



**German Chemical Society
Gesellschaft Deutscher Chemiker**

GDCh-Advisory Committee
on Existing Chemicals of
Environmental Relevance (BUA)

1,1,2-Trichloroethane

BUA Report 152

(April 1994)



S. Hirzel

Wissenschaftliche Verlagsgesellschaft 1995

GDCh-Advisory Committee on Existing Chemicals of Environmental Relevance (BUA)

Chairman:

Prof. Dr. E. Bayer, Institut für Organische Chemie der Universität Tübingen

Members:

Dr. G. Alfke, Mineralölwirtschaftsverband e. V., Hamburg

Prof. Dr. K. Ballschmiter, Abteilung Analytische Chemie und Umweltchemie der Universität Ulm

Dr. R. Bias, BASF AG, Emissionsüberwachung und Ökologie, Ludwigshafen a. Rh.

Dr. B. Broecker †, HOECHST AG, Abteilung Umweltchemikalien/Verbrauchersicherheit, Frankfurt am Main

Prof. Dr. O. Fränzle, Geographisches Institut der Universität Kiel

Prof. Dr. F. H. Frimmel, DVGW-Forschungsstelle am Engler-Bunte-Institut der Universität Karlsruhe

Prof. Dr. H.-P. Gelbke, BASF AG, Toxikologie, Ludwigshafen a. Rh.

Prof. Dr. H. Greim, GSF — Institut für Toxikologie, Neuherberg (Vice Chairman)

Dir. und Prof. Dr. J. Hahn, Institut für Wasser-, Boden- und Lufthygiene des Umweltbundesamtes, Berlin

Dr. H. Jungen, Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e. V., Hamburg

Dir. und Prof. Dr. D. Kayser, Bundesinstitut für gesundheitlichen Verbraucherschutz und Veterinärmedizin, Berlin

Dr. W. Mühlhölzl, Bayerische Landesanstalt für Wasserforschung, München

Prof. Dr. P. Müller, Institut für Biogeographie, Universität des Saarlandes, Saarbrücken

Dir. und Prof. Dr. E. Offhaus, Umweltbundesamt, Berlin

Dr. R. Ott, Deutsche Shell Chemie GmbH, Eschborn/Ts.

MinRat Prof. Dr. U. Schlottmann, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Bonn

Dr. N. Schön, BAYER AG, Umweltschutz/Produktsicherheit, Leverkusen

Vizepräsident Dr. A. Troge, Umweltbundesamt, Berlin

Collaborators and Guests:

Dr. K. H. Adlfinger, Initiative Umweltrelevante Altstoffe, Frankfurt am Main

Priv.-Doz. Dr. J. Ahlers, Fachgebiet IV 1.2 des Umweltbundesamtes, Berlin

Dr. A. Bartsch, GSF - Institut für Toxikologie, Neuherberg

Dr. S. Ettel, Institut für Organische Chemie der Universität Tübingen

Dr. R. F. Hertel, Fachgruppe 821 des Bundesinstituts für gesundheitlichen Verbraucherschutz und Veterinärmedizin, Berlin

Dr. J. Koppenhöfer, Institut für Organische Chemie der Universität Tübingen

Prof. Dr. R. Kümmel, Institut für Umwelt- und Sicherheitstechnik der Fraunhofer Management-Gesellschaft, Oberhausen

Dr. J. Leuschner, Laboratorium für Pharmakologie und Toxikologie, Hamburg

Frau Dr. I. Mangelsdorf, GSF - Institut für Toxikologie, Neuherberg

Frau Dipl.-Biol. V. Müller, DOW Deutschland Inc., Stade

Dr. J. Oberhansberg, BG Chemie, Heidelberg

Frau Dipl.-Biol. M. Rosenberg, Institut für Pharmakologie und Toxikologie, Hamburg

Frau Dr. H. Sterzl-Eckert, GSF - Institut für Toxikologie, Neuherberg

Frau Dr. F. Stibane, Laboratorium für Pharmakologie und Toxikologie, Hamburg

Dr. D. Vogel, Institut für Organische Chemie der Universität Tübingen

Frau Dipl.-Biol. L. Weis, Institut für Organische Chemie der Universität Tübingen

Frau Dr. K. Widmann, Institut für Organische Chemie der Universität Tübingen

GDCh Office:

Dr. H. Behret, GDCh, Frankfurt am Main

1,1,2-Trichloroethane

BUA Report 152

(April 1994)

edited by the GDCh-Advisory
Committee on Existing Chemicals
of Environmental Relevance

Beratergremium für
Umweltrelevante Altstoffe (BUA)



S. Hirzel

Wissenschaftliche Verlagsgesellschaft 1995

Dr. H. Behret
Gesellschaft Deutscher Chemiker
Postfach 90 04 40
D-60444 Frankfurt am Main

Translated by M.-J. Blümich

This book was carefully produced. Nevertheless, authors, editors and publisher do not warrant the information contained therein to be free of errors. Readers are advised to keep in mind that statements, data, illustrations, procedural details or other items may inadvertently be inaccurate.

The use of general descriptive names, trade names, trademarks, etc. in a publication, even if not specifically identified, does not imply that these names are not protected by the relevant law and regulations.

Die Deutsche Bibliothek — CIP-Einheitsaufnahme

1,1,2-Trichloroethane / ed. by the GDCh Advisory Committee on Existing Chemicals of Environmental Relevance (BUA). — (Stand: April 1994). — Stuttgart: Hirzel ; Stuttgart : Wiss. Verl.-Ges., 1995

(BUA report; 152)

Dt. Ausg. u.d.T.: 1,1,2-Trichloroethan

ISBN 3-7776-0671-5

NE: Gesellschaft Deutscher Chemiker / Beratergremium für Umweltrelevante Altstoffe: BUA report

All rights reserved. No part of this publication may be translated, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, microfilming, recording or otherwise, without permission in writing from the publisher.

© 1995 S. Hirzel Verlag, Birkenwaldstraße 44, 70191 Stuttgart

Printed in acid-free and low-chlorine paper.

Printing and binding: Druckhaus Beltz, Hemsbach
Printed in F.R. Germany

Foreword

The German Chemicals Act (Chemikaliengesetz - ChemG) of 1980 stipulates that certain existing chemicals must be reported to the competent authority, if they exhibit properties which indicate that they may be hazardous, either alone or in combination with other substances.

In the summer of 1982, an Advisory Committee on Existing Chemicals of Environmental Relevance (BUA) was set up by the German Chemical Society (Gesellschaft Deutscher Chemiker - GDCh). It brings together representatives from the scientific community, the chemical industry and the governmental authorities. This Advisory Committee is responsible for elaborating appropriate solutions for substances of relevance for health and the environment on the basis of voluntary measures. It selects and examines existing chemicals from the aforementioned angles. The testing and evaluation are based on scientific criteria alone.

It was, therefore, necessary to develop priority setting procedures. In a first phase reports were only prepared for priority chemicals. Within the framework of a first priority setting procedure, chemicals were compiled from several priority lists and 135 chemicals were selected for detailed substance reports.

In a second priority setting procedure the survey of the German Chemical Industry Association (VCI) on all substances with a production volume of more than 10 tons per year was used as a starting list. Since this survey covered 4,600 chemicals, BUA decided to process the corresponding list in several stages. The first stage included approx. 1,050 substances with a production volume of more than 1,000 tons per year.

Detailed reports are drawn up on chemicals suspected of having a hazard potential and abridged reports on those presenting only a minor hazard potential, according to the current state of knowledge.

The detailed BUA reports take in both the published literature and data from industry. If data for the evaluation of the chemicals are not available, additional studies are recommended and the results are published as updates to the reports. The reports serve as a basis for the instigation of administrative measures, when there are indications of risks to health or the environment.

Tübingen, May 1993

Ernst Bayer
Chairman of the Advisory Committee
on Existing Chemicals
of Environmental Relevance

Contents

Summary and Conclusions	XI
--------------------------------------	-----------

Recommendations	XXI
------------------------------	------------

1,1,2-Trichloroethane

1. Chemistry of the Substance	1
1.1 Chemical Identity	1
1.2 Composition of the Technical Product	2
1.3 Chemical Properties	2
2. Physical Properties	4
3. Analysis	8
3.1 Determination in Air	8
3.2 Determination in Water	12
3.3 Determination in Soil, Sediment and Biological Material	20
4. Entry into the Environment during Production, Processing, Use and Waste Disposal	27
4.1 Production Methods	27
4.1.1 Chlorination of 1,2-Dichloroethane	27
4.1.2 Chlorination of Vinyl Chloride (catalytically and radically)	29
4.1.3 Catalytic Gas-Phase Chlorination of Acetylene by means of Hydrogen Chloride and Chlorine	29
4.1.4 Other Production Pathways	30
4.2 Manufacturers and Processors, Export, Import, Total Consumption	30
4.3 Processing, Use, Quantities Consumed	33
4.4 Entry into the Atmosphere	34
4.5 Entry into the Hydrosphere	36
4.6 Entry into the Geo- and Biosphere	38
4.7 Entry from Wastes and Their Treatment	38

4.8	Balance of Entry into die Environment.....	39
5.	Occurrence in the Environment	41
5.1	Atmosphere	41
5.1.1	Ambient Air	41
5.1.2	Indoor Air	46
5.1.3	Respiratory Air	46
5.1.4	Soil Spacial Air	46
5.2	Hydrosphere	47
5.2.1	Surface Water Bodies	47
5.2.2	Groundwater and Drinking Water	53
5.2.3	Rainwater	56
5.2.4	Waste Water	56
5.2.5	Sediment	56
5.3	Geosphere	57
5.4	Biosphere	57
5.4.1	1,1,2-TCE Level in Humans	57
5.4.2	1,1,2-TCE Level in Animals	58
5.4.3	Foodstuffs	58
5.5	Natural Sources	58
6.	Environmental Behaviour	59
6.1	Transformation, Degradation and Degradation Products	59
6.1.1	Biodegradation	59
6.1.1.1	Metabolism	59
6.1.1.2	Aerobic Degradation	60
6.1.1.2.1	Aerobic Degradation with Activated Sludge or Waste Water as the Inoculum	60
6.1.1.2.2	Aerobic Degradation with Special Organisms	60
6.1.1.3	Anaerobic Degradation	61
6.1.2	Hydrolytic Degradation	62
6.1.3	Photochemical Degradation	63
6.1.3.1	Degradation in Air	63
6.1.3.1.1	Ozone Degradation Values (ODP: Ozone Depletion Potential)	65
6.1.3.2	Degradation in Water	66

6.2	Accumulation	67
6.2.1	Bioaccumulation.....	67
6.2.2	Geoaccumulation	68
6.3	Distributional Behaviour and Transport Processes within and between Environmental Compartments	69
6.3.1	Henry's Law Constant	69
6.3.2	n-Octanol/Water Partition Coefficient	70
6.3.2.1	Other Partition Coefficients	71
6.3.3	Soil Sorption Coefficients	71
6.3.3.1	Adsorption onto Clay Minerals and Silicon Dioxide	73
6.4	Environmental Fate	74
7.	Ecotoxicology	76
7.1	Effects on Aquatic Organisms	76
7.1.1	Microorganisms	76
7.1.2	Plants	79
7.1.3	Invertebrates	80
7.1.4	Vertebrates	88
7.2	Effects on Terrestrial Organisms	92
7.2.1	Microorganisms	92
7.2.2	Plants	92
7.2.3	Invertebrates	93
7.2.4	Vertebrates	93
7.3	Effects on Ecosystems	93
8.	Toxicity in Warm-Blooded Organisms	94
8.1	General Effects	94
8.2	Mode of Action	94
8.3	Metabolism, Toxicokinetics	95
8.3.1	Absorption	95
8.3.2	Distribution in Tissue	95
8.3.3	Biotransformation	97
8.3.4	Binding onto Macromolecules	101
8.3.5	Elimination	103
8.4	Acute Toxicity	105
8.5	Skin and Mucous Membrane Tolerance	108

8.6	Sensitizing Effect	109
8.7	Subacute, Subchronic and Chronic Toxicity	109
8.7.1	Subacute Toxicity	109
8.7.2	Subchronic Toxicity	110
8.7.3	Chronic Toxicity	111
8.8	Genotoxicity	112
8.9	Carcinogenicity	113
8.10	Reproductive Toxicity	121
8.11	Effects on the Immune System	122
8.12	Other Effects	123
8.13	Experiences for Humans	124
9.	Substance-Specific Legal Regulations	128
10.	Literature	133

BUA Report on 1,1,2-Trichloroethane

Summary and conclusions

Ecological aspects

Occurrence and distribution in the compartments

1,1,2-Trichloroethane (1,1,2-TCE) is used in the Federal Republic of Germany exclusively as an intermediate for the production of 1,1-dichloroethene (vinylidene chloride). The production takes place by catalytic chlorination of vinyl chloride. It also occurs as a by-product (12 - 20 %) in the production of 1,1,1-trichloroethane and 1,2-dichloroethane.

In 1990, the production capacity of 1,1,2-trichloroethane amounted to 56,000 t, while the production quantity was 21,000 t (direct manufacture: 6,000 t; by-product yield in the 1,1,1-trichloroethane manufacture: 15,000 t) and the consumption (defined as production + import - export) was about 16,000 t. The export volume of 1,1,2-TCE for the Federal Republic of Germany is specified to be 5,750 t for 1990. About 1,000 t were imported in 1990 for internal processing to 1,1-dichloroethene. Data on the production and processing of 1,1,2-TCE in the new German states are unavailable. There is no direct use of 1,1,2-TCE in the Federal Republic of Germany. Possible applications cited below are not practiced in the Federal Republic of Germany, because 1,1,2-TCE is used only as an intermediate: 1,1,2-TCE can be used in glues, varnishes and coatings as well as in the production of teflon tubes. Furthermore, it serves as a solvent for chlorinated rubber, fats, oils, waxes and resins.

The total determinable emission of 1,1,2-TCE into the atmosphere in the Federal Republic of Germany was about 5.5 t for 1990. Of this amount, 0.034 t/a was attributed to production and processing, 0.1 t/a to the by-product yield during the 1,1,1-trichloroethane production, < 0.15 t/a to the by-product yield in the production of 1,2-dichloroethane and 5.2 t/a were attributed to the residual content from 1,1,1-trichloroethane application.

The total discharge via pretreated waste water into the sewage treatment plants in 1990 was 0.005 t during the processing of 1,1,2-TCE and < 0.01 t from the by-product yield in the production of 1,1,1-trichloroethane.

For three companies, an emission of 0.157 t into the sewage plants is quantifiable from the by-product yield during the 1,2-dichloroethane

production. Thus, in 1990 a total emission of about 0.16 t is determinable.

1,1,2-TCE released into the atmosphere can be rained out and be emitted into the geosphere in this way.

Data are unavailable on the emission of 1,1,2-TCE into the hydro-, geo- and biosphere during the use of 1,1,1-trichloroethane.

1,1,2-TCE atmospheric concentrations of up to $17 \mu\text{g}/\text{m}^3$ air were measured in 1978 (Bochum) in the Federal Republic of Germany. The mean values measured in 1986 at 12 different measurement points in Hamburg ranged from $0.04 \mu\text{g}/\text{m}^3$ to $0.05 \mu\text{g}/\text{m}^3$.

In different cities in the U.S.A., mean 1,1,2-TCE concentrations of $0.03 - 1.45 \mu\text{g}/\text{m}^3$ were measured in the early eighties and in the beginning of the nineties.

In 1982, 1,1,2-TCE concentrations of $18 - 26 \mu\text{g}/\text{m}^3$ were measured in indoor air of 30 Canadian offices during working hours.

Mean 1,1,2-TCE values between $0.33 \text{ mg}/\text{m}^3$ and $2.0 \text{ mg}/\text{m}^3$ (maximum: $3 \text{ mg}/\text{m}^3$ were detected in 1989 and 1990 in Southern Finland in gas samples of 3 closed-down landfills as well as a mean value of $8.7 \text{ mg } 1,1,2\text{-TCE}/\text{m}^3$ (maximum: $9.3 \text{ mg}/\text{m}^3$ detected in one, still active landfill.

A minimum value of $< 0.01 \mu\text{g } 1,1,2\text{-TCE}/\text{l}$ and a maximum and mean value of $0.01 \mu\text{g } 1,1,2\text{-TCE}/\text{l}$ were measured in 1988 in the Rhine near Stellendam. In September 1990, the 1,1,2-TCE concentration was below the detection limit of $0.1 \mu\text{g}/\text{l}$. A maximum of $0.1 \mu\text{g } 1,1,2\text{-TCE}/\text{l}$ was measured in 1991 at Hagenstein.

1,1,2-Trichloroethane concentrations ranging from $< 0.1 - 0.2 \mu\text{g}/\text{l}$ (1983) and $< 0.1 - 0.8 \mu\text{g}/\text{l}$ (1985) were measured between 1983 and 1986 in Ruhr water (1986: $< 0.1\text{-}0.3 \mu\text{g } 1,1,2\text{-TCE}/\text{l}$).

In the Elbe, the maximum monthly mean values were $0.26 - 0.82 \mu\text{g } 1,1,2\text{-TCE}/\text{l}$ between 1986 and 1990. The annual mean values at Schnackenburg in 1988 and 1989 were 0.26 and $0.25 \mu\text{g } 1,1,2\text{-TCE}/\text{l}$, respectively. In 1990 and 1991, 1,1,2-TCE in concentrations (weekly mixed samples) of $< 0.001 - 1.39 \mu\text{g}/\text{l}$ and $< 0.01 - 0.03 \mu\text{g}/\text{l}$ were measured at Schnackenburg, respectively. In 1992, the concentration at all the measurement sites was below the detection limit of $0.01 \mu\text{g } 1,1,2\text{-TCE}/\text{l}$.

In the U.S.A., a maximum of $31.1 \mu\text{g } 1,1,2\text{-TCE}/\text{l}$ groundwater and a maximum of $18.7 \mu\text{g } 1,1,2\text{-TCE}/\text{l}$ surface water were determined between 1977 and 1979 in ground- and surface water samples in cities, sub-

urbs, country areas and agricultural regions.

A maximum concentration of 5.8 µg 1,1,2-TCE/l was measured between January and July, 1977 in drinking water of 100 cities of the Federal Republic of Germany. In 1981, 1,1,2-TCE concentrations of 0.03 - 0.09 µg/l and < 0.005 - 0.02 µg/l were detected in tap water samples and in drinking water samples in Tübingen, respectively.

A mean concentration of 0.01 µg 1,1,2-TCE/l (maximum: 0.04 µg 1,1,2-TCE/l) was found during August 1986 to April 1987 in rainwater in Hamburg at one measurement site.

A mean 1,1,2-TCE concentration of < 5 µg/kg was determined in the eighties in 1 % of 359 sediment samples in the U.S.A (no further details).

1,1,2-TCE in a concentration of 5 µg/kg dry substance each was found in 1983 - 1984 in agricultural soils (0 - 20 cm and 70 - 90 cm depth) in the loess zone of the northern foothill region of the Harz, which lies in an area affected by various chlorinated hydrocarbon emitters. In 1984, the 1,1,2-TCE concentrations measured in representative soil samples (0 - 25 cm depth) of the entire metropolitan area of Hamburg were all below the detection limit of 0.2 µg/kg.

The following mean 1,1,2-TCE concentrations were measured in 1980/81: 3 µg/kg in eggs and pasta foodstuffs, 2 µg/kg in decaffeinated coffee, 3 µg/kg in fruit juices as well as < 0.1 µg/kg in other foodstuffs and drinks. Thus, the calculated average daily uptake from food is 0.24 µg/kg (0.11 µg from foodstuffs and 0.13 µg 1,1,2-TCE from drinks).

The high measurement values in the hydrosphere in the beginning of the eighties, the high measured concentrations in the Elbe up to 1990 as well as the occurrence of 1,1,2-TCE in the biosphere, in food stuffs, drinking water and in people all infer an earlier use of 1,1,2-TCE which is not covered in this report.

Because the 1,1,2-TCE concentrations in the Elbe in the period 1986 - 1990 exceeded those of 1,1,1-trichloroethane by about 20-fold, the occurrence also cannot only be explained by the residual content of 1,1,2-TCE in the 1,1,1-isomer. It is unknown to what extent earlier production, processing and, if need be, application processes come into question. Because no comparably high 1,1,2-TCE concentrations were detected anymore in the Elbe in 1991/1992, the results of such inquiries are also irrelevant for the assessment of the actual

environmental occurrence of 1,1,2-TCE. It remains to be seen whether the trend of the 1,1,2-TCE concentration in the Elbe is confirmed in future years.

In most cases and as expected, 1,1,1-trichloroethane was detected in foodstuffs in higher concentrations than 1,1,2-TCE. In comparison, clearly higher concentrations of 1,1,2-TCE were found only in fruit juices. Moreover, the 1,1,2-TCE concentration considerably exceeded the 1,1,1-trichloroethane concentration in human samples (except in lung tissue). Although these measurement values on the occurrence of 1,1,2-TCE from 1977 - 1981, including those in drinking water, do not allow any conclusions to be drawn about a trend regarding the 1,1,2-TCE concentrations, a clear reduction also of 1,1,2-TCE concentrations is to be expected particularly as of 1995 on the basis of the current pattern of use of 1,1,2-TCE and the existing legal regulations for 1,1,1-trichloroethane.

Natural sources of 1,1,2-TCE are unknown.

Degradability

1,1,2-TCE is not readily biodegradable in the hydrosphere. 1,1,2-TCE in a concentration of 5 mg/l was degraded after 7 days only to 6 % by activated sludge. However, a significant reduction of the starting concentration of 1,1,2-TCE could be observed in the laboratory under aerobic conditions by using special bacteria strains. In the laboratory, an 82 % degradation occurred after 7 days with an aerobic, methanotrophic bacteria strain. In water body samples with *Pseudomonas fluorescens* as the inoculum, 1,1,2-TCE could be degraded to around 70 % after 24 hours with the addition of other C-sources. Approximately 40 % were degraded by *Nitrosomonas europaea* after 24 hours. In a bioreactor, 1,1,2-TCE was primarily degraded to > 90 % after 21 days in propane- and methane-oxidating cultures. Vinyl chloride is formed in the aerobic as well as in the anaerobic dehalogenation of 1,1,2-TCE.

It could be shown in one study that 1,1,2-TCE is degraded anaerobically by microorganisms.

A hydrolytic degradation is unexpected under environmentally relevant conditions. A half-lifetime of 139 years has been calculated at 25 °C.

The indirect photochemical degradation in the troposphere is the most

important degradation route for 1,1,2-TCE. By different authors, half-lifetimes of 56.5 days (4 °C) and 87.2 days (22 °C) were calculated for the degradation of 1,1,2-TCE by OH-radicals.

Accumulation

Moderate bioaccumulation can be expected on the basis of an experimentally determined log P_{OW} value of 1.89. However, a bioconcentration factor (BCF) of < 10 was determined experimentally (OECD Guide line 305 C) for 1,1,2-TCE. Thus, 1,1,2-TCE is distinguished by only a low bioaccumulation.

No geoaccumulation is expected on the basis of the physicochemical properties as well as the soil sorption studies in which the determined K_{OC} values of 60 - 108 indicate low soil sorption. However, a transport of 1,1,2-TCE with the leachate water into groundwater is expected because of the high mobility in soil.

Ecotoxicology

In some of the following cited studies, it is not certain which positional isomer was studied. Therefore, this is clarified by the label trichloroethane instead of 1,1,2-TCE which is stated in the rest of the text. Because most of the studies do not specify nominal or effective concentrations, this is indicated only whenever explicit data about this are available.

In the 16 hour cell multiplication inhibition test with a pure culture of the bacterium *Pseudomonas putida* (growth parameter: turbidity) resulted in a toxic limiting concentration of 93 mg trichloroethane/l (closed system).

An IC_{50} value of 6,300 mg 1,1,2-TCE/l (nominal concentration) was found after a 24 hour exposure in one closed-serum-bottle test (inoculum: laboratory activated sludge enriched with organic and inorganic substances and inoculated with activated sludge of the local sewage treatment plant). An IC_{50} value of 240 mg 1,1,2-TCE/l for the inhibition of oxygen uptake was determined after 15 hours for aerobic and heterotrophic bacteria (from activated sludge of one waste water treatment plant, closed bottles), while an IC_{50} value of 1.9 mg 1,1,2-TCE/l was determined after a 24 hour incubation for Nitrosomonas bacteria (from activated sludge of one waste water

treatment plant, closed bottles) (parameter: inhibition of the ammonia uptake). An IC_{50} of 1.4 mg 1,1,2-TCE/l based on the inhibition of the gas production, was specified for methanogenic bacteria (from a laboratory stock over 10 years old, closed bottles) after 48 hours of incubation.

An EC_{50} of 105 and 110 mg 1,1,2-TCE/l, respectively, was determined after 5 minutes on *Photobacterium phosphoreum*.

A 8-day cell multiplication inhibition test was conducted with the cyanobacterium (blue algae) *Microcystis aeruginosa* which resulted in a toxic limiting concentration (TLC) of 350 mg trichloroethane/l (closed system).

A toxic limiting concentration of 430 mg trichloroethane/l was cited for the green algae *Scenedesmus quadricauda* after an 8-day exposure in the cell-reproduction-inhibition test (closed system).

96-h EC_{50} values between 60 mg/l (*Phaeodactylum tricornutum*), and 260 mg/l (*Chlamydomonas spec.*) are available on the acute toxicity, based on growth, for various algae species: *Chlorella pyrenoidosa*: 170 mg 1,1,2-TCE/l, *Dunaliella sp.*: 200 mg 1,1,2-TCE/l, *Chlorella ovalis*: 200 mg 1,1,2-TCE/l.

EC_{50} and LC_{50} values for trichloroethane (test medium corresponded to non-standardized conditions) are available for marine halophilic silica algae and microcrustaceans. Thus, an EC_{50} -value of 5 mg trichloroethane/l seawater exists for the inhibition of ^{14}C -assimilation for *Phaeodactylum tricornutum*. A 48-h LC_{50} value of 7.5 mg trichloroethane/l seawater is available on the acute toxicity in nauplii of the barnacle *Elminius modestus*.

An identical 24-h LC_{50} as well as 7-day LC_{50} value of 43 mg 1,1,2-TCE/l exists for the acute toxicity in water fleas (*Daphnia magna*). Furthermore, 48-h EC_{50} values of 47.1 – 81 mg 1,1,2-TCE/l are available (closed system according to ASTM). 48-h LC_{50} values ranging from 170 to 190 mg 1,1,2-TCE/l are available under the same conditions. The lowest LC_{50} value found after 48 hours was 18 mg 1,1,2-TCE/l.

Regarding the chronic toxicity of 1,1,2-TCE in *Daphnia*, a NOEC (no-

observed-effect concentration) of 13.2 ± 1.7 mg 1,1,2-TCE/l and 26.0 ± 2.2 mg 1,1,2-TCE/l, respectively based on the length and reproduction, is available from a 28-day long-term test (according to ASTM, closed system, animals fed) as well as a NOEC of 32 mg 1,1,2-TCE/l based on the mortality of the adult animals. A NOEC of 18 mg 1,1,2-TCE/l was given for reproduction. In studies with *Artemia* and *Daphnia* larvae, EC_{50} values of 15 mg/l and 32 mg/l and NOEC values of 10 mg/l and 18 mg/l (reproduction) were determined after 21 days, respectively.

96-h LC_{50} values of 110 mg 1,1,2-TCE/l and 320 mg 1,1,2-TCE/l were cited for the adult mussels *Mytilus edulis* and *Dreissena polymorpha* as well as a 96-h LC_{50} value of 170 mg 1,1,2-TCE/l for eggs of the pondsnail *Limnaea stagnalis*.

A 96-h LC_{50} value of 190 mg 1,1,2-TCE/l was specified for adult, 4 weeks-old marine polychaetes of the species *Ophryotrocha diadema*.

Based on reproduction, the 21-day EC_{50} value and the 21-day NOEC for larvae of the brine shrimp (*Artemia salina*) were 15 mg 1,1,2-TCE/l and 10 mg 1,1,2-TCE/l, respectively.

7-day and 14-day LC_{50} values of 80 mg and 65 mg 1,1,2-TCE/l, accordingly, are available for the adult mussel *Mytilus edulis* kept in seawater as well as 7-day and 14-day LC_{50} values of respectively 190 mg and 140 mg 1,1,2-TCE/l for the adult mussel *Dreissena polymorpha* retained in "hard" freshwater. Larvae of the slipper limnet *Crepidula fornicata*, kept in seawater, had a 7-day LC_{50} value of 170 mg 1,1,2-TCE/l. A 16-d LC_{50} value of 58 mg 1,1,2-TCE/l was given for juvenile pondsnail (*Limnaea stagnalis*), and a 16-day EC_{50} value of 36 mg 1,1,2-TCE/l was specified for morphology and hatch. The NOEC for morphology and hatch after 16 days was set at 10 mg 1,1,2-TCE/l.

A NOEC of 3.0 mg 1,1,2-TCE/l (parameters: mortality, growth, developmental disturbances) was determined after 8 weeks in artificial seawater for eggs of the plaice (*Pleuronectes platessa*) which were metamorphosing to larvae.

An identical 24-h, 48-h, 72-h and 96-h LC_{50} value of 40.2 mg 1,1,2-TCE/l exists (static test) for the acute toxicity of 1,1,2-TCE in the bluegill sunfish (*Lepomis macrochirus*). The NOEC was specified to be < 22.0 mg 1,1,2-TCE/l.

Identical 24-h, 48-h, 72-h and 96-h LC₅₀ values of about 82 mg/l were determined (flow-through procedure) for the fathead minnow (*Pimephales promelas*).

A 48-h LC₀ value of 94 mg and a 48-h LC₁₀₀ value of 201 mg trichloroethane/l have been established, besides a 48-h LC₅₀ value of 123 mg trichloroethane/l, for the acute toxicity of trichloroethane in the golden orfe (*Leuciscus idus melanotus*).

A 14-day LC₅₀ value of 94 mg 1,1,2-TCE/l was given after a 14-day exposure (semistatic test conditions, closed system/covered containers) of 2 - 3 months-old guppies (*Poecilia reticulata*) in the prolonged fish toxicity test. In an early-life-stage test (ELS test) for 32 days with fertilized eggs (maximum of 24 hours old) of the fathead minnow (*Pimephales promelas*; flow-through system), the weight of the juveniles, compared with the controls, was significantly reduced at a 1,1,2-TCE concentration of 14.8 mg/l ($p = 0.05$) and 48.3 mg/l ($p = 0.01$), respectively, at the end of the test. The survival rate, compared with the controls, was significantly reduced by 48.3 mg 1,1,2-TCE/l ($p = 0.01$) respectively. The NOEC was 6 mg 1,1,2-TCE/l.

Branch ends (enclosed gas-tight in glass cuvettes) with one- and two-year-old needles of six-year-old spruces (*Picea abies*) were fumigated with 11 - 15 mg trichloroethane/l until symptoms of damage appeared. Fine-structural alterations (distension of the thylakoids applies as the standard symptom for diseased spruces in the vicinity of industrial centers) occurred mainly on the chloroplasts of the needle mesophyll. A further symptom observed was needle discoloration (bleaching of the youngest needles). After a 4-week exposure to trichloroethane, the growth of the newly ejected shoots was inhibited to about 50 % as opposed to the controls. The fine-structural analysis of the needles, which were completely bleached out after 5 weeks, showed pronounced alterations of the mesophyll chloroplasts.

A 2-day contact-filter-paper test (according to OECD Guideline 207) was performed on the acute toxicity in *Eisenia fetida* (an oligochaete related to the earthworm) A 48-h LC₅₀ value of 42 µg/cm³ (open system; evaporation not excluded) was determined for 1,1,2-TCE (taken up through the skin). No further data are available concerning skin alterations.

Toxicological aspects

1,1,2-TCE is readily absorbed through the respiratory tract, the skin and the gastrointestinal tract. After being metabolized, it is excreted mainly through the urine as S-carboxymethylcysteine and thiodiacetic acid. Via the lung, 1,1,2-TCE is exhaled primarily as CO₂.

The values for the acute toxicity (LD₅₀ or LC₅₀) of 1,1,2-TCE are as follows:

- 378 - 835 mg/kg b.w. after oral application in the mouse,
- 5,371 mg/kg b.w. and 963 - 1,925 mg/kg b.w. after dermal application in the rabbit and guinea pig, respectively and,
- 2,309 mg/m³/6 hours and 9,180 mg/m³/6 hours after inhalation exposure in the mouse and rat, respectively.

The target organs after acute application are the liver (centrilobular necrosis, lipid deposition) and the kidney (necrosis). 1,1,2-TCE caused a depression of the central nervous System after a single subcutaneous application to mice; the pentobarbital sleeping time was prolonged (ED₅₀ for an extension of the sleeping time by ≥ 10 minutes: 280 mg 1,1,2-TCE/kg b.w.).

With direct skin contact and open application, 1,1,2-TCE causes mild skin irritation, while severe skin irritation as well as a slight mucosa irritation result from occlusive application.

No data are available concerning a possible sensitizing potential of 1,1,2-TCE.

The NOEL for 1,1,2-TCE in the mouse was about 3.8 mg/kg b.w./day after 14 days of oral application (by gavage). Oral application (in drinking water) of 1,1,2-TCE to mice for 90 days resulted in a NOEL of 3.9 mg/kg b.w./day and 4.4 mg/kg b.w./day for female and male mice, respectively. Repeated inhalation exposure (7 hours/day, 5 days/week) to 83 mg 1,1,2-TCE/m³ air for 6 months did not lead to substance-related histopathological, hematological and biochemical changes in the rat, guinea pig and rabbit. Body weight gain, organ weights and mortality remained unaffected.

Like after single application, the target organs in mice and rats after repeated oral application are the liver and kidney.

XX

1,1,2-TCE showed mainly negative results in *in vitro* and *in vivo* studies on the genotoxic effect. There is an indication of an aneuploidy-inducing effect from studies with *Aspergillus nidulans*.

In vitro cell-transformation tests with 1,1,2-TCE on mouse embryonal cells yielded slightly positive results.

In long-term studies (78 weeks) on the carcinogenicity of 1,1,2-TCE in the mouse and rat, the incidence of hepatocellular carcinomas was increased significantly in male and female mice at doses (by gavage) of 195 mg/kg b.w./day and above, and the incidence of adrenal phaeochromocytomas was raised significantly in female mice at an oral dose of 390 mg/kg b.w./day. There were no indications of a carcinogenic effect of 1,1,2-TCE in the rat.

No initiating properties but rather tumor-promoting properties were indicated in an initiation-promotion study on male rats.

The mostly negative findings in genotoxicity studies as well as in the long-term studies on rats (carcinogenesis study and initiation/promotion test) and the increase of the S-phases in mice liver can be considered as an indication that the formation of tumors in mice does not take place according to a genotoxic mechanism.

With simultaneous maternal toxicity, no fetotoxic effect was displayed in a reproduction toxicology study on mice. The available data do not allow any assessment of the reproduction-toxicological potential of 1,1,2-TCE.

In humans, 1,1,2-TCE in "low concentrations" acts as a narcotic. 1,1,2-TCE irritates the conjunctiva, the mucosa of the respiratory tract and the skin. Prolonged exposure leads to upper gastrointestinal tract ailments as well as to fatty liver and lung damage. A clearance of 7 % via the lung (at an assumed alveolar ventilation of 336 l/hour) and a metabolic clearance of 93 % were calculated for the elimination of 1,1,2-TCE in humans.

Recommendations

Ecology

The available results on ecotoxicology and environmental behaviour of 1,1,2-TCE are considered to be sufficient for an evaluation of the environmental relevance.

Toxicology

Because no data on clastogenicity but rather an indication of aneuploidy are available, an *in vivo* micronucleus test is recommended.

Sensitization is unexpected because of the volatility and the structure of the compound. Thus, this end point does not need any immediate clarification.

Impairment of reproduction is improbable due to use in closed systems. Moreover, because screening tests were negative, a planned study about this likewise is not considered to be urgent.