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1,2-Dichloroethene in Drinking-water

Background document for development of
WHO *Guidelines for Drinking-water Quality*

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Preface

One of the primary goals of WHO and its member states is that "all people, whatever their stage of development and their social and economic conditions, have the right to have access to an adequate supply of safe drinking water." A major WHO function to achieve such goals is the responsibility "to propose regulations, and to make recommendations with respect to international health matters ...."

The first WHO document dealing specifically with public drinking-water quality was published in 1958 as International Standards for Drinking-Water. It was subsequently revised in 1963 and in 1971 under the same title. In 1984–1985, the first edition of the WHO Guidelines for drinking-water quality (GDWQ) was published in three volumes: Volume 1, Recommendations; Volume 2, Health criteria and other supporting information; and Volume 3, Surveillance and control of community supplies. Second editions of these volumes were published in 1993, 1996 and 1997, respectively. Addenda to Volumes 1 and 2 of the second edition were published in 1998, addressing selected chemicals. An addendum on microbiological aspects reviewing selected microorganisms was published in 2002.

The GDWQ are subject to a rolling revision process. Through this process, microbial, chemical and radiological aspects of drinking-water are subject to periodic review, and documentation related to aspects of protection and control of public drinking-water quality is accordingly prepared/updated.

Since the first edition of the GDWQ, WHO has published information on health criteria and other supporting information to the GDWQ, describing the approaches used in deriving guideline values and presenting critical reviews and evaluations of the effects on human health of the substances or contaminants examined in drinking-water.

For each chemical contaminant or substance considered, a lead institution prepared a health criteria document evaluating the risks for human health from exposure to the particular chemical in drinking-water. Institutions from Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Poland, Sweden, United Kingdom and United States of America prepared the requested health criteria documents.

Under the responsibility of the coordinators for a group of chemicals considered in the guidelines, the draft health criteria documents were submitted to a number of scientific institutions and selected experts for peer review. Comments were taken into consideration by the coordinators and authors before the documents were submitted for final evaluation by the experts meetings. A "final task force" meeting reviewed the health risk assessments and public and peer review comments and, where appropriate, decided upon guideline values. During preparation of the third edition of the GDWQ, it was decided to include a public review via the world wide web in the process of development of the health criteria documents.

During the preparation of health criteria documents and at experts meetings, careful consideration was given to information available in previous risk assessments carried out by the International Programme on Chemical Safety, in its Environmental Health

Criteria monographs and Concise International Chemical Assessment Documents, the International Agency for Research on Cancer, the joint FAO/WHO Meetings on Pesticide Residues, and the joint FAO/WHO Expert Committee on Food Additives (which evaluates contaminants such as lead, cadmium, nitrate and nitrite in addition to food additives).

Further up-to-date information on the GDWQ and the process of their development is available on the WHO internet site and in the current edition of the GDWQ.

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GENERAL DESCRIPTION

Identity

Compound	*CAS no.*	*Molecular formula*
cis-isomer	156-59-2	$C_2H_2Cl_2$
trans-isomer	156-60-5	$C_2H_2Cl_2$

Physicochemical properties (*1,2*) [Conversion factor in air: 1 ppm = 3.97 mg/m^3]

Property	*cis-isomer*	*trans-isomer*
Melting point (°C)	-80.5	-50
Boiling point (°C)	60.3	47.5
Density (g/cm^3 at 20 °C)	1.2837	1.2565
Vapour pressure (kPa at 25 °C)	27.7	35.3
Water solubility (g/litre at 20 °C)	3.5	6.3
Log octanol–water partition coefficient	1.86	2.09

Organoleptic properties

A mixture of 1,2-dichloroethene isomers has a pleasant odour (*3*). The odour thresholds for *trans*-1,2-dichloroethene in air and water are 68 mg/m^3 and 0.26 mg/litre, respectively (*4*).

Major uses

1,2-Dichloroethene (*cis*/*trans* mixture) is used mainly as an intermediate in the synthesis of chlorinated solvents and compounds (*5*). It has also been used as an extraction solvent for organic materials.

Environmental fate

1,2-Dichloroethene is removed from the atmosphere mainly through reaction with photochemically generated hydroxyl radicals; the estimated half-lives for the *cis*- and *trans*-isomers are 8.3 and 3.6 days, respectively. Most 1,2-dichloroethene in surface water and surface soils is expected to be volatilized. The compound may be leached through subsurface soils to groundwater. Anaerobic biodegradation may remove both isomers from groundwater, the half-life then being 13-48 weeks (*5*).

ANALYTICAL METHODS

The concentrations of *cis*- or *trans*-1,2-dichloroethene are measured is by a purge-and-trap gas chromatographic procedure used for the determination of volatile organohalides in drinking-water (*6*). The method can differentiate between the *cis*- and *trans*-isomers at concentrations of 0.03–1500 µg/litre. Mass spectrometry is used for confirmation; the detection limit is 0.17 µg/litre (*7*).

ENVIRONMENTAL LEVELS AND HUMAN EXPOSURE

Air

1,2-Dichloroethene has been detected in the air of urban and industrial areas at concentrations in the range 0.04–0.3 μg/m^3 (mean) for the *cis*-isomer to 10.3 μg/m^3 (maximum) for a mixture of isomers. Mean concentrations up to 32.2 μg/m^3 have been measured in indoor air (*5*).

Water

1,2-Dichloroethene has been detected in industrial effluents, surface water, groundwater, and drinking-water supplies in the USA. It was detected in 16 of 466 randomly selected and 38 of 479 purposely selected drinking-water supplies derived from groundwater at levels of up to 2 and 120 μg/litre, respectively (*5*).

The *cis*-form of 1,2-dichloroethene is more frequently found as a water contaminant. The presence of these two isomers, which are metabolites of other unsaturated halogenated hydrocarbons in wastewater and anaerobic groundwater, may indicate the simultaneous presence of more toxic organochlorine chemicals, such as vinyl chloride. Accordingly, more intensive monitoring is necessary if they are found to be present.

Food

1,2-Dichloroethene was not detected in fish samples at 95 stations covered by the STORET database of the US Environmental Protection Agency, but was detected in fish tissue samples from Commencement Bay, WA, at mean levels of 0.04 mg/kg (*5*).

Estimated total exposure and relative contribution of drinking-water

Based on urban air levels of 0.04–0.3 μg/m^3, the average inhalation exposure to 1,2-dichloroethene is about 1–6 μg/day (*5*). At a drinking-water concentration of 2 μg/litre, the daily intake by an adult would be about 4μg.

KINETICS AND METABOLISM IN LABORATORY ANIMALS AND HUMANS

As the *cis*- and *trans*-isomers of 1,2-dichloroethene are lipid-soluble compounds of low relative molecular mass, they would be expected to be readily absorbed by the oral or dermal routes (*8*). In humans, about 75% of inhaled *trans*-1,2-dichloroethene is absorbed through the lungs (*9*). 1,2-Dichloroethene may be preferentially distributed to adipose tissue (*10*). On the basis of distribution data for 1,1-dichloroethene, the highest concentrations might be expected to occur in liver and kidney (*11*).

The first step in the metabolism of both isomers of 1,2-dichloroethene appears to be the formation of the chloroethylene epoxide, which undergoes rearrangement to form dichloroacetaldehyde and possibly monochloroacetic acid (*12,13*). *In vitro* studies indicate that biotransformation involves the hepatic microsomal cytochrome P-450 system (*14,15*). The *cis*-isomer is metabolized at a faster rate than the *trans*-isomer (*14*). High doses may saturate the P-450 system and exceed its metabolic capacity (*5*). If excretion is similar to that of 1,1-dichloroethene, elimination would be expected to be relatively rapid, so that most of a single dose would be excreted in the urine within 24–72 h (*15*).

EFFECTS ON LABORATORY ANIMALS AND *IN VITRO* TEST SYSTEMS

Acute exposure

For a mixture of isomers, the reported oral LD_{50} for rats is 770 mg/kg of body weight (*16*). Reported oral LD_{50}s for *trans*-1,2-dichloroethene are 1275 mg/kg of body weight for female rats, 7902 mg/kg of body weight for male rats, 2221 mg/kg of body weight for male mice, and 2391 mg/kg of body weight for female mice (*17–19*). Administration of single doses of *cis*-1,2-dichloroethene at 400 or 1500 mg/kg of body weight to rats caused significant elevations of liver alkaline phosphatase, whereas the same doses of *trans*-isomer did not (*20*).

Short-term exposure

trans-1,2-Dichloroethene was administered by gavage to male CD-1 mice for 14 days at doses of 0, 21, or 210 mg/kg of body weight per day (*21*). No changes in body or organ weights, serum alanine aminotransferase, or blood urea nitrogen were reported at any dose level. However, fibrinogen levels, prothrombin times, and lactate dehydrogenase levels were significantly decreased at the highest dose. In a similar study, the *trans*-isomer, administered by gavage at doses equal to 1% and 10% of the LD_{50} (22 or 222 mg/kg of body weight per day) to male mice for 14 days, caused no significant changes in body or organ weights, haematological or blood coagulation parameters, serum enzyme levels, or humoral immune response (*18*).

In a study on CD-1 mice (15–24 per sex per dose), male mice received *trans*-1,2-dichloroethene in doses of 17, 175, or 387 mg/kg of body weight per day and female mice received doses of 23, 224, or 452 mg/kg of body weight per day in drinking-water for 90 days (*21*). No changes in water consumption, body weight, or gross pathology were observed in any dose group. There were significant increases in serum alkaline phosphatase levels in male mice at the two highest doses, and liver glutathione concentrations were decreased at the highest dose. In females, thymus weight was significantly decreased at the two highest doses, and lung weight was depressed at the highest dose. A significant decrease in aniline hydroxylase activity was also observed in females exposed to the highest dose. In another phase of this study (*22*), no dose-dependent effects were observed either in cell-mediated immunity in either sex or in the humoral immune status of female mice. However, a significant decrease in spleen antibody-forming cells was noted at all dose levels in male mice. Female mice exposed to the highest dose demonstrated an enhanced spleen cell response to lipopolysaccharide at some, but not all, concentrations.

CD rats were exposed to *trans*-1,2-dichloroethene at doses of 402, 1314, or 3114 mg/kg of body weight per day (males) and 353, 1257, or 2809 mg/kg of body weight per day (females) in drinking-water for 90 days (*19*). No compound-related effects on water consumption, body weight, serum chemistry, or urinary parameters were observed, nor were any effects on gross or histological pathology noted. However, a significant dose-dependent decrease in kidney weight was observed at the two highest doses in females.

Mutagenicity and related end-points

In vitro investigations of the genotoxic potential of 1,2-dichloroethene yielded negative results for both isomers. 1,2-Dichloroethene was not found to be mutagenic in *Escherichia coli*, several strains of *Salmonella typhimurium*, or *Saccharomyces cerevisiae*, with or without metabolic activation (*23–26*). Neither isomer induced chromosomal aberrations or sister chromatid exchanges in Chinese hamster lung fibroblasts (*27*).

In vivo studies indicate that the *cis*-, and possibly the *trans*-, isomer may be genotoxic. The *cis*-isomer was found to be mutagenic in *S. typhimurium* and *S. cerevisiae* strains in two host-

mediated assays in mice (*23,24*). Repeated intraperitoneal injections of *cis*-1,2-dichloroethene induced chromosomal aberrations in mouse bone marrow cells (*24*). The *trans*-isomer yielded negative results in these studies. However, an increase in the number of aneuploid V79 Chinese hamster cells was reported following treatment with the *trans*-isomer (*28*).

EFFECTS ON HUMANS

Inhalation of high concentrations (38 g/m^3 and above) of 1,2-dichloroethene in air causes central nervous system depression (*17*). Neurological effects, including nausea, drowsiness, fatigue, and vertigo, have been reported following exposure to lower levels (*9*). A burning sensation in the eyes was also reported. The *trans*-isomer is reportedly about twice as potent a central nervous system depressant as the *cis*-isomer (*17*), which has been used as an anaesthetic.

GUIDELINE VALUE

In a 3-month study in mice given the *trans*-isomer in drinking-water, there was an increase in serum alkaline phosphatase and reduced thymus and lung weights, as well as transient immunological effects, the toxicological significance of which is unclear. Only one rat toxicity study is available for the *cis*-isomer. There are limited data to suggest that both isomers may possess some genotoxic activity. There is no information on carcinogenicity. Data on the toxicity of the *trans*-isomer in mice (*21*) were used to calculate a joint guideline value for both isomers because of the lack of adequate toxicity data for the *cis*-isomer and because data suggest that the mouse is a more sensitive species than the rat. Accordingly, the NOAEL of 17 mg/kg of body weight per day from the *trans*-isomer toxicity study was used with an uncertainty factor of 1000 (100 for intra- and interspecies variation and 10 for the short duration of the study) to derive a TDI of 17 µg/kg of body weight. This gives a guideline value of 50 µg/litre (rounded figure) for an allocation of 10% of the TDI to drinking-water.

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