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

1,2-Dichlorobenzene

February 1999

Euro Chlor
representing the chlor-alkali industry

EURO CHLOR RISK ASSESSMENT FOR THE MARINE ENVIRONMENT

1,2-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 in 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 1,2-dichlorobenzene 26 data for fish, 24 data for invertebrates and 17 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 values of 37 µg/l.

All the monitoring data available indicate a typical concentration in estuaries lower than 0.1 µg/l. The concentration measured in Dutch coastal waters was 0.019 µg/l. Worst case concentration values in rivers are lower than 0.45 µg/l. With this value the calculated PEC/PNEC ratio give a safety margin of about 100 to 300 between the predicted no effect concentration and the exposure concentration. Dilution within the sea will, of course, increase those safety margins.

Moreover, as the available data on persistence of 1,2-dichlorobenzene indicate a half-life in water of a few hours or days, a significant biodegradation potential and only a slight bioaccumulation potential in marine organisms, it can be concluded that the present use of 1,2-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 co-operating 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 I*. 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 SOURCES

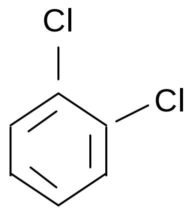
The data used in this risk assessment activity are primarily derived from the data given in IUCLID data sheet (June 1995) and the BUA Report from for this compound. Where necessary additional sources have been used.

3. COMPOUND IDENTIFICATION

3.1 Description

CAS No.	:	95-50-1
EINECS No.	:	202-425-9
IUPAC Name	:	1,2-dichlorobenzene
Common names	:	1,2-dichlorobenzene ortho-dichlorobenzene o-dichlorobenzene

Structural formula:



The purity of the technical product is > 99.8 % w/w.
Impurities are:

Chlorobenzene	<	0.05 %
p-dichlorobenzene	<	0.1 %
1,2,4-trichlorobenzene	<	0.1 %

3.2 EU labelling

1,2-dichlorobenzene is labelled and classified as follows in accordance to Annex 1 of Directive 67/548/EEC: Harmful (Xn), if swallowed (R 22), irritating to eyes, respiratory system and skin (R 36/37/38). Additional classification as dangerous for the environment should be mentioned with the symbol N and risk phrases R 50/53 (very toxic to aquatic organisms / 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 the risk assessment.

Table 1: Physical and chemical properties of 1,2-dichlorobenzene

Property	Value
Molecular weight	147
Aspect	Colourless, slightly viscous liquid, miscible with most organic solvents
Freezing point:	-17.0 °C
Boiling point:	180.3 °C at 1013 hPa
Vapour pressure:	1.4 hPa at 20 °C
Density:	1.3 g/cm^3 at 20°C
Water solubility:	0.13 g/l at 20 °C
log octanol-water partition coefficient, log Kow	3.43 (measured)
log Koc	2.48-2.66 (estimated)
Henry's Law constant	140 Pa.m^3/mol

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 were appropriate. Although this risk assessment only focuses on one compartment, it should be kept 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 1,2-dichlorobenzene are given in Table 2.

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

Compartment	**%**
Air	97.5
Water	1.8
Soil	0.37
Sediment	0.35

(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 AND EMISSIONS

6.1 Production

Approx. 21,000 tonnes of 1,2-dichlorobenzene were produced in Western Europe in 1988.

The manufacturers of 1,2-dichlorobenzene in Western Europe are Bayer AG (Germany), Elf Atochem SA (France) and EniChem (Italy).

World-wide production of 1,2-dichlorobenzene in 1988 totalled approx. 55,000 tonnes (Bayer AG, 1995).

6.2. Uses

Uses of 1,2-dichlorobenzene in Western Europe was estimated to be 24,000 t/y in 1991.

The total consumption of 1,2-dichlorobenzene in Germany in 1989 was approx. 10,000 tonnes. In 1994, 95% of this quantity was used as a raw material, in the crop protection, veterinary medicine and dye sectors. As raw material, 1,2-dichlorobenzene is converted through nitration into 3,4-dichloronitrobenzene which is either used as an educt for further synthesis or is reduced to 3,4-dichloroaniline, the starting point for a range of important herbicides. The remaining 5% was used as a solvent in the chemical industry.

The quantities of 1,2-dichlorobenzene processed in Western Europe in 1988 and 1991 are given below (values are in tonnes):

	1988		1991	
Production of 3,4-dichloro-nitrobenzene	20,000	95.2%	21,000	87.5%
TDI process solvent	500	2.4%	600	2.5%
Solvent for other processes	500	2.4%	400	1.7%
Other uses			2,000	8.3%
Total	21,000	100%	24,000	100%

1,2-dichlorobenzene used as a basic material in product synthesis is converted into intermediate and end products in closed systems (Bayer, 1995)

6.3 Emissions

The primary routes by which it enters the environment during manufacture, processing and usage are via the hydrosphere and atmosphere. Emissions in the water and air represented 14.4 and 20.5 t/y respectively in 1995 as based on a survey of about 76 sites from the European industry producing or using 1,2-dichlorobenzene (Euro Chlor, 1996). This represents between 72 to 89% reduction as compared with the data from 1985.

Indirect entry of 1,2-dichlorobenzene into the environment is possible during
- dumping of sewage sludge in the North Sea or disposal in soil
- metabolic breakdown of lindane
- biotic and abiotic degradation of more highly chlorinated benzenes.

The above indirect routes of entry are not quantifiable but assumed to be low and included in the monitoring data.

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.*

A summary of all data is given in *Appendix 3.* Tests were conducted with a large number of aquatic organisms. In total 26 data for fish, 24 data for invertebrates and 17 data for algae including marine diatom have been evaluated. Respectively 3, 5 and 4 data were considered valid for risk assessment purposes. For the respective taxonomic groups, 11, 7 and 9 should be considered with care and 12, 12 and 4 data respectively were judged not valid or not assignable for the risk assessment.

It is necessary to distinguish the acute studies (LC50/EC50) from chronic studies (NOEC/LOEC). In the tables presented in *Appendix 3*, the data are ranked based on class (fish, invertebrates, algae), criterion (acute, chronic), environment (freshwater/ saltwater) and validity (1, 2, 3, 4) as required by the EU risk assessment process (TGD, 1996).

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

In view of its low solubility in water and high volatility, closed systems should be used in order to avoid evaporation.

7.1 Marine fish

Two acute toxicity studies are reported for the marine fish *Menidia beryllina* (Dawson *et al*, 1977) and C*yprinodon variegatus* (Heitmüller *et al*, 1981). They are conducted with static conditions without analysis of the test compound. The 96 h-EC 50 values range between 7.3 and 9.7 mg/l. No chronic toxicity data are available.

7.2 Freshwater fish

The acute tests on freshwater fish toxicity show LC50 ranges from 1.1 to 57 mg/l. From these data the study with *Brachydanio rerio* (96h-LC50 = 5.2 mg/l) (Roederer *et al*, 1990) seems to be the most valid because it was done according the OECD guideline as a flow-through test and with analytical monitoring. There are acute studies with the rainbow trout, which show lower LC50 values (1.1-1.7 mg/l), but these can not be validated because only secondary literature is available. The LC50 of 2.3 mg/l in a study with *Salmo gairdneri* is a 24h value and based on only 5 animals (Calamari *et al.*, 1983).

Two studies with long term exposure which can be regarded as chronic tests are available. The first is a growth inhibition test with *Brachydanio rerio* resulting in a NOEC of 0.37 mg/l (Roederer *et al*, 1990). The only disadvantage of this study is the short exposure time of only 14 days. The second is an embryo larval test with a NOEC of 1 mg/l (US EPA, 1978). Because the growth inhibition test was more sensitive than the embryo larval test the first figure was used for PNEC calculation.

7.3 Marine invertebrates

The toxicity of 1,2-dichlorobenzene to various species was studied. Although no fully valid studies are available, data on *Artemia Salina* and *Paleomonates pugio* could be considered for the risk assessment with a lowest 96 h EC50 of 9.4 mg/l (Curtis *et al.*, 1981).

One chronic toxicity test on *Mercenaria mercenaria* (Davis & Hidu, 1969) could not be validated.

7.4 Freshwater invertebrates

There are acute EC 50 values which range between 0.74 and 68 mg/l. Three acute studies with *Daphnia magna* are valid without restriction with the lowest 48h-EC50 of 0.74 mg/l (Canton *et al.*, 1985).

Concerning the chronic studies, there is one study which fulfils the current guidelines with respect to the endpoint (NOEC = 0.63 mg/l) and the duration (21d) (Kühn *et al*, 1988). A second semi-static study only had an incubation time of 14 days. Nevertheless this lower EC16-value of 0.37 mg/l was used as NOEC in the risk assessment process (Calamari *et al*, 1983).

7.5 Marine algae

There are a few studies on marine phytoplankton and on the marine diatom *Skeletonema costatum* which seems to be rather insensitive to 1,2-dichlorobenzene. In the phytoplankton study during 10 days a NOEC of 7.6 mg/l was determined (Ukeles, 1962).

7.6 Freshwater algae

The EC50 values range between of 2.2 to 100 mg/l. EC50 data of 2.2 (*Selenastrum capricornutum* under closed system) (Calamari *et al.*, 1983) and 17 mg/l (*Scenedesmus pannonicus*) (Canton *et al*, 1985) were valid without restriction. A NOEC (EC 0) in a 96h test was determined as 0.88 mg/l (Calamari *et al*, 1983), which is in close to the value of < 0.9 mg/l derived from another valid test.

Table 3: Summary of ecotoxicity data selected for the PNEC derivation with the appropriate assessment factors for 1,2-dichlorobenzene

Available valid data	Assigned assessment factor	Lowest toxicity values
At least 1 short-term LC5O from each trophic level (fish, daphnia, algae)	1000 **PNEC = 0.74 µg/l**	- *Brachydanio rerio* LC50-96h = 5.2 mg/l (Roederer *et al*, 1990) - *Daphnia magna* EC50-48h = 0.74 mg/l (Canton *et al*, 1985) - *Selenastrum capricornutum* EC50-96h = 2.2 mg/l (Calamari *et al*, 1983)
Long-term NOEC from at least 3 species representing three trophic levels (fish., daphnia, algae)	10 **PNEC = 37 µg/l**	- *Brachydanio rerio* 14 d NOEC = 0.37 mg/l (Roederer *et al*, 1990) - *Daphnia magna* 14 d NOEC = 0.37 mg/l (Calamari *et al*, 1983) - *Selenastrum capricornutum* 96 h EC 0 = 0.88 mg/l (Calamari *et al*, 1983)

7.7 PNEC for the freshwater and marine environment

If the lowest effect data are used the PNEC (Predicted No-effect Concentration) for the marine environment has to be derived from the freshwater data.

A summary of the valid data selected for the derivation of PNEC values at different levels is given in Table 3. This table summarises the PNEC values derived from acute, chronic and ecosystem studies. Using the lowest valid chronic toxicity data for fish (Brachydanio rerio NOEC = 0.37 mg/l), crustaceans (*Daphnia Magna* EC-16 = 0.37 mg/l) and algae (*Selenastrum capricornutum* EC 0 = 0.88 mg/l) applying an assessment factor of 10 leads to a PNEC of 37 µg/l.

The final PNEC which is calculated for the risk assessment for 1,2-dichlorobenzene is 37 µg/l.

The draft for Surface Waters Quality Objectives of the EU for substances of List I of Directive 76/464 indicates for all dichlorobenzene isomers a value of 10 µg/l (CSTE, 1994).

7.8 Bioaccumulation

Experimentally-derived bioconcentration factors for fish range from 142 - 560 (wet weight of whole fish), with equilibrium between uptake and elimination reached after 7-8 days. Equilibrium between uptake and elimination of 1,2-dichlorobenzene in the bluegill (*Lepomis macrochirus*) was reached within 14 days. The half-life for depuration from tissue was less than 24 hours (Barrows *et al.,* 1980). Oligochaetes inhabiting the sediment exhibited no bioaccumulation, whereas algae showed a BCF of 6212 to 19700 (Casserly *et al.,* 1983 and Davis *et al.,* 1983).

Table 4: Experimental bioconcentration factors

Species	BCF	Reference
Fish	***Whole fish***	
Cynoseion nebulosis	142	)
Ictalurus furcatus	218	) Pereira *et al.,* 1988
Micropogonias undulatus	192	)
Callinectes sapidus	144	)
Salmo gairdneri	270-560	Oliver & Niimy, 1983

Some studies on the bioaccumulation of 1,2-dichlorobenzene have shown that equilibrium between uptake and elimination is reached within 7 - 14 days. The half-life for elimination was less than 24 hours for the bluegill (*Lepomis macrochirus*), and less than 5 days for the worm *Tubifex tubifex* which inhabits the sediment (Oliver, 1984, 1987).

Another test was conducted by the MITI with the carp, *Cyprinus carpio* (MITI, 1992). The organisms were exposed during 4 weeks to 1,2-dichlorobenzene at two concentration levels (0.1 mg/l and 0.01 mg/l). A BCF of 150-230 was determined at the higher concentration and a BCF of 90-260 at the lower concentration.

Although some bioaccumulation is to be expected with a log P_{ow} value of 3.43, only a significant BCF is found in algae but not in fish or crustaceans.

7.9. <u>Persistence in water</u>

The Henry‘s Law constant of 140 Pa.m^3/mol at 20°C indicates that volatization from water will be significant (Lyman *et al.,* 1982). The volatilization half-life from a river one meter deep flowing 1 m/sec with a wind velocity of 3 m/sec is estimated to be 4.4 hours at 20°C (Lyman *et al.,* 1982). Using the model SRC‘s EPIWIN with similar parameters leads to a half-life of 4.3 hours for a river and 120.9 hours for a lake (1 m deep, 0.05 m/sec water current and 0.5 m/sec wind velocity).

1,2-dichlorobenzene is not expected to undergo significant hydrolysis in environmental waters (Callahan *et al.,* 1979). In a isooctane solvent, 1,2-dichlorobenzene absorbs no irradiation above 300 nm; therefore, direct photolysis in the environment should not be expected (Sadtler, 1988).

7.10. Persistence in Air

1,2-dichlorobenzene is predominantly degraded in the atmosphere by reaction with OH radicals. If the OH concentration in the troposphere is assumed to be 5.10^5 molecules/cm^3, 1,2-dichlorobenzene reacts with a calculated half-life of 38 days (Wahner & Zetzsch, 1983).

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 24 days (Atkinson, 1985). Modelised by the SRC's EPIWIN software an atmospheric half-life of 26.7 days is found.

The atmospheric half lives preclude any significant transport to the stratosphere. Hence, 1,2-dichlorobenzene will not contribute to ozone depletion.

7.11. Degradation in Biological Systems

In a screening test for biodegradability, a concentration of 20 mg/l was 30 - 50 % degraded in fluvial water and 15 - 30 % in sea water within three days (Kondo *et al.*, 1983).

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), 1,2-dichlorobenzene was biodegraded 20-45%, 59-66%, 32-40% and 18-29% after the original culture, first, second and third subculture respectively (Tabak *et al.*, 1981). A modified MITI test was conducted during 4 weeks at a concentration of 100 mg 1,2-dichlorobenzene/l; no biodegradation was observed (MITI, 1992).

1,2-dichlorobenzene has BOD's of 0%, 41% and 51% of the ThOD over 5-, 10- and 20-day periods, respectively (Bailey, 1983). 1,2-dichlorobenzene is not hydrolysed under the pH and temperature conditions encountered in the environment (Kuhn *et al*, 1985).

The elimination rate of 1,2-dichlorobenzene through the Hoechst AG treatment plant was >90% from 1985 to 1987 (BUA, 1990). On average, over 87% (>67% - >97%) of 1,2-dichlorobenzene was eliminated in six Dutch communal treatment plants between 1980 and 1983 (Van Luin & Van Starkenberg, 1985).

In conclusion, although 1,2-dichlorobenzene cannot be considered as readily biodegradable, significant biodegradation occurs under sludge adaptation conditions.

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 site in 1994.

7.12. Conclusion

1,2-dichlorobenzene is toxic to aquatic organisms and has some bioaccumulation potential in algae. Specifically, it is not considered as persistent in the hydrosphere mainly due to its volatility. It is not persistent in the atmosphere. It can be deduced from the above information that 1,2-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. 1,2-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 IUCLID Data Sheet for 1,2-dichlorobenzene (June 1995). 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 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 1,2-dichlorobenzene in coastal waters and estuaries from Germany, the Netherlands, France and United Kingdom which are part of the OSPARCOM region are illustrated on the North Sea map in *Appendix 5*.

Typical values are generally lower than 0.1 µg/l. Moreover, the concentration of 1,2-dichlorobenzene in Dutch coastal water is found as 0.019 µg/l which is 10 times lower than the mean level in the Rhine due to adsorption effects, dilution through the strong Atlantic current and evaporation into the atmosphere (Water Quality Monitoring Program North Sea of the Rijkswaterstaat). The concentration falls by a factor of 100 further from the coast (up to 70 km).

Measured values in the Southern North Sea in 1983-1984 showed concentrations from 0.002 to 0.12 µg/l (BUA, 1990).

1,2-dichlorobenzene entering the North Sea from other European rivers is only of relevance in the estuaries of those rivers since the concentrations measured in the middle of the North

Sea are too low. A worst case level of 0.4 µg/l has been identified in the Rhine estuary in 1983.

8.2. River Waters

Background levels in big rivers in Germany, The Netherlands, France and UK are in general lower than 0.3 µg/l (see *Appendix 4*). Typical values are about 0.1 µg/l. A worst case of 0.45 µg/l has been identified at the German/NL border. In the recent years, a decreasing trend is observed in several rivers.

No 1,2-dichlorobenzene was demonstrable in Rhine water treated to yield drinking water (Kühn, 1989).

9. RISK ASSESSMENT CONCLUSION

In the risk characterisation of 1,2-dichlorobenzene for the aquatic organisms, the PNEC is compared to the PEC.

A PNEC of 37 µg/l was obtained for aquatic species exposed to 1,2-dichlorobenzene.

The mean concentration measured in the estuary area of the Rhine in 1983 was 0.4 µg/l (worst case) but a typical value of < 0.1 µg/l can be found. The concentration measured in Dutch coastal waters in 1983 was 0.019 µg/l.

The typical concentration measured recently in surface waters was lower than 0.3 µg/l with a worst case of < 0.45 µg/l.

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

Table 4 : Calculation of PEC/PNEC ratios for 1,2-dichlorobenzene

Type of water	PEC level	PEC/PNEC
Coastal waters/estuaries		
• worst case	0.4 µg/l	0.01
• typical	< 0.1 µg/l	< 0.003
River waters		
• worst case	< 0.45 µg/l	< 0.01
• typical	< 0.3 µg/l	< 0.008

These calculated ratios, **which do not take into account any dilution factor within the sea**, correspond to a safety margin of about 100 to 300 between the aquatic effect and the exposure concentration so that the present use of 1,2-dichlorobenzene should not represent a risk to the aquatic environment. In addition, the above monitoring data satisfy the draft European Water Quality objective (CSTE, 1994) which is set at 10 µg/l for surface waters. Moreover, 1,2-dichlorobenzene has a low bioaccumulation potential (except in algae) and is assumed to have a low persistence both due to volatility abiotic and biotic degradation potentials.

10. REFERENCES

10.1. General References

Atkinson R, 1985; Kinetics and mechanisms of the gas phase reactions of the hydroxyl radical with organic compounds under atmospheric conditions; Chem Rev, 85, pp. 69, 98, 110, 186, 187

Bailey, R.E. (1983); Environ. Sci. Technol., 17: 504

Barrows, M.E., Petrocelli, S.R., Macek, K.J., Caroll, J.J.(1980): Bioconcentration and elimination of selected water pollutants by bluegill sunfish; Dynamics Exposure and Hazard Assess. of Toxic Chem. 1979, Haque, R. (ed.), Ann Arbor Science Pub. Inc., Ann Arbor, MI. 379-392

Bayer AG (1995): internal details on manufacture, import, export, uses and quantities

BUA-Stoffbericht 53: o-Dichlorbenzol (September 1990)

Callahan, M.A. *et al.* (1979); Water-related environmental fate of 129 priority pollutants, vol.II; USEPA-440/4-79-029B

Casserly, D.M., Davis, E.M., Downs, T.D., Guthrie, R.K. (1983): Sorption of organics by Selenastrum capricornutum. Water Res. 17, 1591-1594

CSTE (1994): EEC water quality objectives for chemicals dangerous to aquatic environment (List 1); The views of the Scientific Advisory Committee on Toxicity and Ecotoxicity of Chemicals, DGXI; Environmental Contamination and Toxicology, 137, 83-110

Davis, E.M., Turley, J.E., Casserly, D.M., Guthrie, R.K. (1983): Partitioning of selected organic pollutants in aquatic ecosystems; Biodeterior., pap. Int. Biodeterior. Symp., 5th, Meeting Date 1981, Oxley, T.A., Barry, S. (eds.), John Wiley & Sons Ltd., Chichester, UK, 176-184

Euro Chlor (1996): Personal communication from the COCEM group

Kondo, M., Nishihara, T., Shimamoto, T., Koshikawa, T., Iio, T., Sawamura, R., Tanaka, K. (1988): Biodegradation test of chemicals by cultivation method. Eisei Kagaku 34, 188-195

Kuhn, E.P., Colberg, P.J., Schnoor, J.L., Wanner, O., Zehnder, A.J.B., Schwarzenbach, R.P. (1985): Microbial transofrmations of substituted benzenes during infiltration of river water to groundwater: Laboratory column studies; Environ. Sci. Technol. 19, 961-968

Kühn, W., Brauch, H.J.: Organische Spurenstoffe im Rhein und bei der drinkwasser aufbereitung, gwf Wasser and Abwasser, 129 (1988)

Lyman, W.J. Reehl, W.F., Rosenblatt, D.H. (1982); Handbook of chemical property estimation methods; Environ. Behaviour of organic compounds; Mc Graw-Hill, NY

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

MITI (1992); Biodegradation and bioaccumulation data of existing chemicals based on the CSCL Japan

Oliver, B.G., Niimi, A.J. (1983): Bioconcentration of chlorobenzenes from water by rainbow trout: Correlations with partition coefficients and environmental residues. Environ. Sci. Technol. 17, 287-291

Oliver, B.G. (1984): Uptake of chlorinated organics from anthropogenically contaminated sediments by oligochaete worms. Can. J. Fish. Aquat. Sci. 41, 878-883

Oliver, B.G. (1987): Bio-uptake of chlorinated hydrocarbons from laboratory-spiked and field sediments by oligochaete worms; Environ. Sci. Technol. 21, 785-790

Peck *et al* (1995) Bioremediation of chlorinated benzene compounds in R.E. Hinchee *et al* Bioremediation 3(4) Battelle Press

Pederson, F., Tyle, H., Niemelä, J.R., Guttmann, B., Lander, L., Wedebrand, A. (1994): Environmental Hazard Classification – Data collection and interpretation guide; TemNord 1994:589

Pereira, W.E., Rostad, C.E., Chiou, C.T., Brinton; T.I., Barber, L.B., Demcheck, D.K., Demas, C.R. (1988): Contamination of estuarine water, biota and sediment by halogenated organic comounds: A field study. Environ. Sci. Technol. 22, 772-778

Sadtler 303 UV (1988)

Srour, R. (French Consultant, 10, Rue Riquet 75019 Paris): Aromatic Intermediates and Derivatives (June 1989)

Tabak, H.H., Quave, S.A., Mashni, C.I., Barth, E.F. (1981); Biodegradability studies with organic priority pollutant compounds; J.-Water Pollut. Control Fed. 53, 1503-1518

TGD (1996) – Technical Guidance Documents in support of the Commission Directive 93/67/EEC on Risk Assessment for new notified substances and the Commission Regulation (EC) 94/1488/EEC on risk assessment for existing substances (Parts I, II, III and IV) EC Catalogue numbers CR-48-96-001-EN-C, CR-48-96-002-EN-C, CR-48-96-003-EN-C, CR-48-96-004-EN-C

Van Luin, A.B., van Starkenburg, W. (1985): Hazardous substances in waste water. Water Sci. Technol. 17, 843-853

Wahner, A. and Zetzsch, C. (1983): Rate constants for the addition of OH to aromatics (benzene, p-chloroaniline, and o-, m-, and p-dichlorobenzene) and the unimolecular decay of the adduct. Kinetics into a quasi-equilibrium. (Part) 1.; J. Phys. Chem. 87, 4945-4951 (1983)

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

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 summarised 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 LC5O EC5O 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

APPENDIX 2

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

Fugacity Level I calculation

Chemical: 1,2 dichlorobenzene

Temperature (C)	20
Molecular weight (g/mol)	147
Vapor pressure (Pa)	140
Solubility (g/m3)	130
Solubility (mol/m3)	0.88
Henry's law constant (PA.m3/mol)	158.31
Log octanol water part. coefficient	3.43
Octanol water part. coefficient	2691.53
Organic C-water part. coefficient	1103.53
Air-water partition coefficient	0.06
Soil-water partition coefficient	33.11
Sediment-water partition coefficient	66.21
Amount of chemical (moles)	1
Fugacity (Pa)	.39616460E-6
Total VZ products	2524203.30

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	.63168124E-2	.20912362E+0	.41824724E+0
VZ mol/Pa :	.24617918E+7	.44217687E+5	.94105630E+4	.87831921E+4
Fugacity :	.39616460E-6	.39616460E-6	.39616460E-6	.39616460E-6
Conc mol/m3 :	.16254579E-9	.25024974E-8	.82847376E-7	.39616460E-6
Conc g/m3 :	.23894232E-7	.36786713E-6	.12178564E-4	.16569475E-6
Conc ug/g :	.19818847E-5	.36786713E-6	.81190429E-5	.24357128E-4
Amount mol :	.97527479E+0	.17517482E-1	.37281319E-2	.16238085E-4
Amount % :	97.53	1.75	0.37	0.35

APPENDIX 3

SUMMARY OF ECOTOXICITY DATA ON 1,2-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	F-T,A	LC50	5.2	1		Roederer (1990)
Pimephales promelas	96 h	A	LC50	9.47	1		Environment. Studies (1986)
Brachydanio rerio	24 h	A,S,C	LC50	6.8	2		Calamari *et al.* (1983)
Salmo gairdneri	24 h	A,S,C	LC50	2.3	2		Calamari *et al.* (1983)
Pimephales promelas	96 h	S	LC50	57	2		Curtis & Ward (1981)
Pimephales promelas	72 h	S	LC100	10	2		Dawson *et al.* (1977)
Pimephales promelas	72 h	S	NOEC	3	2		Dawson *et al.*(1977)
Lepomis macrochirus	96 h	S	LC50	5.6	2		Buccafusco *et al.* (1981)
Lepomis macrochirus	48 h/96 h	S	LC50	32/27	2		Dawson *et al.*(1977)
Brachydanio rerio	48 h	F-T,C	LC50	10	3		Slooff *et al.*(1979)
Leuciscus idus melanotus	48 h	S	LC50	20-29	4		Juhnke & Lüdemann (1978)
Leuciscus idus melanotus	48 h	S	NOEC	35.0	4		Hoechst AG (1976)
Salmo gairdneri	96 h		LC50	1.1	4		Ribo *et al.* (1983)
Salmo gairdneri	96 h	F-T	LC50	1.67	4		US EPA (1985)
Salmo gairdneri	96 h	F-T,A	LC50	1.58	4		US EPA (1980)
Oryzias latipes	48 h	SS	LC50	9.9	4		Yoshioka *et al.* (1986)
Barbus conchonius	14 h	S	LC100	ca. 4	4		Toman & St'ota (1959)
Carassius auratus	96 h	S	LC50	20.0	4		Juhnke & Lüdemann (1978)

APPENDIX 3

SUMMARY OF ECOTOXICITY DATA ON 1,2-DICHLOROBENZENE

1. FISH

Species	Duration d (days) h (hours)	Type of study	Criterion (LC50/EC50 NOEC)	Concentration (mg/l)	Validity	Comments	Reference
Acute Studies							
2. SALTWATER							
Menidia beryllina	96 h	S	LC50	7.3	2		Dawson *et al.* (1977)
Cyprinodon variegatus	96 h	S	LC50	9.7	2		Heitmuller *et al.* (1981)
Cyprinodon variegatus	96 h	S	NOEC	7.2	2		Heitmuller *et al.* (1981) US EPA (1985)
Chronic Studies							
1. **FRESHWATER**							
Brachydanio rerio	14 d	F-T, A	NOEC	0.37	1		Roederer *et al.* (1990)
Poecilia reticulata	14 d	SS	LC50	5.8	2		Könemann (1981)
Pimephales promelas	chronic		NOEC	2	4	embryo larval	US EPA (1978)
Pimephales promelas	chronic		NOEC	1	4	embryo larval	US EPA (1978)
Pimephales promelas	chronic		NOEC	2	4	life cycle	US EPA (1980)
2. **SALTWATER**							
No data available							

APPENDIX 3

SUMMARY OF ECOTOXICITY DATA ON 1,2-DICHLOROBENZENE

2. INVERTEBRATES

Species	Duration d (days) h (hours)	Type of study	Criterion (LC50/EC50 NOEC)	Concentration (mg/l)	Validity	Comments	Reference
Acute Studies							
1. FRESHWATER							
Daphnia magna	24 h	S,C,A	EC50	0.78	1		Calamari *et al.* (1983)
Daphnia magna	48 h	S,C,A	EC50	0.74	1		Canton *et al.* (1985)
Daphnia magna	48 h	A,S,C	LC50	2.2	1		Canton *et al.* (1985)
Daphnia magna	48 h	S,C	LC50	2.4	2		LeBlanc *et al.* (1980)
Daphnia magna	48 h	C	EC0	0.36	2		LeBlanc & Kühn (1980)
Daphnia magna	24 h	S,O	EC50	68	2		Bringmann & Kühn (1977)
Daphnia magna	24 h	S,O	EC50	45	2		Bringmann & Kühn (1982)
Daphnia magna	48 h	S,A	EC50	3.8	2		Hermens *et al.* (1984)
Daphnia magna	48 h	S,C	LC50	2.35	3	Distilled water as diluent	Abernethy *et al.* (1986)
Daphnia magna	48 h	S,C	EC50	2.4	3		Bobra *et al.* (1985)
Daphnia magna	48 h	S,N	EC50	2.44	4		US EPA (1980)
Daphnia magna	24 h	S	EC50	1.7	4		Kühn *et al* (1988)
Daphnia magna	48 h	S	EC50	3.0-9.4	4	different populations	Deneer *et al.* (1988)
Cloeon dipterum	48 h	S	EC50	26	4		Nishiuchi (1981)
Tanytarsus dissimilis	96 h	S	EC50	11.8	4		US EPA (1980)

APPENDIX 3

SUMMARY OF ECOTOXICITY DATA ON 1,2-DICHLOROBENZENE

2. INVERTEBRATES

Species	Duration d (days) h (hours)	Type of study	Criterion (LC50/EC50 NOEC)	Concentration (mg/l)	Validity	Comments	Reference
2. SALTWATER							
Artemia salina	24 h	S, N	EC50	15	2	Larvae	Abernethy & Ward (1986)
Palaemonetes pugio	48 h/96 h	S,N	EC50	10.3/9.4	2		Curtis *et al*. (1981)
Crassostrea virginica	24 h	F,T	EC50	≥ 1	4	shell growth inhibition	Butler *et al*. (1960)
Strongylocentrotus purpuratus	28 h	S	EC	21	4	eggs, de-velopment	Oshida *et al*., (1977)
Mysidopsis bahia	96 h	S	EC50	1.97	4		US EPA (1978)
Mercenaria mercenaria	48 h		NOEC	5	4	embryo-larvae	Davis & Hidu (1969)
Chronic Studies							
1. FRESHWATER							
Daphnia magna	21 d	SS,C,N	NOEC	0.63	1		Kühn *et al*. (1988)
Daphnia magna	14 d	SS,A	EC16	0.37	1		Calamari *et al*.(1983)
2. SALTWATER							
Mercenaria mercenaria	10 d	SS	NOEC	5	4	embryo-larvae	Davis & Hidu (1969)

APPENDIX 3

SUMMARY OF ECOTOXICITY DATA ON 1,2-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							
Scenedesmus pannonicus	96 h	A	EC50	17	1		Canton *et al.* (1985)
Selenastrum capricornutum	96 h	S, C, A	EC50	2.2	1		Calamari *et al.* (1983)
Selenastrum capricornutum	96 h	S,C,A	EC0	0.88	1		Calamari *et al.* (1983)
Selenastrum capricornutum	96 h	C,A	EC0	< 0.9	1		Galassi & Vighi (1981)
Selenastrum capricornutum	5 d	S	LOEC	80	2		Milligton *et al.* (1988)
Ankistrodesmus falcatus	4 h	S	EC50	20	2	^{14}C measure	Wong (1984)
Chlorella vulgaris	6 h	S	EC 50	38	2		Kramer *et al.* (1986)
Chlorella vulgaris	5 d	S	LOEC	5-100	2	influence of media	Milligton *et al.* (1988)
Scenedesmus pannonicus	48 h	S	EC50	14	2	biomass	Kühn *et al.* (1990)
Scenedesmus pannonicus	5 d	S	LOEC	50-100	2	influence of media	Milligton *et al.* (1988)
Selenastrum capricornutum	3 h	S	EC50	10	2	^{14}C measure	Calamari *et al.* (1983)
Scenedesmus pannonicus	48 h		EC10	3	4		Kühn & Pattard (1990)
Selenastrum capricornutum	96 h	S	EC50	91.6	4	chlorophyll *a* content	US EPA (1978)
2. **SALTWATER**							
Marine phytoplankton	10 d		NOEC	7.6	2	cell growth	Ukeles (1962)
Skeletonema costatum	96 h	S	EC50	44.2	4	chlorophyll *a*	US EPA (1978)
Phaeodactylum tricornutum			EC100	13	4		Ware (1970)

LIST OF ABBREVIATIONS USED IN TABLES

A	=	Analysis
C	=	Closed system or controlled evaporation
h	=	hour(s)
d	=	day(s)
N	=	nominal concentration
S	=	static
SS	=	semistatic
FT	=	flowthrough

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 1,2-DICHLOROBENZENE IN NATURAL SURFACE WATERS

Area	Year of measurement	Average or median concentration (µg/l)	Reference
1. Open sea			
Southern North Sea	1983-1984	0.002-0.12	BUA, 1990
2. Coastal waters and estuaries			
Rhine Maasluis (NL)	1997	< 0.01	EU COMMPS, 1998
Scheldt (NL)	1997	< 0.03	EU COMMPS, 1998
Weser estuary (D)	1993-1994	< 0.025	ARGE Weser, 1993
Ijsselmeer (NL)	1980	< 0.1	Meijers, 1981
Holland Coast (NL)	1983	0.019	Van de Meent, 1986
Rhine estuary (NL)	1983	0.4	Van de Meent, 1986
Seine estuary (F)	1995	< 0.2	Agence de Bassin, 1995
Forth estuary (GB)	1987	< 1.2	Rogers, 1989
Solent estuary (GB)	1990	0.035-0.107	Bianchi *et al.*, 1991
Tees (Redcar Jetty) (GB)	1995	< 0.1	Environment Agency,1997
Elbe	1994	< 0.006	EU COMMPS, 1998
	1995	< 0.004	EU COMMPS, 1998
3. Rivers			
Germany, Elbe (Magdeburg)	1993	< 0.45	IKSE, 1994
Germany, Rhine (Wiesbaden)	1986	0.18	Kühn, 1988
Germany, Rhine (Köln)	1986	0.15	Kühn, 1988
Germany, Rhine (Düsseldorf)	1986	0.23	Kühn, 1988
Germany, Rhine (Wesel)	1986	< 0.06	Kühn, 1988
Germany, Rhine (D/NL border)	1993	< 0.3	Deutsche Komission zur Rheinhaltung des Rheines, 1995
	1996-1997	< 0.1	EU COMMPS, 1998
The Netherlands, Rhine (Lobith)	1990	< 0.1	RIZA, 1991
The Netherlands, Maas (Eysden)	1990	< 0.1	RIZA, 1991
	1996-1997	< 0.04	EU COMMPS, 1998
France, Seine River	1995	< 0.2	Agence de Bassin, 1995

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

APPENDIX 5

NORTH SEA MONITORING DATA ON 1,2-DICHLOROBENZENE

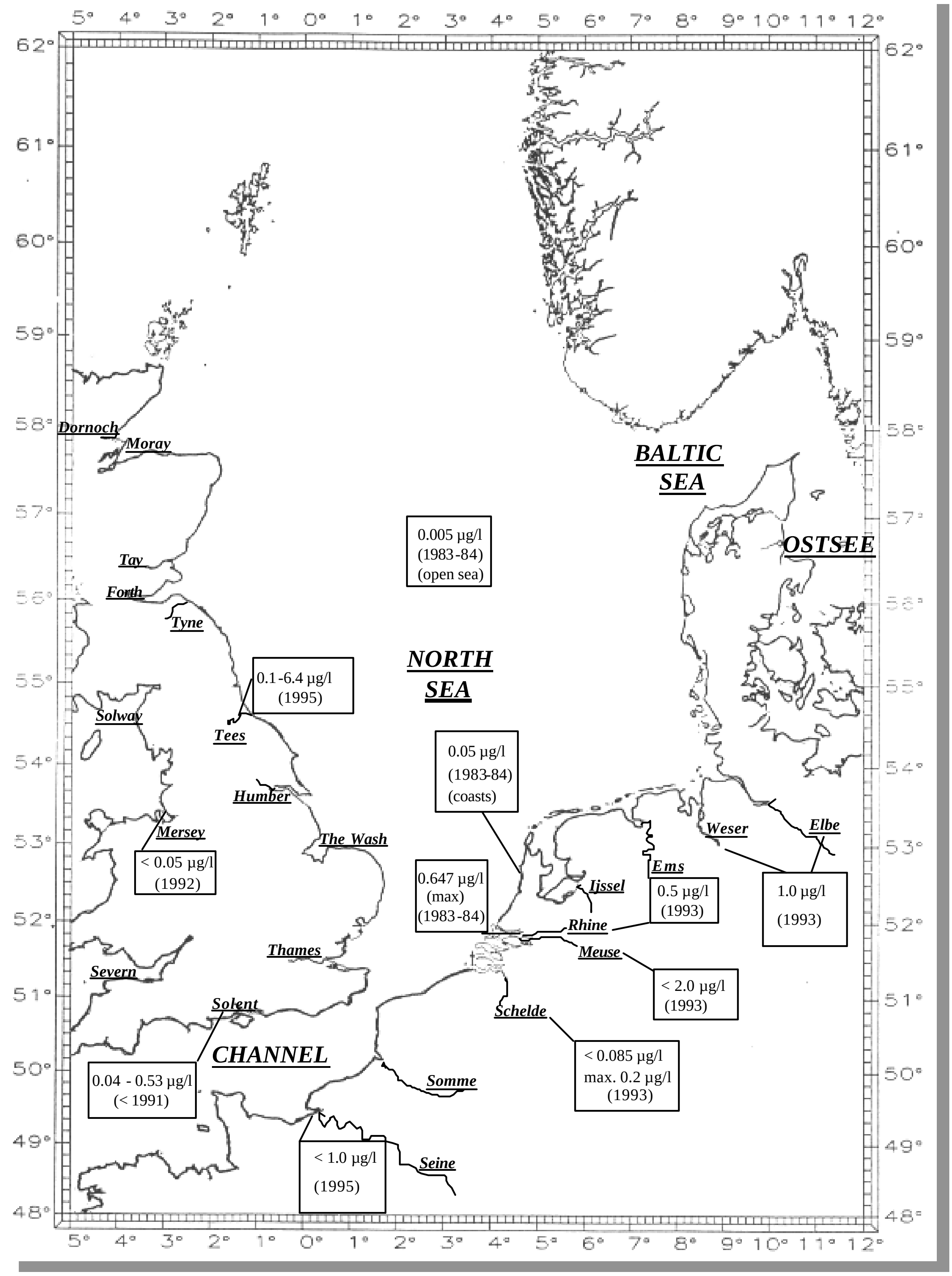


Figure 1: North Sea monitoring data on 1,2-dichloroethane

APPENDIX 6

REFERENCES FOR ECOTOXICITY DATA

Abernethy, S., Bobra, A.M., Shiu, W.Y., Wells, P.G., Mackay, D. (1986): Acute lethal toxicity of hydrocarbons and chlorinated hydrocarbons to two planktonic crustaceans: The key role of organism-water partitioning; Aquatic Toxicology 8, 163-174

Bobra, A., Shiu, W.Y., Mackay, D. (1985): Quantitative structure-activity relationships for the acute toxicity of chlorobenzenes to Daphnia magna; Environ. Toxicol. Chem. 4, 297-305

Bringmann, G., Kühn, R. (1982): Ergebnisse der Schadwirkung wassergefährdender Stoffe gegen Daphnia magna in einem weiterentwickelten standardiisierten Testverfahren; Z. f. Wasser- und Abwasser-Forschung 15, 1-6

Bringmann, G., Kühn. R. (1977): Befunde der Schadwirkung wassergefährdender Stoffe gegen Daphnia magna; Z. f. Wasser- und Abwasser-Forschung 10, 161-166

Buccafusco, R.J., Ells, S.J., LeBlanc, G.A. (1981): Acute toxicity of priority pollutants to bluegill (Lepomis macrochirus); Bull. Environm. Contam. Toxicol. 26, 446-452

Butler, P.A., Wilson, A.J., Rick, A.J. (1960): Effect of pesticides on oysters; Proc. Natl. Shellfisheries Assoc. 51, 23-32

Calamari, D., Galassi, S., Setti, F. Vighi, M. (1983): Toxicity of selected chlorobenzenes to aquatic organisms; Chemosphere 12, 253-262

Canton, J.H., Slooff, W. Kool, HJ., Struys, J., Pouw, T.J.M., Wegman, R.C., Piet, G.J. (1985): Toxicity, biodegradability, and accumulation of a number of Cl/N-containing compounds for classification and establishing water quality criteria; Regul. Toxicol. Pharmacol. 5, 123-131

Curtis, M.W., Ward, C.H. (1981): Aquatic toxicity of forty industrial chemicals: Testing in support of hazardous substance spill prevention regulation; J. Hydrol. 359-367

Davis, H.C., Hidu, H. (1969): Effects of pesticides on embryonic development of clams and oysters and on survival and growth of the larvae; Fish. Bull. (U.S. Fish Wildl. Serv.) 67, 393-404

Dawson, G.W., Jennings, A.L., Drozdowski, D., Rider, E. (1977): The acute toxicity of 47 industrial chemicals to fresh and saltwater fishes; Journal of Hazardous Materials 1, 303-318

Deneer, J.W., Sinnige, T.L., Seinen, W. Hermens, J.L.M. (1988): The joint acute toxicity to Daphnia magna of industrial organic chemicals at low concentrations; Aquatic Toxicology 12, 33-38

Environmental Studies, Centre for Lake Superior, „Acute toxicities of organic chemicals to Fathead minnows (1986)

Galassi, S., Vighi, M. (1981):Testing toxicity of volatile substances with algae; Chemosphere 10, 1123-1126

Heitmuller, P.T., Hollister, T.A., Parrish, P.R. (1981): Acute toxicity of 54 industrial chemicals to sheepshead minnows (Cyprinodon variegatus); Bull. Environ. Contam. Toxicol., 27, 596-604

Hermens, J., Canton, H., Janssen, P., De Jong, R. (1984): Quantitative structure-activity relationships and toxicity studies of mixtures of chemicals with anaesthetic potency: Acute lethal and sublethal toxicity to Daphnia magna; Aquatic Toxicology 5, 143-154

Hoechst AG: Ergebnis der abwasserbiologischen Untersuchungen von o-Dichlorbenzol; Bericht Nr. OEK 7029 vom 28.06.1976

Juhnke, I., Lüdemann, D. (1978): Ergebnisse der Untersuchung von 200 chemischen Verbindungen auf akute Fischtoxizität mit dem Goldorfentest; Z. f. Wasser- und Abwasser-Forschung 11, 161-164

Könemann, H. (1981): Quantitative structure-activity relationships in fish toxicity studies. Part 1: Relationship for 50 industrial pollutants; Toxicology 19, 209-221

Kühn, R., Pattard, M, Pernak, K.-D., Winter, A. (1988): Schadstoffwirkungen von Umweltchemikalien im Daphnien-Reproduktions-Test als Grundlage für die Bewertung der Umweltgefährlichkeit in aquatischen Systemen; Forschungsbericht Nr. 10603052 des Institutes für Wasser, Boden- und Lufthygiene des Bundesgesundheitsamtes Berlin, I-III, 390, 412-413

Kühn, R., Pattard, M. (1990): Results of the harmful effects of water pollutants to green algae (Scenedesmus subspicatus) in the cell multiplication inhibition test; Wat. Res. 24, 31-38

LeBlanc, G.A. (1980): Acute toxicity of priority pollutants to water flea (Daphnia magna); Bull. Environm. Contam. Toxicol. 24, 684-691

Millington, L.A., Goulding, K.H., Adams, N. (1988): The influence of growth medium composition on the toxicity of chemicals to algae; Wat. Res. 22, 1593-1597

Nishiuchi, Y. (1981): Evaluation of the effect of pesticides on some aquatic organisms. I. Effect of pesticides on some aquatic insects; Seitai Kagaku 4, 31-46

Oliver, B.G., Niimi, A.J. (1983): Bioconcentration of chlorobenzenes from water by rainbow trout: Correlations with partition coefficients and environmental residues; Environ. Sci. Technol. 17, 287-291

Oshida, P.S. (1977): Toxicity of a chlorinated benzene to sea urchin embryos; Coastal Water Res. Proj. Annu. Rep. (South Calif.) 187-192

Ribo, J.M., Kaiser, K.L.E. (1983): Effects of selected chemicals to photoluminescent bacteria and their correlations with acute and sublethal effects on other organisms; Chemosphere 12, 1421-1442

Roederer, G. (1990): Umweltbundesamt, UFOPLAN-Nr. 116 08 071/01, 79

Slooff, W. (1979): Detection limits of a biological monitoring system based on fish respiration; Bull. Environm. Contam. Toxicol. 23, 517-523

Toman, M., St'ota, Z. (1959): Über die Toxizität des Benzols und seiner Chlorsubstitutions-derivate gegenüber Fischen. (Beiträge zur Kenntnis des Einflusses der Konstitution von Isomeren und Homologen auf deren biologische Wirksamkeit. V); Biologia 14, 674-679

Ukeles, R.: Growth of, pure cultures of marine phytoplankton in the persence of toxicants; Appl. Microbiol. 10, 32-537 (1962)

US-EPA (1978): In-depth studies on health and environmental impacts of selected water pollutants; US Environmental Protection Agency, Contract N° 68-01-4646

US-EPA: Ambient water quality (1980). Criteria for dichlorobenzenes. US Environmental Protection Agency, Washington, DC; Order-N° PB81-117509, National Technical Information Service (NTIS), Springfield, Va., B-1-B-14

US-EPA (1985): Health assessment document for chlorinated benzenes, Final Report. EPA/600/8-84/015F. Order No. PB85-150332 NTIS, Springfield, VA, 1-1-14-77

Ware, G.W. (1970); Residue Reviews 33, 15

Wong, P.T.S., Chau, Y.K., Rhamey, J.S., Docker, M. (1984): Relationship between water solubility of chlorobenzenes and their effects on a freshwater green alga; Chemosphere 13, 991-996

Yoshioka, Y., Mizuno, T., Ose, Y., Sato, T. (1986): The estimation for toxicity of chemicals on fish by physico-chemical properties; Chemosphere 15, 195-203

APPENDIX 7

REFERENCES FOR MONITORING DATA

Agence de Bassin Seine Normandie (F) (1995) – personal communication

Arbeitsgemeinschaft zur Reinhaltung der Weser (ARGE) - Gütebericht (1993) - Published 1994.

Bianchi, A.P., Varney, M.S., Philips, J. (1991); Analysis of volatile organic compounds in estuarine sediments using dynamic headspace and gas chromatography-mass spectrometry; *J Chromatogr*., **542**: 413-450

BUA Stoffbericht (1995) 1,2-dichloroethane

Deutsche Kommission zue Reinhaltung des Rheins Zahlentafeln der physikalisch-chemisch Untersuchungen 1993 - Bericht Oct 1995 - ISSN 0173-1653

EU COMMPS Database, Fraunhofer Institute, Umweltchemie und Ökotoxicologie, Report 97/723/3040/DEB/EI prepared for the European Commission DGXI – Proposal for a list of priority substances in the context of the draft water framework directive COM(97)49FIN, 13 August 1998

IKSE (Internationale Kommission zum Schutz der Elbe), gewässergütebericht Elbe, (1993)

Kühn, W; Brauch, H-J: Organische Spurenstoffe im Rhein und bei der Trinkwasseraufbereitung, gwf Wasser und Bawasser, 129 (1988)

Meijers, A.P. (1981): Organische Spurenstoffe im Rheinwasser in: Bericht über die 8. Arbeitstagung der internationalen Arbeitsgemeinschaft der Wasserwerke im Rheineinzugsgebiet vom 18.20.Mai 1981 im Amsterdam, 80-95

RIZA, 1991: Rhein en Maas 1988-1990

Rogers, H R, Crathorne, B, Letherland, T M (1989, Occurrence of chlorobenzene isomers in the water column of a UK estuary. Mar. Pollut. Bull., 20, 276-281

UK Environment Agency (1997), Personal communication

Van de Meent, D., den Hollander, H.A., Pool, W.G., Vredenbregt, M.J., van Oers, H.A.M., de Greef, E., Luijten, J.A. (1986): Organic micropollutants in Dutch coastal waters. Water Sci. Technol. 18, 73-81