



**German Chemical Society  
Gesellschaft Deutscher Chemiker**

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

**1,1,1-Trichloroethane**

BUA Report 156

(August 1994)



S. Hirzel

Wissenschaftliche Verlagsgesellschaft 1996

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

### **GDCh Office:**

Dr. H. Behret, GDCh, Frankfurt am Main

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

Beratergremium für  
Umweltrelevante Altstoffe (BUA)



S. Hirzel

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

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## 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

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# **BUA Report on 1,1,1-Trichloroethane**

## **Summary and conclusions**

### **Ecological aspects**

#### **Occurrence and distribution in the compartments**

1,1,1-Trichloroethane (1,1,1-Tri) is produced in the Federal Republic of Germany only by one manufacturer by means of photochlorination of 1,1-dichloroethane in the gas phase.

In 1990, the production capacity for 1,1,1-Tri was 100,000 t and the production quantity 80,678 t (without stabilizers). The 1990 export volume of 1,1,1-Tri for the Federal Republic of Germany is specified to be 70,207 t. Import data are unavailable.

A further substantial decrease in the production quantity is expected for the coming years in the Federal Republic of Germany, because a reduction in the production and the consumption of fluorochlorohydrocarbons and halones by at least 95 % until the mid-nineties had already been decided in 1987 by the Enquête Commission of the German parliament on the basis of the Montreal protocol, in addition to the Second Federal Immissions Regulation (2. BImSchV) currently in force. The EU is aiming for a production stop of this substance until the end of this century.

1,1,1-Tri is used exclusively in the Federal Republic of Germany as a solvent for oils, fats, waxes, resins, tar, various plastics as well as bitumen and asphalt. For technical application, stabilized 1,1,1-Tri is used mainly for industrial cleaning techniques and degreasing of metallic surfaces, especially for cold cleaning of various unit pieces and construction parts, machines and engines as well as instruments. Its especially stabilized qualities are moreover applied in light-metal cleaning and vapor-degreasing for aluminium parts. In accordance with the fluorochlorohydrocarbons-halone prohibition regulation, the production, marketing and use of 1,1,1-Tri to more than 1 % in cleaning agents is prohibited. One exception dealt with cleaning agents used solely in units in accordance with the Second Federal Immissions Regulation (2. BImSchV).

The total determinable emission of 1,1,1-Tri from production into the atmosphere after treatment of the exhaust gas streams was 10 t for 1990.

The atmospheric emission from use in the Federal Republic of Germany is estimated at 26,000 t ( $\Delta$  80 % of consumed 1,1,1-Tri) for 1990, at

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16,000 t ( $\Delta$  70 % of consumed 1,1,1-Tri) for 1991 as well as 4,000 t ( $\Delta$  60 % of consumed 1,1,1-Tri) for 1992.

As of 1996, no more emissions via production and use are anticipated in the Federal Republic of Germany.

The total emission from 1,1,1-Tri production via pretreated waste water into sewage treatment plants amounted to  $< 0.01$  t in 1990. Open use in 1982 in Germany caused emissions into the hydrosphere of about 100 t via exhaust gas scrubber units but are no longer permitted since 1993.

No direct emissions into the hydrosphere are expected anymore as of 1996 for the Federal Republic of Germany.

No emission into the geosphere occurred in 1990 from production.

An indirect emission of 1,1,1-Tri from the atmosphere into the geosphere (about 12 t/a) or into the hydrosphere can take place, for example, by being rained out or deposited with precipitation or also in gaseous or aerosol form.

1,1,1-Tri is detectable worldwide in the atmosphere. From a global viewpoint, main sources of 1,1,1-Tri emission into the atmosphere are production and processing sites of the northern hemisphere. Significant concentration differences thus result between the northern and southern hemisphere. In 1991, the global 1,1,1-Tri contamination in the northern hemisphere was approximately  $0.83 \mu\text{g}/\text{m}^3$  but was about  $0.59 \mu\text{g}/\text{m}^3$  in the southern hemisphere.

The typical, not routinely measured atmospheric 1,1,1-Tri concentrations in the Federal Republic of Germany fluctuated in 1988 between 1 and  $3 \mu\text{g}/\text{m}^3$  in country areas and between 2 and  $10 \mu\text{g}/\text{m}^3$  in urban areas. Single values of up to  $43 \mu\text{g} \text{ 1,1,1-Tri}/\text{m}^3$  could be measured in 1986/87 in the Federal Republic of Germany at one industrial location such as Hamburg.

The annual mean values of the Offenbach measurement station decreased during the period of 1987 to 1992 from 2.1 to  $1.7 \mu\text{g} \text{ 1,1,1-Tri}/\text{m}^3$  while those of Deuselbach rose from 0.95 to  $1.02 \mu\text{g} \text{ 1,1,1-Tri}/\text{m}^3$ . Similarly, the annual mean values of Schauinsland increased from 0.89 to  $1.25 \mu\text{g} \text{ 1,1,1-Tri}/\text{m}^3$  during the period of 1988 - 1992.

Daytime values of  $0.98 \pm 0.18 \mu\text{g}/\text{m}^3$  and nighttime values of  $0.86 \pm 0.16 \mu\text{g}/\text{m}^3$  were determined from October 1985 to June 1986 at Schauinsland (southern Black Forest).

Data are available from 1978 about the occurrence of 1,1,1-Tri in soil spacial air in different soil depths at various elevations above sea level for the western as well as eastern slope of the Black Forest. 1,1,1-Tri concentrations for the western slope at Rhine elevation (< 200 m above sea level) were < 1.0  $\mu\text{g}/\text{m}^3$ . At 300 meters above sea level, these values were 3 - 5  $\mu\text{g}/\text{m}^3$  for the western slope and < 1.0  $\mu\text{g}/\text{m}^3$  for the eastern slope. At an elevation of 500 m above sea level, the 1,1,1-Tri levels were found to be 7 - 15  $\mu\text{g}/\text{m}^3$  for the western slope and 1.2 - 1.3  $\mu\text{g}/\text{m}^3$  for the eastern slope.

In the Rhine-Main region, 1,1,1-Tri at concentrations of up to 20  $\mu\text{g}/\text{m}^3$  was detected between 1978 and 1980 in soil spacial air of areas immediately affected by industry and commerce. Concentrations of up to 6  $\mu\text{g}$  1,1,1-Tri/ $\text{m}^3$  were determined in soil spacial air of other areas. Maximum values in polluted soils (published in 1983) reached up to 1,200  $\mu\text{g}/\text{m}^3$  (Heidelberg-Wieblingen) and 1,900  $\mu\text{g}/\text{m}^3$  (Mannheim).

In ground-level landfill gas of one former industrial sludge landfill, 1,1,1-Tri at concentrations of 174 - 296  $\mu\text{g}/\text{m}^3$  was detected during 1983 - 1988 at various sampling sites. In March 1987, 1,1,1-Tri concentrations ranging from 50 to 7,000  $\mu\text{g}/\text{m}^3$  were measured in soil spacial air of one hazardous waste landfill. From June 1985 to April 1986, maximum and mean indoor 1,1,1-Tri concentrations of 264.1  $\mu\text{g}/\text{m}^3$  and 7.97  $\mu\text{g}/\text{m}^3$  were determined, respectively, at 100 locations within 55 districts of the Federal Republic of Germany (5 homes each). 1,1,1-Tri concentrations ranging from 1.18 to 61.91  $\mu\text{g}/\text{m}^3$  (geometric mean values: 1.6 - 10.0) were measured from January to April 1985 in indoor air from 94 residences. The corresponding geometric mean values for the outdoor 1,1,1-Tri concentration were 1.4 - 9.3  $\mu\text{g}/\text{m}^3$  during the same period.

In 1989, the 1,1,1-Tri concentrations of water body sediment ranged from 0.45  $\mu\text{g}/\text{kg}$  (June) to 1.0  $\mu\text{g}/\text{kg}$  (November) and were < 0.2 - 1.1  $\mu\text{g}/\text{kg}$  during 1972 - 1981 in Hamburg Harbor.

1,1,1-Tri concentrations of < 0.10  $\mu\text{g}/\text{l}$  were measured in Dutch coastal waters, while concentrations of 0.01 - 0,257  $\mu\text{g}/\text{l}$  were determined in the Gulf of Mexico, 0.03  $\mu\text{g}/\text{l}$  in the Seto Sea (Japan), 0.0018  $\mu\text{g}/\text{l}$  in the Antarctic and 0.0025  $\mu\text{g}/\text{l}$  in the Arctic.

In 1984 - 1992, the 1,1,1-Tri concentrations in the Rhine ranged from < 0.01 to 3.70  $\mu\text{g}/\text{l}$ . Maximum concentrations of < 0.05 to 5  $\mu\text{g}$  1,1,1-Tri/ $\text{l}$  were determined in 1986 to 1991 in Rhine tributaries.

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The concentrations in the Elbe were between  $< 0.001$  and  $2.8 \mu\text{g } 1,1,1\text{-Tri/l}$  during 1980 - 1982. The annual mean values of 1,1,1-Tri at Schnackenburg were  $< 0.001 \mu\text{g/l}$  and  $0.13 \mu\text{g/l}$  in 1981/82, respectively. 1,1,1-Tri concentrations of  $0.001 - 0.974 \mu\text{g}$  were measured in 1984 - 1992 in the Elbe. In Elbe tributaries, levels ranging from  $< 0.01$  to  $0.06 \mu\text{g/l}$  were determined in 1991 and  $< 0.01 - 0.02 \mu\text{g/l}$  in 1992. In 1991, the values in the Weser were between  $< 0.01$  and  $0.03 \mu\text{g } 1,1,1\text{-Tri/l}$ .

During 1983 - 1989, 1,1,1-Tri concentrations of  $4 - 56 \text{ ng/l}$  were measured in rainwater and  $0.68 \mu\text{g/l}$  in fog samples.

With drinking water preparation, the adsorption to activated charcoal leads to almost 100 % elimination.

Most drinking waters are only slightly contaminated with a base amount of 1,1,1-Tri. In 1985, about 2.5 % of unharmed groundwater supplies contained  $> 1 \mu\text{g } 1,1,1\text{-Tri/l}$ . Average drinking water contamination lies at  $0.1 - 0.2 \mu\text{g/l}$ . 1,1,1-Tri concentrations of less than  $0.1 \mu\text{g/l}$  (Berlin-Spandau) up to  $7,200 \mu\text{g/l}$  (industrial area in Berlin) were measured in groundwater.

1,1,1-Tri in concentrations of up to  $1.020 \mu\text{g/l}$  was found in leachate-water of hazardous waste landfills.

Industrial and commercial waste water contain up to  $35 \mu\text{g } 1,1,1\text{-Tri/l}$  depending on the branch of industry and in extreme cases, up to  $10,800 \mu\text{g/l}$ . Generally, municipal waste water contained a maximum of  $1 - 2.7 \mu\text{g/l}$ ; values up to  $62 \mu\text{g/l}$  were also found.

In 1983 - 1984, 1,1,1-Tri concentrations of  $2 - 4 \mu\text{g/kg}$  dry substance were determined in agricultural soils in the loess zone of the northern foothills of the Harz, which lies in an area affected by various chlorinated hydrocarbon emitters.

In Hamburg, the 1,1,1-Tri concentrations measured in 1984 in representative soil samples (0 - 25 cm depth) of the total municipal area ranged from  $< 0.2$  to  $1.4 \mu\text{g/kg}$ . In one soil contaminated with chlorinated hydrocarbons, levels of up to  $430 \mu\text{g/kg}$  were found, while up to  $1,370 \text{ mg } 1,1,1\text{-Tri/kg}$  soil were detected underneath one former factory.

1,1,1-Tri is taken up essentially via respiratory air and food. The relative fractions of total uptake amount to about 4 % for drinking

water, 79 % for respiratory air and 17 % for food. The daily uptake for a 70 kg adult was calculated to be 15.88 µg via respiratory air, 0.18 µg via drinking water and 0.17 µg via food.

Human tissue analyses resulted in the following average 1,1,1-Tri concentrations per kilogram wet weight: subcutaneous adipose tissue: 3 µg fibrous capsule of the kidney fat: 3 µg; liver parenchyma: 2 µg; lung tissue: 7 µg muscle tissue: 5 µg. Blood of employees in the metal-degreasing branch contained up to 23 µg 1,1,1-Tri/l. 1,1,1-Tri could likewise be detected in marine organisms such as molluscs and fish. 1,1,1-Tri in a concentration of 4 µg/kg dry weight could be found in the middle intestinal gland of the horse mussel *Modiolus modiolus* as well as 9 and 16 µg/kg dry weight in the brain of the conger eel (*Conger conger*) and of cod (*Gadus morhua*), respectively. Nearby estuaries, concentrations of up to 34 µg/kg were found in crustaceans and up to 43 µg/kg in the eggs of aquatic birds. Individual organs of freshwater fish contained up to 31 µg/kg wet weight.

1,1,1-Tri in concentrations of up to 5.5 µg/kg needles were found in spruce needles from one industrial area.

1,1,1-Tri was also analyzed in foodstuffs in Germany including olive oil (up to over 100 µg/kg), dairy products (up to 0.6 µg/kg) and baked goods with a long shelf life (up to 335 µg/kg). Dairy products in the U.S.A. were partially more contaminated (up to 3,300 µg/kg).

Natural sources of 1,1,1-Tri are unknown.

### **Degradability**

1,1,1-Tri is not readily biodegradable in the hydrosphere. In several studies under aerobic conditions, either no biodegradation or only a slight primary degradation was found, which, however, can amount to > 98 % with adapted inoculum. Results on anaerobic degradation are available after a test period of 56, 60 and more than 100 days. Primary degradation here was found only after the addition of further C-sources or after adaptation.

Under anaerobic methanogenic conditions, 1,1,1-Tri is degraded almost completely (e.g. in a 8-week batch test in a mixture of various chlorinated hydrocarbons, after an acclimatization phase of 16 days).

1,1,1-Tri is metabolized anaerobically by reductive dehalogenation to 1,1-dichloroethene. Hydrolytic degradation is not expected under environmentally relevant conditions. Half-lifetimes exist of 0.5 to > 2.8 years, determined at 20 - 25 °C. In contrast, an abiotic degradation to 1,1-dichloro-ethene does take place.

Indirect photochemical degradation in the troposphere is the most important degradation route for 1,1,1-Tri. Half-lifetimes ranging from 2 to 10 years were calculated for the degradation of 1,1,1-Tri by OH-radicals.

Regarding the ozone depletion potential (ODP) in the stratosphere, ODP values between 0.1 and 0.2 are available, and a value of 0.1 (relative to ethene) is given for the photochemical ozone creating potential (POCP) in the troposphere.

### **Accumulation**

A moderate bioaccumulation is expected on the basis of an experimentally determined log  $P_{OW}$  of 2.46. A bioconcentration factor (BCF) of 0.7 - 4.9 was determined experimentally (OECD Guideline 305C) for 1,1,1-Tri. According to this, 1,1,1-Tri is classified with having only a low bioaccumulation.

No geoaccumulation is expected based on the physicochemical properties as well as soil sorption studies. A  $K_{OC}$  value of 45 indicates a very low soil sorption, and a  $K_{OC}$  value of 1,047 infers a high soil sorption. One can expect a leachate-to-groundwater transport of 1,1,1-Tri because of its high mobility in soil. Moreover, 1,1,1-Tri is highly volatile from water, so that the principle target compartment is the atmosphere.

### **Ecotoxicology**

In some of the following cited studies, it is not clear which positional isomer was investigated. Therefore, this is clarified by the labeling 'trichloroethane' instead of "1,1,1-Tri" as has been done in the rest of the text. Because most of the studies do not specify nominal or effective concentrations, this is only indicated when explicit data are available on this.

On one pure culture of the bacterium *Pseudomonas putida*, a 16-h cell-reproduction inhibition test (growth parameter: turbidity) resulted in a toxic limiting concentration of 93 mg trichloroethane/l (closed System).

A 5-minute EC<sub>50</sub> of 105 mg 1,1,1-Tri/l was determined for *Photobacterium phosphoreum*, while another test showed an EC<sub>50</sub> of 8.04 mg/l after 15 minutes.

Digester gas-producing microorganisms exhibited a 7-day EC<sub>50</sub> of 1 mg/l sludge (anaerobic sludge) in a closed system.

An 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 trichlorethane/l was given for the green algae *Scenedesmus quadricauda* after an 8-day exposure (closed system).

Regarding the acute toxicity of 1,1,1-Tri in the freshwater green algae *Selenastrum capricornutum* and the halophilic silica algae *Skeletonema costatum*, a 96-h EC<sub>50</sub> value of > 669 mg 1,1,1-Tri/l was determined for the reduction of the cell count and of the chlorophyll-a content (*in vivo*).

A 24-h EC<sub>10</sub> of 100 mg/l and a 24-h EC<sub>50</sub> of 320 mg/l were established for the acute toxicity in a green algae-mixed culture (principle organism: *Scenedesmus subspicatus*).

The NOEC (no-observed-effect concentration) for silica algae amounted to > 167 mg/l.

For the inhibition of <sup>14</sup>C-assimilation, 3-h EC<sub>50</sub> values of 153 mg/l and 280 mg/l were determined for the algae *Chlorella vulgaris* and *Chlamydomonas*, respectively.

EC<sub>50</sub> and LC<sub>50</sub> values for trichloroethane (test medium corresponded to unstandardized conditions) are available for marine silica algae and microcrustaceans. For instance, an EC<sub>50</sub> value of 5 mg trichloroethane/l seawater exists for the inhibition of <sup>14</sup>C-assimilation in *Phaeodactylum tricorutum*. A 48-h LC<sub>50</sub> value of 7.5 mg trichloroethane/l seawater is available on the acute toxicity in nauplii of the barnacle *Elminius modestus*.

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For the shrimp *Mysidopsis bahia*, a 96-h LC<sub>50</sub> value of 31.2 mg 1,1,1-Tri/l and a NOEC of < 7.5 mg 1,1,1-Tri/l (no time specification: probably a 96-h value) were determined.

The 24-h LC<sub>50</sub> and 48-h LC<sub>50</sub> values for the acute toxicity in water fleas (*Daphnia magna*) lie above 530 mg 1,1,1-Tri/l. The NOEC was given as 530 mg 1,1,1-Tri/l. The 48-h LC<sub>50</sub> in another study is 57.6 mg/l.

A LC<sub>50</sub> value of 5.4 mg 1,1,1-Tri/l (effective concentration) is available from a 17-day long-term test (closed semistatic system, animals fed) on the chronic toxicity of stabilized 1,1,1-Tri in *Daphnia*. A NOEC of 1.3 mg 1,1,1-Tri/l was cited for reproduction and maternal mortality.

A 96-h LC<sub>50</sub> value of 69.7 mg 1,1,1-Tri/l (static test) is available on the acute toxicity of 1,1,1-Tri in the bluegill sunfish (*Lepomis macrochirus*). The NOEC was cited as 46 mg 1,1,1-Tri/l.

A 96-h LC<sub>50</sub> value of 52.8 mg/l (effective) was determined in the fathead minnow (*Pimephales promelas*).

Besides a 48-h LC<sub>50</sub> value of 123 mg trichloroethane/l, there is a 48-h LC<sub>0</sub> value of 94 mg trichloroethane/l available on the acute toxicity of trichloroethane in the golden orfe. A 24-h LC<sub>50</sub> value of 68 mg/l as well as identical 48-h, 72-h and 96-h LC<sub>50</sub> values of 71 mg 1,1,1-Tri/l each (based on the nominal concentration at the test start) have been found for the sheepshead minnow *Cyprinodon variegatus*. The NOEC was specified to be 43 mg 1,1,1-Tri/l.

Based on the effective concentration, a 48-h LC<sub>50</sub> value of 79 mg/l (LC<sub>0</sub>: 35 mg/l) and a 96-h LC<sub>50</sub> of 55 mg 1,1,1-Tri/l (LC<sub>0</sub>: 35 mg/l) were found for the zebra fish (*Brachydanio rerio*). In a 14-day test, a NOEC of 3.4 mg 1,1,1-Tri/l was determined, based on the effective concentration.

After a 14-day exposure, a NOEC of 7.7 mg stabilized 1,1,1-Tri/l (effective concentration) was determined on the common carp (*Cyprinus carpio*).

For ciliate protozoa (*Colpoda sp.*) living in soil, an EC<sub>50</sub> value of 205 mg 1,1,1-Tri/l was ascertained (based on growth inhibition) after several days of incubation.

A 21-day EC<sub>50</sub> (based on growth) value of 104 mg 1,1,1-Tri/l nutrient solution (based on the nominal concentration) was determined for the sprouts of lettuce seedlings (*Lactuca sativa*).

In the plant fumigation test, a 14-day EC<sub>50</sub> value of 19 mg 1,1,1-Tri/l air and a 14-day NOEC of 6.9 mg/l air were found for rape with respect to growth. For sorghum (*Sorghum bicolor*), the corresponding values were 48 mg/l and 19 mg/l air.

A 24-h LC<sub>50</sub> value of 208.4 mg 1,1,1-Tri/l air was found for the pupae of *Tribolium castaneum*.

After several days of incubation, the EC<sub>50</sub> value for a soil-habiting oligochaete (*Aeolosoma hemprichi*) was 92 mg 1,1,1-Tri/l air.

With respect to acute toxicity, a 2-day contact-filter paper test was performed on *Eisenia fetida* (an oligochaete related to the earth worm). A 48-h IC<sub>50</sub> value of 83 µg/cm<sup>2</sup> was determined (open system; evaporation not excluded) for 1,1,1-Tri (uptake by skin). There are no further data available on skin alterations.

### **Toxicological aspects**

1,1,1-Tri is absorbed well from the intestinal tract and after inhalative uptake as well as percutaneously after direct contact with the intact skin. It is distributed rapidly among all body tissues. On the basis of its lipophilic properties, accumulation takes place mainly in tissue with a high fat content. The plasma elimination half-life is ca. 3 hours.

A transplacental transfer of absorbed 1,1,1-Tri was detected after inhalative exposure of pregnant mice.

Absorbed 1,1,1-Tri is exhaled mostly unchanged, and only a very small fraction is metabolized to 2,2,2-trichloroethanol which is excreted with the urine as a glucuronic acid adduct. In addition, the metabolite trichloroacetic acid (likewise excreted in urine) as well as CO<sub>2</sub> are formed only in small quantities.

Absorbed 1,1,1-Tri is also metabolized only to a slight extent in humans. After inhalative exposure, small amounts of 2,2,2-trichloroethanol (about 2 % of the amount absorbed) as well as trichloroacetic acid (about 0.5 % of the amount absorbed) were detected in urine. Other metabolites could not be detected. Elimination half-lives from the blood of 26 and 53 hours were calculated for 1,1,1-Tri.

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Independent of the application route, 1,1,1-Tri shows low toxicity after acute and repeated application.

The value for the acute oral toxicity of 1,1,1-Tri ( $LD_{50}$ ) for the rat is about 16,000 mg/kg body weight and is about 5,660 mg/kg b.w. for the rabbit. With parenteral application, however, the acute toxicity of 1,1,1-Tri is greatly dependent on the vehicle: After i.p. application to the mouse, the lowest  $LD_{50}$  value was 2,570 mg 1,1,1-Tri/kg b.w. by using plant oil as vehicle but only 84 mg 1,1,1-Tri/kg b.w. after application in dimethylsulfoxide solution. For the rabbit, the occlusive dermal application resulted in a  $LD_{50}$  value of over 16,000 mg/kg b.w..

After parenteral administration of 1,1,1-Tri in dosages which lay in the range of the  $LD_{50}$  values, liver damage occurred through centrilobular necroses, moderate neurotropic infiltration in the portal area and the sinusoids as well as mild subcapsular necroses. Moreover, a slight calcification of the tubuli of the Medulla renalis was observed.

1,1,1-Tri was also shown to be low-toxic after acute inhalative uptake. The  $LC_{50}$  values for the rat range from 57,131 mg 1,1,1-Tri/ $m^3$  for a 6-hour exposure to 210,775 mg 1,1,1-Tri/ $m^3$  for a 15-minute exposure.

The intoxication profile after acute inhalative exposure to 1,1,1-Tri is characterized by depression of the central nervous system which can be preceded by a phase of nervous hyperactivity. The symptoms comprise a reduced activity and prenarctic effects which lead to a staggering gait after a few minutes and to somnolence after a few hours accompanied by an irregular respiration. Higher concentrations lead to lethargy, ataxia, narcosis and finally to coma.

Indications of slight liver damage through mild fatty liver, central hyperemia as well as hemorrhaging necroses were likewise observed.

Furthermore, inhalative uptake of 1,1,1-Tri caused functional damage of the cardiovascular system, which can result in hypotonia and a reduction of the peripheral vascular resistance as well as the myocardial contraction and the cardiac output.

Liquid and gaseous 1,1,1-Tri acted slightly to mildly irritating to skin and mucosa.

1,1,1-Tri does not act sensitizing in the guinea pig.

With repeated oral and dermal application of 1,1,1-Tri to rats and mice, a significant increase of the microsomal and cytoplasmatic protein content of the liver occurred (in both sexes). Damage through focal, intralobular inflammatory infiltration (without histopathological alterations) occurred after the occlusive dermal application of 240 - 320 mg 1,1,1-Tri/kg b.w./day for a total of 16 days.

A no-effect level for oral application is unavailable in the literature.

1,1,1-Tri exhibits a low toxicity after chronic inhalative uptake, too. For the rat, the NOEL after inhalative exposure amounts to 9,000 mg 1,1,1-Tri/m<sup>3</sup> (with 6 hours of exposure per day on 5 days/week for 12 months). A depression of the central nervous System (ataxia, sedation) as well as a significantly increased liver weight occurred in the rat after subchronic exposure to 55,467 mg 1,1,1-Tri/m<sup>3</sup> for 1 hour/day for 5 days/week over a period of 14 weeks.

For the guinea pig, a NOEL of 2,773 mg 1,1,1-Tri/m<sup>3</sup> ( $\Delta$  500 ppm) can be derived for intermittent exposure (for 7 hours/day on 5 days/week for 6 months).

*In vitro* as well as *in vivo* studies on mutagenicity conducted with 1,1,1-Tri produced negative results in numerous test systems. Individual positive results *in vitro* (in the Ames test and tests on chromosomal damage to mammalian cell cultures) are supposedly attributed to the influence of stabilizer additions to the test substance (the most of which possess electrophilic properties, such as e.g. butylenoxide).

The results of several long-term studies on rats and mice as well as one short-term test on rats (initiation/promotion study) showed no indication of a carcinogenic potential of 1,1,1-Tri. One positive *in vitro* result was obtained in a transformation test only in an unconventional test system (p 108-subculture of the F1706 cell line of Fischer rat embryos chronically infected with Rauscher leukemia viruses). Undifferentiated fibrosarcomas were induced after subcutaneous inoculation of newborn rats with transformed cells from this system.

From the studies on reproductive toxicity of 1,1,1-Tri on the mouse and rat, there were neither indications of an impairment of fertility nor of an increase in the rate of malformations or variations/retardations. Moreover, in the rat, no behavioural deviations were observed in offspring of dams exposed to 1,1,1-Tri. For the rabbit, a weak fetotoxic effect, manifested in a slight increase of the skeletal variation rate, was noted only in the maternally-toxic dosage range.

Like all halogenated hydrocarbons, 1,1,1-Tri sensitizes the heart for sympathetic stimulation and for stimulation from adrenergics (e.g. adrenaline), whereby mainly cardiac arrhythmias constitute the symptoms of intoxication which can lead to death.

In humans, the acute oral intoxication with 1,1,1-Tri causes pronounced gastrointestinal irritation. A depression of the central nervous system is also the primary effect in humans after inhalative uptake of 1,1,1-Tri, whereby high concentrations act as a narcotic.

In several studies which mainly involved tests on motor function, motoric coordination and sense of equilibrium as well as psycho physiological performance, an impairment of the central nervous system was observed from exposure of the volunteers to 1,1,1-Tri concentrations ranging from 4,992 to 5,547 mg/m<sup>3</sup> (dizziness, vertigo) and a loss of ability to stand upright as of a concentration of about 13,867 mg/m<sup>3</sup>. No adverse effect on the central nervous system was established at concentrations below 2,773 mg 1,1,1-Tri/m<sup>3</sup> transient eye irritation partially occurred, however.

In the course of field studies on groups of persons occupationally exposed to 1,1,1-Tri, the established findings comprised a partially elevated number of sleep apnoeas, increased frequency of complaints of the "neurotic type (e.g. headache, anxiety, nervousness, irritability, insomnia, psychic depression, digestive disorders etc.) as well as symptoms (e.g. impairment of short-term memory), which could possibly indicate an organic solvent encephalopathy. Pronounced sclerodermia appeared in two cases following chronic occupational exposure to 1,1,1-Tri and trichloroethene, simultaneously or consecutively.

The autopsy findings after lethal inhalative intoxication of humans with 1,1,1-Tri were lung edema in all cases and also single cases of cerebral edema, hyperemia in the brain, in the kidney, in the stomach and in the lung, myocardial infarct as well as hemorrhage in the lung and a mild case of fatty liver.

Repeated skin contact with 1,1,1-Tri can lead (like for other chlorinated hydrocarbons) to dermatitis through degreasing. However, there have only been a few known cases of dermal irritation by 1,1,1-Tri. Sensitization in humans could not be observed after repeated, open dermal application.

In volunteers, the repeated inhalative 1,1,1-Tri-uptake did not have any effect on the results of neurological, manual dexterity as well as coordination tests; hematological as well as biochemical parameters and the urinalysis were likewise unaffected in comparison to the results prior to exposure.

The available epidemiological findings are not sufficiently evaluable regarding a reproductive toxicological risk to humans. Nonetheless, a risk to humans should not be expected on the basis of experimental animal studies.

## **Recommendations**

### **Ecology**

Existing results on ecotoxicology and environmental behaviour are considered to be sufficient for an evaluation of the environmental relevance.

### **Toxicology**

Because the toxicological effect profile of 1,1,1-Tri is known and has been sufficiently investigated, no further studies are necessary.