buccafusco et al,1981
Pimephales promelas	96 h	A F-T	LC50	44	2		Veith et al,1983
Onkorynchus mykiss (Rainbow trout)	48 h	N S	LC50	42	3		Sloof et al,1983
Leuciscus idus melanotus (Golden Orfe)	48 h	N S	LC50	213	3		Sloof et al,1983
Jordanella floridae (American flagfish)	96 h	A F-T	LC50	28.3	1		Smith et al,1991
Brachydanio rerio	48 h	N F-T	LC50	60	3		Sloof,1979
Pimephales promelas	48h		LC50	44	4		Geiger et al,1985

SUMMARY TABLE OF ECOTOXICITY DATA ON TRICHLOROETHYLENE

1./b FISH

Species	Duration d (days) - h (hours)	Type of study	Criterium (LC50/EC50 NOEC/LOEC)	Concentration (mg/l)	Validity	Comments & remarks	Reference
EC50/LC50 STUDIES							
1. FRESHWATER							
Pimephales promelas	96h	A F-T	LC50	40.7	2		Alexander et al,1984
Pimephales promelas	96 h		LC50	21.9	4	end point : loss of equilibrium	USEPA, 1980
Jordanella floridae (American flagfish)	96 h	A S	LC50	63.1	2		Smith et al,1991
2. SALTWATER							
Cyprinodon variegatus	96 h	A S	LC50	52	2		Ward et al,1986
Cyprinodon variegatus	96 h		LC50	20	4		Borthwick, 1977
Limanda limanda (Dab)	96 h	N F-T	LC50	16	2		Pearsons et al,1975

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SUMMARY TABLE OF ECOTOXICITY DATA ON TRICHLOROETHYLENE

1./c FISH

Species	Duration d (days) - h (hours)	Type of study	Criterium (LC50/EC50 NOEC/LOEC)	Concentration (mg/l)	Validity	Comments & remarks	Reference
NOEC/LOEC STUDIES							
1. FRESHWATER							
Jordanella floridae (American flagfish)	28 d	A F-T C	MATC	11	1	larvae	Smith et al,1991
Brachydanio rerio	14 d		NOEC	3.1	4		Scheubel, 1984
Poecilia reticulata	14 d	N SS	LC50	55	3		Hermens et al,1985
Poecilia sphenops (Black mollies)	60 d	N	LC0	7.3	3		Loeckle,1983

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TRI

SUMMARY TABLE OF ECOTOXICITY DATA ON TRICHLOROETHYLENE

2./a INVERTEBRATES

Species	Duration d (days) - h (hours)	Type of study	Criterium (LC50/EC50 NOEC/LOEC)	Concentration (mg/l)	Validity	Comments & remarks	Reference
EC50/LC50 STUDIES							
1. FRESHWATER							
Daphnia magna	48 h	N S O	EC50	2.2	3		McCarty, 1979
Daphnia magna	48 h	N S O	EC50	18	3		Leblanc, 1980
Daphnia magna	48 h	N S C	EC50	7.8	3		Abernethy et al,1986
Daphnia magna	24 h	N S	EC50	76	3		Bazin et al,1987
Daphnia pulex	48 h	N S	EC50	39-51	3		Canton et al,1978
Daphnia cucullata	48 h	N S	EC50	56-58	3		Canton et al,1978
Daphnia magna	48 h	N S	EC50	85.2	3		USEPA,1980
Daphnia magna	48 h	N S	EC50	42-97	3		Canton et al,1978
Daphnia magna	24 h	N S	EC50	72	3		Devillers et al,1978
Daphnia magna	48 h	A S C	EC50	20.8	1		Hermens et al,1984

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TRI

SUMMARY TABLE OF ECOTOXICITY DATA ON TRICHLOROETHYLENE

2./b INVERTEBRATES

Species	Duration d (days) - h (hours)	Type of study	Criterium (LC50/EC50 NOEC/LOEC)	Concentration (mg/l)	Validity	Comments & remarks	Reference
EC50/LC50 STUDIES							
1. FRESHWATER							
Daphnia magna	24 h	S	EC50	1300	4		Bringmann et al,1982
Cloëon dipterum (Ephemeroptera)	48 h	N S	LC50	42	3		Sloof,1983
Moina macrocopa	3 h	S	LC50	200	4		Yoshioka et al. 1986
Nemoura cinerea (Plecoptera)	48 h	N S	LC50	70	3		Sloof,1983
Asellus aquaticus (Isopoda)	48 h	N S	LC50	30	3		Sloof,1983
Tubificidae (Oligochaete)	48 h	N S	LC50	132	3		Sloof,1983
Erpobdella octoculata (Hirudinae)	48 h	N S	LC50	75	3		Sloof,1983

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SUMMARY TABLE OF ECOTOXICITY DATA ON TRICHLOROETHYLENE

2./c INVERTEBRATES

Species	Duration d (days) - h (hours)	Type of study	Criterium (LC50/EC50 NOEC/LOEC)	Concentration (mg/l)	Validity	Comments & remarks	Reference
EC50/LC50 STUDIES							
1. FRESHWATER							
Ischnura elegans (Odonata)	48 h	N S	LC50	49	3		Sloof,1983
Lymnaea stagnalis (Gasteropoda)	48 h	N S	LC50	56	3		Sloof,1983
Dugesia lugubris (Tricladida)	48 h	N S	LC50	42	3		Sloof,1983
Hydra oligactis (Hydrozoa)	48 h	N S	LC50	75	3		Sloof,1983
Corixa punctata (Heteroptera)	48 h	N S	LC50	110	3		Sloof,1983
Gamarus pulex (Amphipoda)	48 h	N S	LC50	24	3		Sloof,1983
Chironomus thummi (Diptera)	48 h	N S	LC50	64	3		Sloof,1983

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TRI

SUMMARY TABLE OF ECOTOXICITY DATA ON TRICHLOROETHYLENE

2./d INVERTEBRATES

Species	Duration d (days) - h (hours)	Type of study	Criterium (LC50/EC50 NOEC/LOEC)	Concentration (mg/l)	Validity	Comments & remarks	Reference
EC50/LC50 STUDIES							
2. SALTWATER							
Elminius modestus (Mollusc)	48 h	N S	LC50	20	2		Pearsons et al,1975
Mysidopsis bahia	96 h	A SO	EC50	14	2		Ward et al,1986
Palaemonetes pugio	96 h		EC50	2	4		Borthwick, 1977

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TRI

SUMMARY TABLE OF ECOTOXICITY DATA ON TRICHLOROETHYLENE

2./e INVERTEBRATES

Species	Duration d (days) - h (hours)	Type of study	Criterium (LC50/EC50 NOEC/LOEC)	Concentration (mg/l)	Validity	Comments & remarks	Reference
NOEC/LOEC STUDIES							
1. FRESHWATER							
Daphnia magna	16 d	N SS	EC50-16d	20.8	3		De Wolf et al,1988
Daphnia magna	21 d	A SS O	NOEC-21d	0.15	3		Kordel et al,1984
Daphnia magna	chonic		NOEC	**>** 10	4	life-cycle	USEPA, 1978

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SUMMARY TABLE OF ECOTOXICITY DATA ON TRICHLOROETHYLENE

3./a AQUATIC PLANTS

Species	Duration d (days) - h (hours)	Type of study	Criterium (LC50/EC50 NOEC/LOEC)	Concentration (mg/l)	Validity	Comments & remarks	Reference
1. FRESHWATER							
Selenastrum capricornutum	96 h	N S O	EC50	175	3		Sloof et al,1983
Selenastrum capricornutum	96 h	S	NOEC	180	4		Sloof et al,1983
Chlamydomonas reinhardtii	72 h	SC	EC50 NOEC	36.5 12.3	1		Brack & Rottler, 1994
Thalassiosira pseudonana	72 h	N S	EC0	0.1	3		Biggs,1972
Dunaliella tertiolecta	72 h	N S	EC0	0.1	3		Biggs,1972
Scenedesmus subspicatus	96 h	N S O	EC10	300	3		Geyer,1985
Scenedesmus subspicatus	24 h		EC10	70-82	4		Schübel,1984
Scenedesmus quadricauda			EC	430	4		Farhni,1984
Microcystis aeruginosa	8 d	N S	LOEC	63	3		Bringmann et al,1978
Microcystis aeruginosa	8 d	N S	NOEC	32	3		Bringmann et al,1978
Scenedesmus quadricauda	8 d	N S	NOEC	1000	3		Bringmann et al,1978
Scenedesmus subspicatus	96 h		EC10	46-61	4		Schübel,1984

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TRI

SUMMARY TABLE OF ECOTOXICITY DATA ON TRICHLOROETHYLENE

3./b AQUATIC PLANTS

Species	Duration d (days) - h (hours)	Type of study	Criterium (LC50/EC50 NOEC/LOEC)	Concentration (mg/l)	Validity	Comments & remarks	Reference
1. FRESHWATER							
Chlorococcales species	96 h		EC10	230	4		Krebs et al,1985
Chlorococcales species	96 h		EC50	530	4		Krebs et al,1985
2. SALTWATER							
Skeletonema costatum	96 h	A S O	EC50	95	2		Ward et al,1986
Phaeodactylum tricornutum	48 h	N S	EC50	8	3		Pearsons et al,1975

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LIST OF ABBREVIATIONS USED IN TABLES

A = analysis

C = closed system or controlled evaporation

O = open vessel

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

BACKGROUND LEVELS OF TRICHLOROETHYLENE IN NATURAL SURFACE WATERS

APPENDIX 4

Area	Year of measurement	Average or medium concentration (µg/l)	Reference
1. Oceans			
• North sea, open sea	1983 - 1984	<0.005	ECOLAS
• North-east atlantic	ca 1972	0.007	Rippen
• East atlantic	ca 1972	0.0005 - 0.0185	Rippen
2. Coastal waters and estuaries			
• North sea, estuary Rhine/Meuse	1983 - 84	<0.005 - 0.026	ECOLAS
• North sea, british coast	1992	< 0.5	Dawes et al.
• North sea, german coast	1983	<0.01 - 0.54	ECOLAS
• Ostsee, german coast	1983	< 0.01 - 0.4	ECOLAS
• Baltic sea, Koster Trench at Skagerrak	1988	0.002	ECOLAS
• Rhine estuary (NL)	1993	0.0013 - 0.074	Krysell
• Wear estuary (UK)	1994	0.01 - 0.132	Dawes
• Weser estuary	1993	0.002 - 0.007	Weser Güte bericht
• Seine estuary	1995	< 1	Agence de bassin
• UK River estuaries	1993	< 0.03 - 3.5	MAFF
• Schelde estuary	1993	0.51	De Rooij
• Meuse estuary	1992	0.50	De Rooij
• Maas estuary	1992	< 0.28	RIZA
3. Fresh waters			
• Germany, Rhine : Bad Honef	1989	≤ 0.1	BUA
• Germany, Rhine : Düsseldorf	1989	≤ 0.1	BUA
• Germany, Rhine : Kleve-Bimmen (borderline NL/D)	1989	≤ 0.1	BUA

BACKGROUND LEVELS OF TRICHLOROETHYLENE IN NATURAL SURFACE WATERS

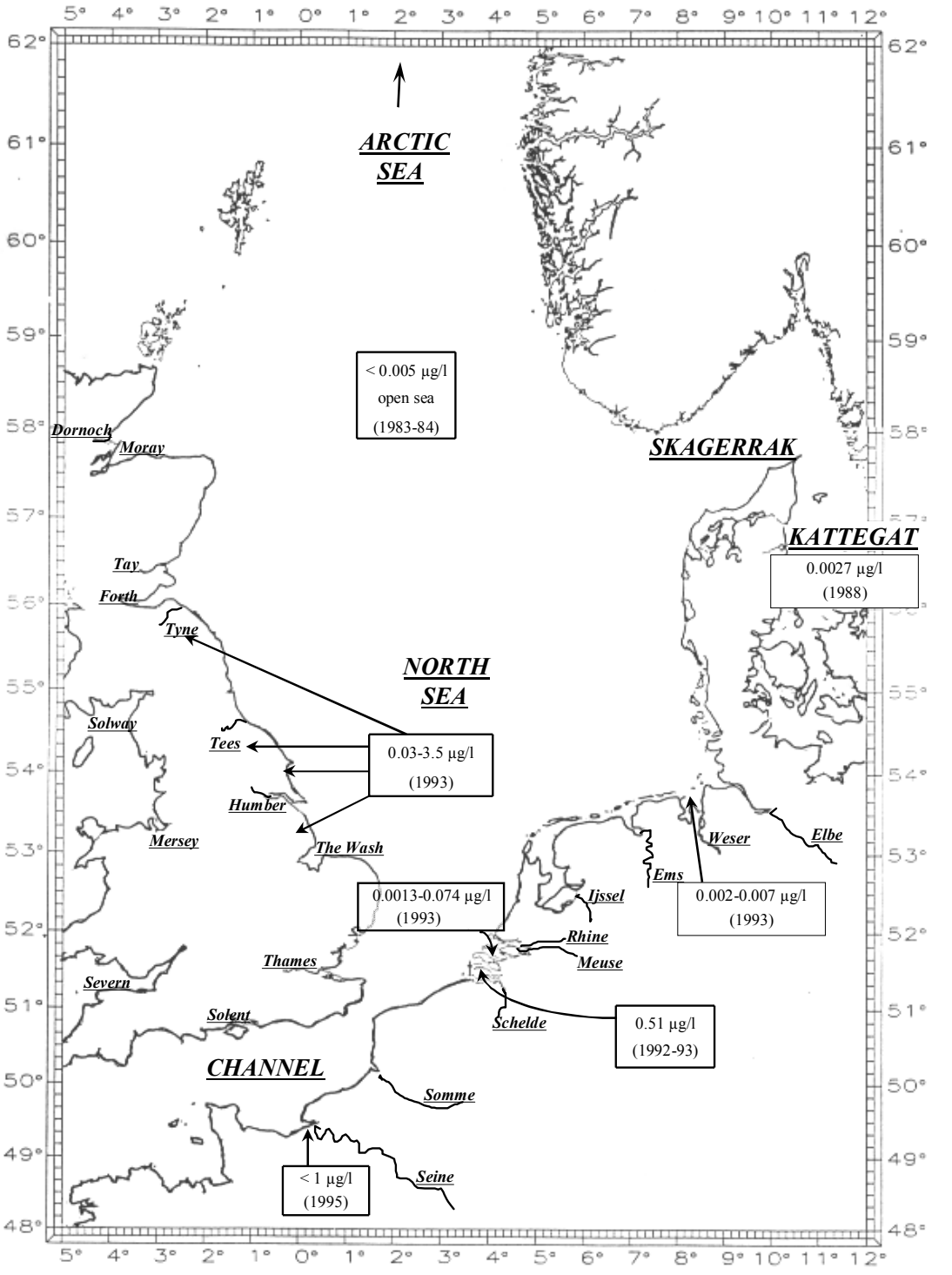
APPENDIX 4

Area	Year of measurement	Average or medium concentration (µg/l)	Reference
3. Freswaters			

Area	Year of measurement	Average or medium concentration (µg/l)	Reference
• Germany, Rhine affluents (Sieg, Wupper, Emscher, Lippe)	1989	< 0.1 - 0.75	BUA
• Germany, Rhine : Wiesbaden	1988	< 0.01 - 0.2	BUA
• Germany, Rhine : Köln	1988	<0.01 - 0.6	BUA
• Germany, Rhine : Karlsruhe	1988	< 0.01 - 0.2	BUA
• Germany, Ruhr : km 5.4 - 162 (Duisburg - Wilsdhausen)	1988	< 0.1 - 0.99	BUA
• Germany, Ruhr : Duisburg	1989	≤ 0.1	BUA
• Germany, Elbe : km 475 - 746	1989	< 0.001 - 0.77	BUA
• Germany, Elbe : affluents	1989	< 0.001 - 0.16	BUA
• Main	1989	< 0.1 - 0.1	BUA
• Donau	1989	< 0.1 - 1.0	BUA
• Weser, lower part	1985 - 87	0.1	ECOLAS
• The Netherlands, Rhine : (Lobith, Stellendam, Ijsselmeer at Anddijk	1990 - 91	< 0.1	RIWA
• The Netherlands, Rhine : Lek affluent	1986	0.2	ECOLAS
• The Netherlands/Belgium, Meuse : (Tailfer, Eijsden, Keizersveer)	1992	0.04 - 0.2	RIWA
• Rhine D/NL border	1990	< 0.05 0.150	Etat du Rhin
• Rhine D/NL border	1993	< 0.05	Rhine Gütebericht
• Maas (Eijsden)	1991	< 1	Janus
• Rhine (Lobith)	1991	< 1	Janus
• Rhine D/NL border	1990	0.3	De Rooij

APPENDIX 5

NORTH SEA MONITORING DATA ON TRICHLOROETHYLENE



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